OPTIMAL WATER UTILIZATION
AND
INTRA-BASIN WATER TRANSFERS
IN
CAUVERY BASIN, INDIA

A THESIS

Submitted in fulfilment of the requirements for the award of the degree

of

DOCTOR OF PHILOSOPHY

in

WATER RESOURCES DEVELOPMENT

By

MAHADEO DNYANOBA PATIL

WATER RESOURCES DEVELOPMENT TRAINING CENTRE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE-247 667 (INDIA)

MARCH 2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

ROORKEE

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled "**OPTIMAL WATER UTILIZATION AND INTRA-BASIN WATER TRANSFERS IN CAUVERY BASIN, INDIA**" in fulfillment of the requirement for the award of the Degree of Doctor of Philosophy, submitted in the Department of Water Resources Development Training Centre (WRDTC), Indian Institute of Technology Roorkee, Roorkee is an authentic record of my own work carried out during the period from July 2000 to March 2004 under the supervision of Prof. Nayan Sharma, WRDTC, IIT Roorkee and Prof. D.K. Srivastava, Department of Hydrology, IIT Roorkee, Roorkee (India).

The matter embodied in this thesis has not been submitted by me for the award of any other degree in this or any other institute.

M. D. Patil

(M. D. PATIL)

This is to certify that that the above statement made by the candidate is correct to the best of my knowledge.

(NAYAN SHARMA)
Professor, WRDTC
IIT Roorkee, Roorkee

(D.K.SRIVASTAVA)
Professor, Dept. of Hydrology
IIT Roorkee, Roorkee

Date : March, 2004.

The Ph. D. Viva-Voce examination of Mr. M. D. PATIL, Research Scholar has been held on 13.09.2004.

Dr. S. Vedula External Examiner	Nayan Sharma Signature of Supervisor	D. K. Shrivastava Signature of Supervisor	S. K. Tripathi Head of Depptt.

ABSTRACT

According to the National Water Policy 2002 of India, water resources development and management will have to be for a hydrological unit such as drainage basin as a whole or a sub-basin, taking into account surface and ground waters for sustainable use incorporating quantity and environmental considerations. All individual developmental projects and proposals should be formulated and considered within the frame work of such an overall plan keeping in view the existing agreements/awards for a basin or sub-basin so that the best possible combination of options can be selected and sustained. Water should be made available to water short areas by transfer from other areas including transfers from one river basin to another, if necessary, based on a national perspective, after taking into account the requirements of all areas/basins. Integrated and coordinated development of surface water and ground water resources and their conjunctive use, should be envisaged right from the project planning stage and should form an integral part of the project implementation. Irrigation intensity should be such as to extend the benefits of irrigation to as large a number of farm families as possible, keeping in view the need to maximize production. Irrigation being largest consumer of fresh water, the aim should be to get optimal productivity per unit of water. In view of the vital importance of water for human and animal life, for maintaining ecological balance and for economic and developmental activities of all kinds, and considering its increasing scarcity, the planning and management of this resource and its optimal and equitable use has become a matter of the utmost urgency.

The Cauvery is an inter state river in South India originating in the state of

Karnataka and flowing through the states of Karnataka, Kerala, Tamilnadu, and Pondicherry having a catchment area of 81,155 Km^2. This basin has 16-sub-basins. It has 75% and 50% water year dependable surface water potential of 16,470 MCM and 20,776 MCM, respectively. The total of 3,866 MCM ground water potential is available for future use. The water requirement for the population of human and livestock projected to the year 2050AD for all purposes as estimated is 39516 MCM. There are 15 major reservoirs and 58 medium and a large number of minor irrigation projects in the basin. The total irrigable area is 2605200 Ha.

The sharing of the water resources of the Cauvery river is under dispute between Karnataka and Tamilnadu for a long time and creates a law and order problems in the states. The issue has been referred to The Cauvery Water Disputes Tribunal (CWDT). The purpose of the study is to find out the technological and realistic solution for the problem. The optimal allocation of surface water and ground water is therefore necessary so as to optimize the annual water utilizations for irrigation, domestic, industrial, hydropower and environmental uses. The interim award of CWDT (CWDTIA) is to release 5800 MCM (205 TMC ft) of water from Karnataka to Tamilnadu at Mettur reservoir.

To identify water surplus and water deficit basins, water balance studies are generally carried out on an annual basis, and are usually done on a lumped basis. They also do not take into account many important aspects, which influence the water balance of a river basin to a large extent. In the present study, some of the most important among them are considered for the water balance study, and two of them are (i) the timewise variability and distribution in the surface water availability and its use with respect to the yearly and the within year time periods, and (ii) the availability and use of the ground water in the basin. Further, in conventional water balance studies it may not be possible to consider, the aerial variability and distribution of the surface and ground water available and its use in the basin, with respect to the locations of the various reservoirs and water use points. Therefore, an optimization model based on linear programming was applied, which incorporates the above aspects of planning effectively.

The main objectives of this study are as follows: (i) To evaluate the utilizable surface and ground water resources on monthly basis for all 16 sub-basins and Cauvery river basin as a whole, (ii) To estimate the water demands for the year 2050 AD for different uses and to make the water balance studies on monthly basis for all the 16 sub-basins and the Cauvery basin as a whole, (iii) To develop a linear programming optimization model for a river basin, planning and development for conjunctive water use, with the aim to maximize the water utilization including intra-basin water transfers, and to determine optimal and sustainable cropping pattern in terms of irrigation intensity and productivity per unit of water, and apply it to the Cauvery river, (iv) To study and analyze in detail the interim award given by the CWDT for sharing of the Cauvery waters by the co-basin states in respect of the present study objective at Sl. No. (iii), and (v) To draw suitable conclusions from the above study.

It is found that during normal and bad water years, the Middle Cauvery sub-basin is the only water surplus sub-basin, where as the Noyil and Arkavathi sub-basins suffer the most from water deficit and the Chinnar sub-basin the least. The Kabini sub-basin is not able to fulfill its intra-basin requirements completely during normal and bad water years. From Mettur reservoir, a maximum of 7200 MCM can be exported (as intra-basin export) to the sub-basins below Mettur during a normal water year. During a normal water year, the water share ratios above and below Mettur for 5800 MCM exports (as intra-basin export) from Mettur reservoir to the sub-basins below Mettur is 0.98. The intra-basin water importing needs from outside the Cauvery basin, during normal water year may be about 13444 MCM. From the linear programming results, during a normal water year, the water extensive crops would not completely acquire their respective crop areas at six reservoirs. The high benefit crops would acquire very little crop areas at two reservoirs. Two reservoirs would require import of Sugarcane. Upper Nugu reservoir is the most affected reservoir in terms of the crop area occupation. Out of sixteen sub-basins nine sub-basins would spill in all the months during a normal water year. Generally, a maximum monthly water utilization factor of 1 would be achieved in different months at all the sub-basins, except two sub-basins. Similarly, a minimum of about 0.25 monthly water utilization factors would be achieved, with and without ground water considerations. From the LP model result, the maximum annual water utilization factor of 1 at Chinnar sub-basin and the minimum annual water utilization factor 0.19 at Noyil sub-basin would be achieved.

ACKNOWLEDGEMENTS

I wish to record my sincere thanks with profound sense of respect and gratitude to Prof. D. K. Srivatsava, Department of Hydrology, I.I.T. Roorkee, Roorkee and Prof. Nayan Sharma, WRDTC, I.I.T. Roorkee, Roorkee, for their valuable guidance, constant encouragement alert supervision and whole hearted cooperation throughout the preparation of this research work.

I am thankful to Dr. Bharat Singh, Professor Emeritus, Water Resources Development Training Centre (WRDTC) and former Vice Chancellor, University of Roorkee, Now Indian Institute of Technology, Roorkee, (India), for suggestion of the topic and help for collection of data from National Water Development Agency, New Delhi.

I also express my gratitude to Prof. S. K. Tripathi, who has guided me in getting permission for Ph.D. from Irrigation Department, Government of Maharashtra and to come to I.I.T. Roorkee for research work, after completion of my M.E. (IWM) from WRDTC, University of Roorkee, Roorkee, in July 1992- December 1993.

I also express my special gratitude to Prof Devadutta Das, Professor WRDTC, for purchasing and providing me LINDO software from Chicago USA, for running my linear programming model at computer laboratory of WRDTC to complete my research work.

I am also thankful to Prof. U.C. Chaube, Head of the Department, WRDTC, IIT Roorkee, Prof. G.C.Mishra, Prof. Gopal Chauhan, Prof. B.N Asthana, Prof. V. Bhairati, Prof. Rajpal. Singh, Prof. Rampal Singh, Dr. Deepak Khare, Associate Professor, Dr. M.L. Kansal, Associate Professor, WRDTC, for providing me the latest technology whenever required throughout my research work.

I am very much thankful to Dr. Sunita Devi, Programmer, Computer Laboratory, WRDTC, IIT Roorkee, for her constant encouragement and valuable help for running my Linear Programming computer model.

I am thankful to all staff at WRDTC and Department of Hydrology for their cooperation.

I am deeply indebted to the Irrigation Department, General Administration Department and Finance Department; Government of Maharashtra, for permitting me and sanctioning my leave to complete this Ph.D. work.

I am thankful to Er. S.A. Nagre, Chief Engineer, Irrigation Department, Government of Maharashtra, for guiding me to do my M.E (IWM) course at WRDTC, University of Roorkee, Roorkee, which is further extended my study in this Ph.D. work. I am thankful to Er. V. V. Gaikwad, Chief Engineer, Irrigation Department, Government of Maharashtra who has first sown the seed of Ph.D. in my mind and told me to continue research work after my completion of M.E. (I.W.M) in December 1993 here but which was not possible due to family constraints at that time and now the dream came true.

I am thankful to Er. Sodal, Secretary, Irrigation Department, Government of Maharashtra for sanctioning my study leave. I am thankful to Er. Ekanathrao Patil, Chief Engineer, Er. B.N Kandarphale, Superintending Engineer, Er. A.A.Kapole, Executive Engineer, Irrigation Department, Government of Maharashtra, for their constant departmental help during completion of this research work.

I wish to express my special thanks to Dr. M.P. Rajurkar, for preparation of my paper presentation at International conference at Colorado, USA and constant guidance during the research work and all my research colleagues Dr. S. Bala Prasad, Dr. U P Gupta, Dr. M.G Sharma, Dr. M. Abdullah, Dr. Naresh Aggrawal, Dr. (Mrs.) Shagufta, Dr. Harne, Mr. Joy Gopal Jena, Mr. Panigrahi, Mr. Srivastava, Mr. Bibhas Sharma, Mr. Mohd. Fahimoddin, Mr. S. S. Pusadkar and Trainee officers Mr. N. S. R. K. Reddy, Mr. J. Deva Sundar from National Water Development Agency.

I wish to record my sincere thanks with folded hands, profound sense of respect and gratitude to my father D. N. PATIL for encouragement to this study and to attend the international conference at Colorado, U.S.A. for paper presentation.

Finally. I am very much thankful to my wife Sarla Devi, my daughters, Deepali, Mayuri and Samruddhi Patil for showing their patience and understandings during this research work.

(M. D. PATIL)

CONTENTS

LIST OF TABLES

Table No.	Title	Page No.
Table 4.10.2 (h)	Kabini sub-basin-monthly water balance for 100% water year dependable flow, with ground water	172
Table 4.10.3 (a)	Shimsha sub-basin-monthly water balance for 75% water year dependable flow, without ground water	173
Table 4.10.3 (b)	Shimsha sub-basin-monthly water balance for 75% water year dependable flow, with ground water	173
Table 4.10.3 (c)	Shimsha sub-basin-monthly water balance for 50% water year dependable flow, without ground water	174
Table 4.10.3 (d)	Shimsha sub-basin-monthly water balance for 50% water year dependable flow, with ground water	174
Table 4.10.3 (e)	Shimsha sub-basin-monthly water balance for 90% water year dependable flow, without ground water	175
Table 4.10.3 (f)	Shimsha sub-basin-monthly water balance for 90% water year dependable flow, with ground water	175
Table 4.10.3 (g)	Shimsha sub-basin-monthly water balance for 100% water year dependable flow, without ground water	176
Table 4.10.3 (h)	Shimsha sub-basin-monthly water balance for 100% water year dependable flow, with ground water	176
Table 4.10.4 (a)	Arkavathi sub-basin-monthly water balance for 75% water year dependable flow, without ground water	177
Table 4.10.4 (b)	Arkavathi sub-basin-monthly water balance for 75% water year dependable flow, with ground water	177
Table 4.10.4 (c)	Arkavathi sub-basin-monthly water balance for 50% water year dependable flow, without ground water	178
Table 4.10.4 (d)	Arkavathi sub-basin-monthly water balance for 50% water year dependable flow, with ground water	178

Table No.	Title	Page No.
Table 4.10.6 (b)	Suvarnavathi sub-basin-monthly water balance for 75% water year dependable flow, with ground water	185
Table 4.10.6 (c)	Suvarnavathi sub-basin-monthly water balance for 50% water year dependable flow, without ground water	186
Table 4.10.6 (d)	Suvarnavathi sub-basin-monthly water balance for 50% water year dependable flow, with ground water	186
Table 4.10.6 (e)	Suvarnavathi sub-basin-monthly water balance for 90% water year dependable flow, without ground water	187
Table 4.10.6 (f)	Suvarnavathi sub-basin-monthly water balance for 90% water year dependable flow, with ground water	187
Table 4.10.6 (g)	Suvarnavathi sub-basin-monthly water balance for 100% water year dependable flow, without ground water	188
Table 4.10.6 (h)	Suvarnavathi sub-basin-monthly water balance for 100% water year dependable flow, with ground water	188
Table 4.10.7 (a)	Palar sub-basin-monthly water balance for 75% water year dependable flow, without ground water	189
Table 4.10.7 (b)	Palar sub-basin-monthly water balance for 75% water year dependable flow, with ground water	189
Table 4.10.7 (c)	Palar sub-basin-monthly water balance for 50% water year dependable flow, without ground water	190
Table 4.10.7 (d)	Palar sub-basin-monthly water balance for 50% water year dependable flow, with ground water	190
Table 4.10.7 (e)	Palar sub-basin-monthly water balance for 90% water year dependable flow, without ground water	191
Table 4.10.7 (f)	Palar sub-basin-monthly water balance for 90% water year dependable flow, with ground water	191

Table No.	Title	Page No.

Table No.	Title	Page No.
Table 4.10.14 (c)	Upper Coleroon sub-basin-monthly water balance for 50% water year dependable flow, without ground water	218
Table 4.10.14 (d)	Upper Coleroon sub-basin-monthly water balance for 50% water year dependable flow, with ground water	218
Table 4.10.14 (e)	Upper Coleroon sub-basin-monthly water balance for 90% water year dependable flow, without ground water	219
Table 4.10.14 (f)	Upper Coleroon sub-basin-monthly water balance for 90% water year dependable flow, with ground water	219
Table 4.10.14 (g)	Upper Coleroon sub-basin-monthly water balance for 100% water year dependable flow, without ground water	220
Table 4.10.14 (h)	Upper Coleroon sub-basin-monthly water balance for 100% water year dependable flow, with ground water	220
Table 4.10.15 (a)	Lower Coleroon sub-basin-monthly water balance for 75% water year dependable flow, without ground water	221
Table 4.10.15 (b)	Lower Coleroon sub-basin-monthly water balance for 75% water year dependable flow, with ground water	221
Table 4.10.15 (c)	Lower Coleroon sub-basin-monthly water balance for 50% water year dependable flow, without ground water	222
Table 4.10.15 (d)	Lower Coleroon sub-basin-monthly water balance for 50% water year dependable flow, with ground water	222
Table 4.10.15 (e)	Lower Coleroon sub-basin-monthly water balance for 90% water year dependable flow, without ground water	223
Table 4.10.15 (f)	Lower Coleroon sub-basin-monthly water balance for 90% water year dependable flow, with ground water	223
Table 4.10.15 (g)	Lower Coleroon sub-basin-monthly water balance for 100% water year dependable flow, without ground water	224

Table No.	Title	Page No.
Table 7.1.3 (b)	Results of LP model for 90% water year dependable flow with 5800 MCM export from Mettur reservoir to the sub-basins below Mettur	355-356
Table 7.1.3 (c)	Results of LP model for 90% water year dependable flow with 6200 MCM export from Mettur reservoir to the sub-basins below Mettur	357-358
Table 7.1.3 (d)	Results of LP model for 90% water year dependable flow with 6900 MCM export from Mettur reservoir to the sub-basins below Mettur	359-360
Table 7.1.4 (a)	Results of LP model for 100% water year dependable flow with 4200 MCM export from Mettur reservoir to the sub-basins below Mettur	361-362
Table 7.1.4 (b)	Results of LP model for 100% water year dependable flow with 5800 MCM export from Mettur reservoir to the sub-basins below Mettur	363-364
Table 7.1.4 (c)	Results of LP model for 100% water year dependable flow with 6200 MCM export from Mettur reservoir to the sub-basins below Mettur	365-366
Table 7.1.4 (d)	Results of LP model for 100% water year dependable flow with 6700 MCM export from Mettur reservoir to the sub-basins below Mettur	367-368
Table 7.1.5 (a)	Results of LP Model for 50%, 75%, 90%, 100% Water Year Annual Dependable Flows With Various Exports From Mettur to the Sub-Basins Below Mettur Reservoir (Above Mettur)	369
Table 7.1.5 (b)	Results of LP Model for 50%, 75%, 90%, 100% Water Year Annual Dependable Flows With Various Exports From Mettur To The Sub-Basins Below Mettur Reservoir (Below Mettur)	370

TABLES IN APPENDIX – I – III

LIST OF FIGURES

Figure No.	Title	Page No.

Figure No.	Title	Page No.
Figure 4.8 (b)	Chinnar Sub-basin: Monthly Water Deficits-Surpluses With Ground Water	260
Figure 4.9 (a)	Bhavani Sub-basin: Monthly Water Deficits-Surpluses Without Ground Water	261
Figure 4.9 (b)	Bhavani Sub-basin: Monthly Water Deficits-Surpluses With Ground Water	261
Figure 4.10 (a)	Noyil Sub-basin: Monthly Water Deficits-Surpluses Without Ground Water	262
Figure 4.10 (b)	Noyil Sub-basin: Monthly Water Deficits-Surpluses With Ground Water	262
Figure 4.11 (a)	Amaravathi Sub-basin: Monthly Water Deficits-Surpluses Without Ground Water	263
Figure 4.11 (b)	Amaravathi Sub-basin: Monthly Water Deficits-Surpluses With Ground Water	263
Figure 4.12 (a)	Tirumanimuttar Sub-basin: Monthly Water Deficits-Surpluses Without Ground Water	264
Figure 4.12 (b)	Tirumanimuttar Sub-basin: Monthly Water Deficits-Surpluses With Ground Water	264
Figure 4.13 (a)	Ponnanai Ar Sub-basin: Monthly Water Deficits-Surpluses Without Ground Water	265
Figure 4.13 (b)	Ponnanai Ar Sub-basin: Monthly Water Deficits-Surpluses With Ground Water	265
Figure 4.14 (a)	Upper Coleroon Sub-basin: Monthly Water Deficits-Surpluses Without Ground Water	266
Figure 4.14 (b)	Upper Coleroon Sub-basin: Monthly Water Deficits-Surpluses With Ground Water	266

Figure No.	Title	Page No.

Figure No.	Title	Page No.
Figure 8.2.6 (a)	Percent deficit in annual water supply for medium and minor irrigation projects in Suvarnavathi sub-basin vs. annual water exports from Mettur reservoir to the sub-basins below Mettur for different flows	422
Figure 8.2.6 (b)	Percent deficit in annual water supply for major, medium and minor irrigation projects in Suvarnavathi sub-basin vs. annual water exports from Mettur reservoir to the sub-basins below Mettur for different flows	422
Figure 8.2.7 (a)	Percent deficit in annual irrigation for major irrigation projects in Amaravathi sub-basin vs. annual water exports from Mettur reservoir to the sub-basins below Mettur for different flows	423
Figure 8.2.7 (b)	Percent deficit in annual irrigation for major, medium and minor irrigation projects in Amravathi sub-basin vs. annual water exports from Mettur reservoir to the sub-basins below Mettur for different flows	423
Figure 8.2. 8 (a)	Percent deficit in annual water supply for major irrigation projects in Tirumanimuttar sub-basin vs. annual water exports from Mettur reservoir to the sub-basins below Mettur for different flows	424
Figure 8.2.8 (b)	Percent deficit in annual water supply for major, medium and minor irrigation Projects in Tirumanimuttar sub-basin vs. annual water exports from Mettur reservoir to the sub-basins below Mettur for different flows	424
Figure 8.2.9	Percent deficit in annual irrigation for major,medium and minor irrigation projects in Ponnana Ar sub-basin vs. annual water exports from Mettur reservoir to the sub-basins below Mettur for different flows	425

Figure No.	Title	Page No.
Figure 8.3.1	Percent deficit of annual irrigation vs. annual water exports from Mettur reservoir to the sub-basins below Mettur reservoir for Harangi project	425
Figure 8.3.2	Percent deficit of annual irrigation vs. annual water exports from Mettur reservoir to the sub-basins below Mettur reservoir for Cauvery project	426
Figure 8.3.3	Percent deficit of annual irrigation vs. annual water exports from Mettur reservoir to the sub-basins below Mettur reservoir for Banasursagar project	426
Figure 8.3.4	Percent deficit of annual irrigation vs. annual water exports from Mettur reservoir to the sub-basins below Mettur reservoir for Taraka project	427
Figure 8.3.5	Percent deficit of annual irrigation vs. annual water exports from Mettur reservoir to the sub-basins below Mettur reservoir for Upper Nugu project	427
Figure 8.3.6	Percent deficit of annual irrigation vs. annual water exports from Mettur reservoir to the sub-basins below Mettur reservoir for Amaravathi project	428
Figure 8.4.1(a)	Variation in Annual Irrigation from Medium and Minor Projects with respect to Various Percent Water Year Dependable Flows in Upper Cauvery Sub-Basin	428
Figure 8.4.1(b)	Variation in Annual Irrigation from Major Projects with respect to Various Percent Water Year Dependable Flows in Upper Cauvery Sub-Basin	429
Figure 8.4.2(a)	Variation in Annual Irrigation from Medium and Minor Projects with respect to Various Percent Water Year Dependable Flows in Kabini Sub-Basin	429

NOTATIONS

(A) Variables with Normal Characters

Variable Notation	Descriptions
$A^{k}_{i,j}$	Irrigation area of crop k, for site i, in sub-basin j
$b^{k}_{i,j}$	Net benefit from crop k, of site i, in sub-basin j
$CC_{i,j}$	Annual capacity of canal at site i, in sub-basin j
C_f	Conversion factor from m cm/month to mw-h
$\bar{E}_{i,j,t}$	Secondary energy generated at dam in mw-h for site i, in sub-basin j, in time t
$E_{i,j}$	Annual energy target at site i, in sub-basin j
$e_{i,j}$	Turbine and generator efficiency of hydropower plant at site i, in sub-basin j
$E_{i,j,t}$	Total energy generated from hydropower plant at site i, in sub-basin j, in time t
$El_{i,j,t}$	Evaporation losses from site i, in sub-basin j, in time t
$FC_{i,j}$	Cereal food requirements of the people living in the area of site i, in sub-basin j
$F_{i,j,t}$	Contribution from upstream sites to the site i, in sub-basin j, in time t
$FO_{i,j}$	Oilseed crops requirements of the people living in the area of site i, in sub-basin j
$Fp_{i,j}$	Pulses food requirements of the people living in the area of site i, in sub-basin j
$He_{i,j,t}$	Average storage head at dam, for site i, in sub-basin j, in time t
$H_{i,j}$	Hydro power capacity at site i, in sub-basin j
$H_{i,j,t}$	Number of hours in the period t at site i, in sub-basin j
$\bar{I}_{i,j,t}$	Local inflow from the surrounding area at site i, in sub-basin j, in time t
$I_{i,j,t}$	Natural catchment inflow of site i, in sub-basin j, in time t

Variable Notation	Descriptions
$Ir''_{i,j,t}$	Water that joins the main stream just above the irrigation diversion canal site i, in sub-basin j
$Ir'_{i,j}$	Total annual irrigation target from site i, in sub-basin j
$Ir^{g}_{i,j}$	Total annual ground water irrigation target from site i, in sub-basin j
$Ir^{s}_{i,j}$	Total annual surface water irrigation target from site i, in sub-basin j
$Iu^{r}_{i,j}$	Total annual upstream irrigation water use targets of site i, in sub-basin j
$Iu^{r,s}_{i,j}$	Total annual upstream irrigation water use targets from surface water of site i, in sub-basin j
$Iu^{r,g}_{i,j}$	Total annual upstream irrigation water use targets from ground water of site i, in sub-basin j
$Iu^{m}_{i,j}$	Total annual upstream M & I water use target of site i, in sub-basin j
$Iu^{m,s}_{i,j}$	Total annual upstream M & I water use target from surface water of site i, in sub-basin j
$Iu^{m,g}_{i,j}$	Total annual upstream M & I water use target from surface water of site i, in sub-basin j
$K'_{i,j,t}$	Reservoir evaporation coefficient for site i, in sub-basin j, in time t
$K''_{i,j,t}$	% of return flow to river from irrigation from site i, in sub-basin j, in time t
$K''_{w,j,t}$	% of return flow to river from irrigation from site w, in sub-basin j, in time t
$K_{i,j,t}$	% annual irrigation from site i, in sub-basin j, in time t
$K_{w,j,t}$	Reservoir evaporation from site w, in sub-basin j, in time t
N_j	Number of sites, in sub-basin j
NB	Number of sub-basins
$NCI^{i,j}$	Total number of irrigated crops at site i, in sub-basin j
$NCI^{C}_{i,j}$	Number of cereal crops irrigated by the site i, in sub-basin j
$NCI^{O}_{i,j}$	Number of oilseed crops irrigated by the site i, in sub-basin j

Variable Notation	Descriptions
$NCI_{i,j}^{p}$	Number of pulses crops irrigated by the site i, in sub-basin j
$OC_{i,j}^{m}$	Annual water supply diversion from sites i, in sub-basin j
$OC_{i,j}^{r}$	Annual irrigation diversion from site i, in sub-basin j
$Od_{i,j,t}$	Total release at site i, in sub-basin j, in time t for irrigation and water supply
$Od_{i,j,t}^{m}$	Release at site i, in sub-basin j, in time t, for water supply
$Od_{i,j,t}^{r}$	Release at site i, in sub-basin j, in time t, for irrigation
$OE_{i,j,p}^{q,j_E}$	Export from site i, in sub-basin j, to irrigation area p, upstream of site q, in importing sub-basin j_E
$Og_{i,j}$	Total annual ground water target for irrigation, and municipal and industrial from site i, in sub-basin j
$Og_{i,j,t}^{m}$	Ground water available for municipal and industrial from site i, in sub-basin j, in time t
$Og_{i,j,t}^{r}$	Ground water available for irrigation, from site i, in sub-basin j, in time t
$Og_{i,j}^{r}$	Total annual ground water target for irrigation, and municipal and industrial from site i, in sub-basin j
$Og_{i,j}^{us}$	Annual upstream ground water available for site i, in sub-basin j
$Og_{i,j}^{ds}$	Annual downstream ground water available for site i, in sub-basin j
$OI_{i,j,p}^{q,j_I}$	Import to irrigation area p, upstream of site i, in sub-basin j, from site q of exporting sub-basin j_E
$O_{i,j,t}$	Total release from site i, in sub-basin j, in time t
$O_{i,j,t}^{m}$	Mandatory releases to downstream natural channel from site i, in sub-basin j, in time t
$O_{w,j,t}^{m}$	Mandatory releases to downstream natural channel from site w, in sub-basin j, in time t
p	p^{th} irrigation area contributing regenerated flow to downstream site i
$P_{i,j,t}$	Precipitation directly upon the site i, in sub-basin j, in time t
$S_{i,j,t-1}$	Initial storage in the site i, in sub-basin j, in time t

Variable Notation	Descriptions
$S_{i,j,t}$	Final storage in the site i, in sub-basin j, in time t
$Sp_{i,j,t}$	Secondary water release (spill) from site i, in sub-basin j, in time t
$Sp_{w,t}$	Secondary water release (spill) from site w, in time t
$TA_{i,j}$	*Total cultivable command area (CCA) irrigation for site i, in sub-basin j*
$TE_{i,j}^{q,j_I}$	Export from site i, in sub-basin j, to site q, of importing sub-basin j_E
$TI_{i,j}^{q,j_E}$	Import to site i, in sub-basin j, from site q, of exporting sub-basin j_I
$W_{i,j,t}^{k}$	Total water diversion requirements in depth of crop k, at site i, in sub-basin j, in time t
$Ws'_{w,j}$	Total annual water supply target from site w, in sub-basin j
$Ws'_{i,j}$	Annual water supply diversion from sites w, sub-basin j
$Ws_{i,j}^{I}$	Annual water requirement for industrial use from sites i, in sub-basin j
$Ws_{i,j}^{RH}$	Annual water requirement for rural human domestic use from sites i, in sub-basin j
$Ws_{i,j}^{R}$	Annual water requirement for rural domestic use from sites i, in sub-basin j
$Ws_{i,j}^{RL}$	Annual water requirement for live stock use from sites i, in sub-basin j
$Ws_{i,j}^{U}$	Annual water requirement for urban domestic use from sites i, in sub-basin j
$X_{i,j}$	Number of upstream irrigation areas contributing the regenerated flow to site i, in sub-basin j
$y_{i,j}^{k}$	Yield per quintal per hector area of crop k, from site i, in sub-basin j
$Yd_{i,j}$	Dead storage capacity of reservoir/site i, in sub-basin j
$Ydmin_{i,j}$	Gross capacity up to the minimum pool level of the reservoir/site i, in sub-basin j, in time t
$Y_{i,j}$	Gross storage capacity of reservoir/site i, in sub-basin j
$Ymax_{i,j,t}$	Gross capacity up to the normal pool level of the reservoir/site i, in sub-basin j, in time t
$Z_{i,j}$	Number of upstream reservoirs/sites contributing to the flow of downstream site i, in sub-basin j.

(B) Variables with Special Characters

Variable Notation	Descriptions
$\alpha_{i,j,t}$	Load factor at hydropower site i, in sub-basin j, in time t, for each period t is an indicator of the energy demand
$\alpha_{i,j,t}$	% of annual upstream water use for irrigation of site i, in sub-basin j, in time t
$\alpha''_{i,j,t}$	% of return flow to river from upstream water use for irrigation of site i, in sub-basin j, in time t
$\beta_{i,j,t}$	% of annual water supply from site i, in sub-basin j, in time t
$\beta''_{i,j,t}$	% of return flow to river from water supply from site i, in sub-basin j, in time t
$\beta''_{w,j,t}$	% of return flow to river from water supply from site w, in sub-basin j, in time t
$\beta_{w,j,t}$	% of annual water supply ($Ws'_{w,j}$) from site w, in sub-basin j, in time t
$\delta''_{w,j,t}$	% of downstream mandatory release ($O'_{i,t}$) returning to river from site w, in sub-basin j, in time t
$\delta_{i,j,t}$	Energy requirement in percentage at site i, in sub-basin j, in time t
$\xi_{i,j,t}$	% of annual water use for industrial and urban from site i, in sub-basin j, in time t
$\phi^{Ig}_{i,j}$	% of annual ground water for industrial requirement from sites i, in sub-basin j
$\phi^{Is}_{i,j}$	% of annual surface water for industrial requirement from sites i, in sub-basin j
$\phi^{RHg}_{i,j}$	% of annual ground water for rural human domestic requirement from site i, in sub-basin j
$\phi^{RHs}_{i,j}$	% of annual surface water for rural domestic requirement from site i, in sub-basin j
$\phi^{RLg}_{i,j}$	% of annual ground water for live stock requirement from sites i, in sub-basin j
$\phi^{RLs}_{i,j}$	% of annual surface water for live stock requirement from sites i, in sub-basin j
$\phi^{Ug}_{i,j}$	% of annual ground water for urban domestic water requirement from site i, in sub-basin j
$\phi^{Us}_{i,j}$	% of annual surface water for urban domestic water requirement from site i, in sub-basin j

Variable Notation	Descriptions
$\lambda^{k}_{i,j,t}$	Land use coefficient for crop k, for site i, in sub-basin j, in time t
$\omega^{q,j_E}_{i,j}$	% of export from site i, in sub-basin j, in time t, to site q, of importing sub-basin j_E
$\psi^{q,j_I}_{i,j,t}$	% of import to site i, in sub-basin j, in time t, from site q, of exporting sub-basin j_I

(C) Subscripts and superscripts

Variable Notation	Descriptions
i	Reservoir/site i
j	Sub-basin j
k	Crop k
t	Time t
w	Reservoir/site contributing to the flow of downstream reservoir/site i
j_I	Exporting sub-basin j_I
j_E	Importing sub-basin j_E

Symbols for Units

Ha	Hectare
Ham	Hectare-meter
Kg	Kilogram
Km	Kilometer
m	Meter
mm	millimeter
MCM	Million cubic meter
MW	Megawatts

MWhr	Megawatt hours
TCM ft	Thousand million cubic feet

Abbreviations

CCA	Culturable command area
CGWB	Central Ground Water Board, Ministry of Water Resources, Government of India
CWDT	Cauvery Water Dispute Tribunal
CWDTIA	Cauvery Water Dispute Tribunal Interim Award
G & D	Gauge and Discharge
NWDA	National Water Development Agency, the society under the Ministry of Water Resources, Government of India
NCIWRD	The National Commission for Integrated Water Resources Development, under the Ministry of Water Resources, Government of India

INTRODUCTION

1.1 GENERAL

Water resources planning and management is broadly concerned with the accurate assessment, identification and development of different water resources systems. The careful planning for allocation of water resources to different activities has become extremely important to meet the ever increasing demand of water supply, hydropower, irrigation, and environmental purposes etc. It emphasizes the need of planning and development of river basin water resources, which is a complex and difficult task, creates numerous political, social, economical, environmental and engineering problems. Most of these difficulties are due to variable inflows and large number of possible alternatives. Optimum panning of a large-scale river basin as a unit of water resources system is having a high priority in the economic development of the country. This has resulted in an urgent need for accurate and efficient management of the water resources for its conservation and use. System engineering provides systematic methodologies for studying and analyzing various aspects of a system and its response to various parameters by using mathematical models. It assists in decision-making process for all pertinent constraints by using optimization techniques. Efficient planning of limited water resources is an important requirement in comprehensive planning of river basin water resources. Hence river basin water resource planning has become an increasingly important concept in comprehensive planning of water resources.

1.2 INDIA'S NATIONAL WATER POLICY 2002

According to the National Water Policy 2002 of India, water resources development and management will have to be a hydrological unit such as drainage basin as a whole or a sub-basin, taking into account surface and ground water for sustainable use incorporating quantity and environmental considerations. All individual developmental projects and proposals should be formulated and considered within the framework of such an overall plan keeping in view the existing agreements/awards for a basin or sub-basin so that the best possible combination of options can be selected and sustained. Water should be made available to water short areas by transfer from other areas including transfers from one river basin to another, based on a national perspective, after taking into account the requirements of the areas/basins. Integrated and coordinated development of surface water and ground water resources and their conjunctive use, should be envisaged right from the project planning stage and should form an integral part of the project implementation. Irrigation intensity should be such as to extent the benefits of irrigation to as large number of farm families as possible, keeping in view the need to maximize production. Irrigation being the largest consumer of fresh water, the aim should be to get optimal productivity per unit of water. In view of the vital importance of water from human and animal life, for maintaining ecological balance and for economic and developmental activities of all kinds, and considering scarcity, the planning and , management of this resources and its optimal and equitable use has become a matter of the utmost urgency.

1.3 STUDY AREA

The Cauvery is an inter state river in south India originating in the state of Karnataka and flowing through the states of Karnataka, Kerala, Tamil Nadu and

Pondicherry having a catchment area of 81,155 Km^2. The state wise drainage areas of Cauvery river basin are Karnataka 34,273 Km^2 (42.2%); Tamilnadu 43,867 Km^2 (54.1%); Kerala 2,866 Km^2 (3.5)% and Pondicherry 149 Km^2 (0.2)%. This river basin has 16-sub-basins. It has 75% and 50% water year dependable surface water potential of 16,470 MCM and 20,253 MCM, respectively. The total of 3,866 MCM ground water potential is available for future use. The water requirement for the population of human and livestock projected to the year 2050AD for all purposes are estimated as 39516 MCM. There are 15 major reservoirs and 58 medium irrigation projects and a large number of minor irrigation projects in the basin. The total irrigable area is 2605200 Ha.

1.4 IMPORTANCE OF THE STUDY

The utilization of the water resources of the transboundary Cauvery river system is under dispute. The interstate water dispute between Karnataka and Tamilnadu about sharing of water and intra basin water transfers is pending from a long time and sometimes creates a law and order problem in the states. The issue has been referred to The Cauvery Water Disputes Tribunal (CWDT). The Supreme Court of India has given the directives to the Government of India for interlinking of major rivers in the Himalayan and the Peninsular regions to reduce the natural imbalance of water in the country. The purpose of the study is also to find the technological and realistic solution for the problem of Cauvery basin. Optimal utilization of available water resources and conservation of the Cauvery river waters are the vital needs in the present context, to meet the growing needs of the population are the vital needs in the present context. The optimal allocation of surface water and ground water is therefore necessary so as to maximize the annual water utilization for irrigation, domestic, industrial, hydropower and environmental uses. The interim award of CWDT is to release 5800 MCM (205 TMC ft) of water from Karnataka to Tamilnadu at Mettur, the 13^{th} reservoir in the 8^{th} sub-basin. It would be interesting to carry out the study in reference to the interim award of Cauvery Water Disputes Tribunal (CWDT).

1.5 THE PROBLEM IDENTIFICATION

The transboundary Cauvery river basin, the last but one at the tail end of the Peninsular river system is short of adequate water resource to meet its present and future demands, and the problem of sharing of waters between the two major basin states, Karnataka and Tamilnadu, involving intra basin water transfers has been the subject of a long-standing dispute. The National Water Development Agency (NWDA), the society under the Ministry of Water Resources, Government of India, and The National Commission for Integrated Water Resources Development (NCIWRD) under Ministry of Water Resources, Government of India have carried the studies on the water balance, i.e., the study comprising of the sub-basins/basin wise assessment of, the water yields, the existing uses, the reasonable requirements of the basin states in the foreseeable future and the determination of the order of surpluses/deficits of Cauvery river basin on an annual basis. The NWDA studies have not considered ground water and the environmental water requirements while NCIWRD has considered 2/3 of the estimated ground water potential and the environmental water requirements. For accurate assessment of the water resources, the water balance studies should be carried out on a monthly basis, considering the environmental requirements and ground water availability. In this study the water balance studies are carried out on a monthly basis, considering the environmental requirements and ground water availability. This study is also directed to develop a methodology to test the spatial variations with respect to project sites and storage effect on the water balance studies of the system. The approach and appropriate technique will naturally vary from problem to problem as the configuration, state of development of the system and stage of decision making vary over a vast range. (Maass et al., 1962; Hufschmids and Fiering, 1966; Hall and Dracup, 1970; Haimes, 1977; Loucks et al., 1981; Stedinger et al., 1983; Goodman, 1984; Vedula, 1985; Srivastava, 1976; Chaturvedi, 1987; Simonomic, 1992; Srivastava and Patel, 1993; Wurbs, 1993; Boney 1993; Sadeghian, 1995; Kohistanti, 1995; Sunita Devi, 1997; Waikar, 1998; Dahe, 2000; Dahe and Srivastava, 2002; Kamal-Ali Abd Al-Mohseen (2002); Jena, 2004; Deepti Rani, 2004). A large number of the studies on river basin planning for large river systems generally have considered basic problem constraints only. Very few such studies in the Indian context have incorporated the interest of co-basin states in terms of sharing of the river waters with intra basin water transfers and limiting its use under numerous techno-economic and management constraints pertaining to treaties/ agreements/ tribunal awards.

Keeping the above facts in view this study is directed to develop a methodology using linear programming optimization model to test the functioning of the transboundary Cauvery river basin system.

1.6 THE OBJECTIVES OF THE STUDY

Keeping the above facts in view this study is directed to develop a methodology using linear programming optimization (LP) model to test the functioning of the transboundary Cauvery river basin system, which is an inter state river originating in Karnataka and flowing through the sates of Karnataka, Kerala, Tamilnadu and Pondicherry.

The main objectives of this study are as follows:

(i) To evaluate the utilizable surface and ground water resources on monthly basis for all 16 sub-basins and Cauvery river basin as a whole,

(ii) To estimate the water demands for the year 2050 AD for different uses and to make the water balance studies on monthly basis for all the 16 sub-basins and the Cauvery basin as a whole,

(iii) To develop a linear programming optimization model for a river basin, planning and development for conjunctive water use, with the aim to maximize the water utilization including intra-basin water transfers, and to determine optimal and sustainable cropping pattern in terms of irrigation intensity and productivity per unit of water, and apply it to the Cauvery river,

(iv) To study and analyze in detail the interim award given by the CWDT for sharing of the Cauvery waters by the co-basin states in respect of the present study objective at Sl. No. (iii), and (v) To draw suitable conclusions from the above study.

1.7 THE METHODOLOGY

The methodology adopted to achieve the objectives is outlined below:

1.7.1 Water Balance Studies

The monthly water balance studies were made to know the surplus and deficits to find out whether the monthly water requirements are met or not and whether the monthly intra-basin water transfers within the Cauvery basin are possible. The monthly and annual water balances for each sub-basin are calculated and the monthly and annual surplus and deficit are worked out.

1.7.1.1 Estimation of surface water and ground water potential

The 75% water year dependable surface water yields on monthly basis for each sub-basins are calculated by distributing the annual 75% water year dependable yields in the proportion of actual average monthly inflows/yields observed at the nearest gauge and discharge (G&D) sites within or outside of the sub-basins. The sub-basin wise ground water potential and the existing uses are calculated on the area basis from districtwise ground water statistics, the data collected from the Water Resources of India, a publication of Central Ground Board, under the Ministry of water Resources, Government of India, Faridabad. The same procedure is adopted for 50%, 90% and 100% water year dependable flows.

1.7.1.2 Assessment of the water requirements/needs

Domestic requirements/needs

The rural, urban and livestock population has been computed by projecting the 1981 census human population and 1982/83 census livestock population To 2050 AD by using suitable compound annual growth rates for human and one percent for livestock. The domestic water requirements are calculated considering the per capita water requirements of 70 liters, 200 liters and 50 liters per day respectively. The urban population by 2050 AD is taken 60.70% of the total projected population by 2050 AD. The entire water requirement for the urban population and the 50% of the rural population is proposed to be met from surface water. The entire water requirement for live stock population and 50% of the requirement for the rural population is proposed to be met from ground water resources.

Irrigation requirements/needs

The irrigation needs are calculated by keeping the utilization of existing and ongoing major, medium and minor projects undisturbed while the net and gross crop water requirements for future major medium and minor projects have been worked out by climatological approach. It is considered that at least 30% of the maximum culturable area for each sub-basin should be under irrigation for the year 2050 AD and in case of sub-basins having less than 30% of irrigation area the additional area to be brought under irrigation is computed and 50% of this is proposed to be irrigated from future medium projects and the remaining 50% from future minor projects. The ultimate irrigation needs for the future projects are calculated and are used for the water balance studies.

Industrial requirements/needs

For the industrial requirements, in the absence of relevant data, it has been assumed to be same order as that of domestic water requirements by 2050 AD.

Hydropower requirements/needs

The total evaporation losses of all Hydropower projects in the catchment area of each sub-basin are considered, as hydropower needs.

Environmental requirements/needs

The environmental needs to each month are taken equal to 1% of the inflows of those months.

The intra-basin water transfer quantities are taken from the data collected. The regeneration from irrigation, domestic and industrial is taken 10%, 80%, and 80%, respectively of net utilization. The monthly and annual water balances for each month in each sub-basin are calculated and the monthly and annual surplus and deficits are worked out.

1.7.2 The Mathematical Modeling Approach

The following is carried out:

(i) An optimization model for planning and management is considered suitable for this study in view of the large size of problem to be addressed. In accordance with the reported findings, regarding the modeling approaches, and the nature and scope of the present study, and huge number of variables to be handled the linear programming model is found to be promising.

(ii) To study the effects of the spatial variations with respect to project sites and reservoir storage on the water balance of the system, a project-by-project analysis, and sub-basin wise analysis are carried out.

(iii) The optimization model was run for 75%, 50%, 90%, and 100% water year dependable flows by using LINDO software package for solution. Irrigation was considered as lumped. The monthly diversions from reservoirs and ground water are obtained.

(iv) The cropping pattern is studied for each reservoir. The water availability is taken from step (iii) above. The cropping patterns are analyzed keeping in mind: (a) The number of paddy crops to be grown, (b) Reducing the area for water extensive crops and (c) Opting for high revenue crops.

(v) To see the effect of the water surplus and the water deficit years on the water utilization and on intra basin water transfers, the step (iii) is repeated.

(vi) The minimum food requirement with respect to calorific value of crops is also studied.

(vii) The above studies also include the consideration of the interim Cauvery Water Dispute Tribunal (CWDTIA) award.

Initially, the LP model has been applied to the existing, ongoing and proposed individual reservoir sites (major projects) in the Cauvery river basin and again the above models were used to study and analyze the combined developmental strategies of the river sub-basins and the Cauvery river system as a whole. The approach and the characteristics of the type of the models used are a methodological framework for optimal water utilization of the Cauvery river basin planning. And this thesis is an attempt to combine the major advances of systems analysis by optimization (LP). models, which can be used for multi-reservoir, multi-purpose and multi-irrigation areas water resources systems.

1.8 THE MAIN FINDINGS OF THIS STUDY

The main findings of this study are as follows:

(1) The water balance study showed that, with ground water availability considerations, the Upper Cauvery, Kabini, Tirumanimuttar and Ponnanai Ar sub-basins become water surplus from water deficits, during normal and good water years,

(2) All the sixteen sub-basins in the Cauvery river system except Middle Cauvery sub-basin, are found short of water during normal and bad water years as determined from the linear programming model, whereas the Noyil and Arkavathi sub-basins suffer the most from water deficit, and the Chinnar sub-basin the least,

(3) The Kabini sub-basin is not able to fulfill its intra-basin water exports requirements completely during normal and bad water years, as determined from linear programming model,

(4) As per the LP model results, it is found that the maximum intra-basin water exports (reservoir releases) possible from the Mettur reservoir to the other sub-basins below Mettur for 75%, 50%, 90% and 100% water year dependable flows are 7200 MCM, 7800 MCM, 6900 MCM and 6700 MCM, respectively, while in the water balance studies of the NWDA the maximum proposed exports from Mettur is shown as 12712 MCM for a normal year,

(5) As per LP model results for 5800 MCM exports from Mettur reservoir to the sub-basins below Mettur it is found that the water share ratios for above and below Mettur for a normal year, and other water years, i.e., a water surplus year, a water deficit year, and a critical water year are in the ratios of 0.98, 1.07, 0.79, and 0.72, respectively,

(6) From water balance studies it is found that the inter-basin water importing needs from outside the Cauvery basin during a normal and other water years, i.e., a water surplus year, a water deficit year, and a critical water year are in the ratios
:0·93:
of 1.00:93:1.26:1.67, respectively,

(7) Similarly, from LP model results the inter-basin water importing needs from outside the Cauvery basin, during a normal and other water years, i.e., a water surplus year, water deficit year, and a critical water years are in the ratios of
:0·92:
1.00:92:1.18:1.40, respectively,

(8) From the linear programming results, during a normal water year, the water extensive crops would not completely acquire their respective crop areas at six reservoirs. The high benefit crops would acquire very little crop areas at two reservoirs. Two reservoirs would require import of Sugarcane. Upper Nugu reservoir is the most affected reservoir in terms of the crop area occupation. Out

of sixteen sub-basins nine sub-basins would spill in all the months during a normal water year. Generally, a maximum monthly water utilization factor of 1 would be achieved in different months at all the sub-basins, except two sub-basins. Similarly, a minimum of about 0.25 monthly water utilization factors would be achieved, with and without ground water considerations. From the LP model result, the maximum annual water utilization factor of 1 at Chinnar sub-basin and the minimum annual water utilization factor 0.19 at Noyil sub-basin would be achieved.

1.9 CHAPTERWISE PLANNING OF THE THESIS REPORT

With respect to the said objectives, this research work is reported in 9 chapters.

Chapter 1 This chapter is introductory in nature, it emphasizes the need for planning and management of limited water resources together with problem identification and objectives of the study.

Chapter 2 This is related to literature review. This chapter deals with the review of literature on the topics of surface water resources, planning of surface water reservoirs, cropping pattern and conjunctive water use within the framework of multi-purpose, multi-receivers and multi-irrigation areas.

Chapter 3 The characteristics of the Cauvery river system, undertaken for this study and the data required for this purpose are given in Chapter 3. This includes data such as inflow at dams, gauging and discharge measurement, capacities of canals and dams, monthly water requirement and time period for each crop, sub-basin wise and projectwise culturable command area (CCA), project wise irrigation and annual utilization, availability of sub-basin wise surface and ground water.

Chapter 4 The water balance studies for all the 16 sub-basins of the Cauvery river are made and the detailed methodology is described in Chapter 4.

Chapter 5 A general linear programming model for a complex river basin for surface and ground water utilization is developed in Chapter 5. The model developed in this chapter can be used for the planning and development of any river basin by changing the specific design constraints. The objective function of the model is to maximize the annual water utilisation from irrigation and water supply; to maximize the area to be irrigated; and to maximize the annual food production for self-sufficiency.

Chapter 6 Certain data has to be computed from the available information. The same has been done in Chapter 6. It includes the computation of land use coefficients, computations of irrigation and water supply diversion coefficients and computations of flows for different water year dependable flows.

Chapter 7 The results of the LP model developed and applied to Cauvery river system are presented in Chapter 7. This model has 3600 constraints based on continuity equation, total release from the reservoir, state wise annual irrigation, water supply, land use, crop water requirement, hydroelectric energy, and some designs constraints according to CWDTIA. Out of these 3570 constraints are equalities and 30 are, less than or equal to type. The decision variables include crop areas; reservoir storage, release and spill;

monthly diversions for irrigation and water supply; capacities of reservoirs and canals; upstream and downstream total annual irrigation and water supply.

The entire analysis of LP model was carried out using LINDO package.

Chapter 8 The analysis and discussion in respect of the model developed and applied to Cauvery river basin is carried out in Chapter 8. The model has been analyzed over one year interval with monthly time periods. The various graphs drawn are presented in this chapter.

Chapter 9 The conclusions drawn on the basis of the present study and scope for further work are finally given in Chapter 9.

Chapter - 2

LITERATURE REVIEW

2.1 GENERAL

The history of Water Resources Development Planning shows a long series of evolutionary changes in analytical methodologies. Water resources systems are very complex in nature. These serve the basic demands of humanity and face numerous social, political, economical, environmental, and engineering problems. Reservoirs are the most important elements of complex water resources system.

As the water resources and river basin planning has become more complex, corresponding analytical techniques have evolved the wide spread use of systems analysis. For optimal utilization of irrigation potential, selection of a suitable cropping pattern, adoption of intensive farming techniques and application of desirable amount of water at proper timing are very important.

Mathematical modeling provides a way, perhaps the principal way of predicting the future behavior of existing or proposed water resources system. A mathematical model is a set of equations that describes and represents the real life water resources system. Application of the systems approach and use of systems analysis techniques and models to the real life systems have improved our understanding of such systems, and contributed to continuous process of developing the methodologies for improving the system planning, management, and operation. Over the last 50 years, we have witnessed advances in our abilities to model the engineering, economic, ecologic, hydrologic, environmental, and sometimes even the institutional or practical aspects of large complex multipurpose water resources systems. Evaluating the applications of numerous types of models has taught us how limited our modeling skills remain (Loucks, 1992).

Water resources system analysis has now been generally accepted to provide an efficient way of answering the numerous questions regarding planning of a large-scale real life water resources system for which the conventional methods of analysis will be inadequate. The approach and appropriate technique varies from problem to problem depending up on state of development of the system and range of decision-making (Maass et al., 1962; Hufschmidt and Fiering, 1966; Hall and Dracup, 1970; Srivastava, 1976 and 1987; Haimes, 1977; Loucks et al., 1981; Stendinger et al., 1983; Marino and Mohammadi, 1983; Goodman, 1984; Vedula, 1985; Helweg, 1985; Chaturvedi, 1987; Sadeghian, 1991; Afshar et al., 1991; Chavez-Morales et al., 1992; Simonovic, 1992; Srivastava and Patel, 1992; Wurbs, 1993; Wurbs et al. 1993 ; Boney, 1993; Sadeghian, 1995; Sunita Devi, 1997; Waikar, 1998; Dahe, 2001; Dahe and Srivastava, 2002; Kamal-Ali Abd Al-Mohseen (2002); Jena, 2004; Deepti Rani, 2004).

Good work started around in 1955 with the system analysis application. A system may be optimized with the objective of getting maximum benefit out of a given volume of water or minimizing water losses through flood run off, evaporation or seepage etc. This helped in the planning and management of complex river basins, operation of single reservoir, single and multiobjective reservoirs, and multi reservoirs with multi objective, and cropping pattern, conjunctive use of surface and ground waters, etc.

For a large water resources system the difficulty in the system analysis is primarily due to large number of possible alternative development strategies, and hence the vast computational effort required establishing an optimal development plan. However, the huge costs involved in the construction and operation of such a large scale system and the great potential for cost reduction through improved system design necessitate a planning programme that will determine such an optimal development strategy. Therefore, in a large and complex system, one of the major challenges is to reduce the large set of alternative configurations that need to be examined in detail to a reasonable number without mistakenly eliminating an attractive option. The most commonly suggested approach has been to screen all alternating configurations with mathematical programming techniques to determine the most attractive alternatives.

A critical review related to the problems of multiple reservoirs planning and management and inter sub-basin (intra-basin) and inter-basin water transfers, available in literature of water resources planning and management have been presented in two parts as follows:

2.2 REVIEW OF STUDIES IN SYSTEMS ANALYSIS OF COMPLEX WATER RESOURCES SYSTEM

A river basin water resource planning has become an increasingly important concept in comprehensive planning of a complex water resources system. Comprehensive river basin water resources planning are a complex and difficult task, posing numerous social, economic, environmental, and engineering problems. One of most difficult engineering aspects of such a planning effort is the development of optimum expansion policies for timing, sizing and sequencing of surface water storage and conveyance facilities. For large-scale water resources systems the difficulty of this task is primarily due to a large number of possible alternative development strategies. The term optimization means the achievement of best results and may be interpreted in different ways depending on the relative importance of the specific objectives.

A most widely used and popular approach for studying water resources planning problem is based upon mathematical programming or optimization techniques. The advent of high-speed, high-capacity personal computers and the growing requirement of the society for the optimal use of available water resources have further increased the importance of this subject. Although optimization concept has been used during last four decades, the introduction of modern computing facilities and availability of interacting software has greatly accelerated the solution of optimization problems of complex river basin planning.

This approach consists of solving a set of mathematical equations using digital computers to get an optimal solution. Different types of programming problems have been formulated and solved for carrying out the planning and management of water resources river basin planning. A brief description of the reported research works on water resources systems analysis is presented here.

Maass et al. (1962) reported the results of research on system design conducted over several years by Harvard Water program of the Graduate School of Public Administration. This comprehensive treatment emphasizes the systematic research on the methodology of systems design.

Hall et al. (1968) used deterministic dynamic programming for reservoir operation. Their loss function depends on state as well as control variables. It presented in detail, the operational analysis of a component reservoir-river system and procedure to be used to combine optimally a number of such system into a coordinated, mutually reinforcing, and multiple river system.

Stephenson (1970) illustrates the optimum design of multi-interlinked river basins using linear programming and the principle of decomposition of linear programming.

Bargur (1972) presented a multisector planning and management approach to water resources that is based on a general equilibrium analysis employing input-output model and linear programming techniques.

Nayak and Arora (1973) considered a chance-constrained formulation of a multireservoir system. Some of the other applications in multi-reservoir analytic models are Simonovic and Marino (1982), Marino and Loaiciga (1985a, 1985b), Pereira and Pinto (1985), Gunaa et al. (1990) and Benedito et al. (1991).

A study (Srivastava, 1976; and Chaturvedi and Srivastava, 1981) dealt with the first stage preliminary screening design model in the context of a sequential system analysis iterative modeling of a complex water resources system. The models were developed in the context of river Narmada, a large river basin in India. Two types of analytical optimization models were used to find a reasonably small set of possible optimal design alternatives. These were linear programming deterministic continuous (LPDC) model and linear programming deterministic discontinuous (LPDD) model. The simulation continued screening on the basis of the information obtained from linear programming model. The LPDC model results may be assumed to be nearly optimum in terms of the objective function and could serve as an input for further screening by simulation. The LPDC model was helpful in selecting the ranges of variables for simulation by random sampling.

Decomposing the problem into simulation and optimization components derives a compact, non-linear optimization formulation for selecting among and sizing potential reservoirs. Reservoir storage capacities needed are determined using a modified sequent peak algorithm to simulate monthly reservoir operation (Lall and

Miller, 1988). Simulation is also employed to determine optimal sizes for hydropower generators at each site.

A simulation model in conjunction with an optimization model was developed for water-development planning and policy-issue analysis on Platte River in Nebraska (Razavian et al., 1990). The general model consisted of three components: simulation, screening and optimization. The focus of this paper was on the economic simulation component, which consisted of water-use and economic sub models. The economic simulation model simulated water uses and losses and calculated associated system costs and economic benefits for a large number of alternative water-development options. The out put was used to analyze the physical and economic efficiencies of each alternative, to select preferred alternatives for further analysis, and to generate data for direct input to a subsequent multi-objective optimization model. The technique was found to be a very efficient and cost effective method of evaluating development opportunities for a complex, multipurpose, multi-reservoir river basin.

Grygier and Stendinger (1985) have examined successive LP, optimal control, and LP-DP algorithms to optimize the operation of a single reservoir, two reservoirs in series, and three reservoirs in parallel. The successive linear programming algorithm was found to be easier to implement and appeared to find a global optimum. For simple system the optimal control algorithm is faster but harder to implement. The solutions obtained by LP-DP algorithm were not found optimal.

Vedula and Mohan (1990) developed a real time operational methodology for the Bhadra reservoir in the state of Karnataka (India). The algorithm has three phases of operation. The first phase determines the optimal release policy for a given initial storage and inflow using SDP. Second phase constituted the flow forecasting using ARIMA model and in the last phase a real time simulation model was developed. In the

SDP model, the inflows were assumed to follow a discrete Markov process.

Braga et al. (1991) proposed a methodology to identify the parameters in identifying drought, which include onset, termination and severity, from the available historic data on stream flow and rainfall having seasonal pattern. This modified methodology is applied to the stream flow series of the Bhadra river and the mean a real rainfall series for the catchment of the Bhadra reservoir in Karnataka State, India. The droughts identified by the proposed methodology are concurrent with the historically realized droughts, thus providing the viability and applicability of the methodology in the identification of drought conditions.

Loucks (1992) discussed the role of water resources system models in planning. The major challenge facing water resources system planners and managers, the information they need to meet these challenges, and the role analysis in helping to provide this information, have been discussed. He has reviewed some criteria for evaluating the success of any modeling activity designed to help planners and managers to solve real life problems.

Afzal et al. (1992) developed a linear programming model of different quality water by alternative irrigation. The model described provides a methodology of allocating land and water to different crops wherever low rainfall, limited quantity, and different quality waters are the basic parameters governing the irrigation system.

Mohan and Raipure (1992) developed a linear multi-objective programming model and used the constraint technique to derive the optimal releases for various purposes from a system of five reservoirs in India. Trade-off analysis between conflicting objectives of irrigation and hydropower was carried out.

In the study by Karamouz et al. (1992), a multivariate hydrological time-series analysis and a deterministic optimization technique for determining reservoir-operating rules for multiple reservoirs were investigated. This comprised a three-step cyclic procedure that attempts to improve the initial operating rules for the system. The system required two sets of synthetically generated stream flow series to be used in simulation model. The three step cycle begins with an optimization of reservoir operations for a given set of stream flows. The optimal operations from the solution are then analyzed in a regression procedure to obtain a set of operating rules. These rules are evaluated in a simulation model using a different set data. Based on the simulation results bounds are placed on operations and cycle returns to the optimization model. This continues until one of the stopping rules is satisfied.

In the study by Srivastava and Patel (1992), optimization-simulation models were used for the systems analysis of Karjan irrigation project in India. Two types of optimization models, i.e., linear programming and dynamic programming (continuous and discontinuous) were used for preliminary design purposes. The simulation technique was used for further screening. The linear programming model is most suitable for finding reservoir capacity. Dynamic programming (continuous and discontinuous models) are used for further refining the output targets and finding the possible reservoir carryover storages, respectively.

Crawely and Dandy (1993) used the linear programming thchnique for identification of optimum monthly operation policies for the Adelaide headwork's system in Australia. They developed model with the objective function to minimize the pumping costs while ensuring system reliability by maintaining minimum-target levels in the reservoirs.

Loucks (1995) reviewed the needs and opportunities in developing and implementing decision support system (DSS). The focus of the paper is on the process of the successful DSS development and implementation. An approach and some guidelines are outlined for the development of DSSs. The approach emphasizes and requires considerable iterations. The feedback is required throughout the DSS building, testing and evaluation (debugging), and implementation process. The paper concludes by identifying some research needs and opportunities affecting DSS development and its effective use.

Wurbs (1996) presented a computer-based methodology for optimally sizing flood damage reduction system. The decision variables are the size of each structural component of the system, such as storage capacity for reservoirs and flow capacity for channel improvements, and the choice of which non-structural plan to implement in various regions of the floodplain. The decision criteria are to minimize total system cost, which is the sum of the discounted annual cost of implementing and maintaining each measure and the residual expected annual flood damages. A hydrologic and economic simulation model is combined with a search algorithm. The simulation model incorporates procedures for determining the total economic cost for a specified plan. The optimization algorithm iteratively executes the simulation model in an automated search for the optimum plan.

Wurbs (1997) conducted a simulation study of the Brazos river basin and identified issues and concerns that illustrate the practical complexities of administering and modeling a water allocation system. The key considerations involve sharing of limited supplies by numerous water quality constraints, return flows, hydrologic data compilations, and reliability assessment. He states that the issues affecting evaluation of water availability within the Texas water rights system are representative of other states as well. The study is useful in highlighting the major concerns, issues and constraints, which are to be handled while managing such systems.

Dandy et al. (1997) made a comparison of simulation, network linear programming, full optimization LP model and the LP yield model for estimating the safe yield of the Canberra water supply system consisting of four reservoirs. They pointed out that, although a simulation model will accurately assess the system yield for an assumed set of operating rules, it will not assess the maximum yield that can be achieved by adopting the best possible set of operating rules for the system. The optimization models can be said to use the optimal operating rules for the system in order to obtain the maximum models. They however pointed out that, if the system yield with a specified reliability needs to be determined, there is considerably more difficulty in using the optimization and yield models.

Srinivasan et al. (1999) presented a mixed-integer linear programming model for reservoir performance optimization. They improved the mixed-integer formulation of Moy et al. (1986) for a more complete representation of the resiliency criteria. The improvements achieved with the modified model is demonstrated using the same example as presented with the original model.

Loucks et al. (2000) presented a discussion on sustainable water resources management in an editorial. As defined in the Brundtland Commission's report "Our Common Future (WCED 1987), a development is sustainable if: it meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable water resources system are those designed and managed to fully contribute to the objectives of society, now and in future, while maintaining their ecological, environmental, and hydrological integrity (ASCE, 1998). They must be planned, designed, and managed in such a way that the life-support system at all biological levels remains functional and that the water and related land resources are not irreversibly degraded over time.

Mariam and Srivastava (2000) adopted implicit stochastic Yield model based on linear programming for planning optimal yield of proposed Morand reservoir in Narmada basin in India, and work out optimal allocations of land and water resources, using crop planning model, to develop cropping pattern for annual reservoir yields that can be obtained from the reservoir for different degree of annual project dependability. They opined that the yield model provides a reasonably acceptable estimate of the annual reservoir yield for planning of the project.

Dahe and Srivastava (2000) have demonstrated the use of yield model for assessment of annual yield of Upper Narmada irrigation reservoir with specified reliability and the extent of availability of irrigation supply failure years. Such an assessment can assist the planners to decide upon the irrigation polices regarding the area to be brought under irrigation with sustainable cropping pattern and to reduce the damage due to the likely shortages in supply during failure years.

Dahe and Srivastava (2001) have worked on effect of reliability and extent of supply during failure years on the annual yield of irrigation reservoir. The paper demonstrates adoption of yield model for the analysis of Halon irrigation reservoir. The effect of reliability as well as the extent availability of annual supply during the failure years on the annual yield irrigation project is studied.

Dahe (2001) has made an optimization approach employing the implicit stochastic yield model based on linear programming address issue of assessment and optimal utilization of annual yield for system of reservoirs. Basic yield is extended to develop multiple yield model for multi-reservoir system to achieve the desired annual reliabilities target. The study carried out for 25 major irrigation reservoirs in Narmada river basin in India for optimal planning of the river basin projects.

Dahe and Srivastava (2002) have further extended the basic yield model and presented a multi-yield model for multi-reservoir system consisting of single purpose and multipurpose reservoirs with an objective to achieve pre-specified reliabilities for irrigation and energy generation and to incorporate an allowable deficit in annual irrigation target. The yield model is applied to a system of eight reservoirs in the upper basin of the Narmada River in India. They have opined that model can act as a better screening tool in planning by providing output that can be very useful in improving the efficiency and accuracy of detailed analysis methods such as simulation.

2.3 APPLICATION OF LINEAR PROGRAMMING IN IRRIGATION

Linear programming (LP) is capable of handling complex water resources problem. Where a large number of decision variables and constraints are involved. The constraints may be on social needs, limitation of resources and other physical and technological, environmental requirements propelling in region.

2.3.1 Irrigation Planning Using Linear Programming

The linear programming approach has now become regular exercises in different phases of irrigation project in general and the cropping pattern planning in particular. Simple linear programming models can be formulated to handle water resources system related to a single time period. But in reality the irrigation situations are usually much more complex. The fact remains that the supply of irrigation water from a river or a reservoir depends on rainfall and varies during the same period from year to year. The quantity of water required by a crop at a particular time depends on two factors, namely the moisture available in the soil and the evapotranspiration rate at that time. Again these factors in turn depend on two other factors, firstly the previous irrigation and secondly the prevailing weather conditions which include rainfall, humidity and temperature etc.

Apart from these considerations the quantity of irrigation water and its time of application also influence the crop returns significantly.

Thus an irrigation system actually involves lot of periodic uncertainties. Therefore attempts have also been made by some researchers to introduce dynamic and stochastic elements in the linear programming models to overcome the drawbacks of simple deterministic models.

The pioneering applications of linear programming were by Heady (1961), Dorfman (1961) and Guise and Flinn (1970) for the river basin planning and development. Windsor and Chow (1972) developed multi crop and multi soil mathematical model to maximize the net returns from crops grown in a season using various methods of irrigation by using LP technique subject to resource availability. Heady and Micol (1975) formulated a LP model of land and water allocations to improve environment and water quality through soil loss controls. Sarkar and Maji (1976) attempted to develop an optimal drainage program and a cropping pattern for an existing canal irrigation system consistent with most efficient use of available resources through linear programming technique under the availability of unlimited and restricted funds, respectively. Matanga and Marino (1979) developed a linear programming model to obtain optimal cropping pattern. The objective was to maximize yield from the crop under constraints of availability of irrigation water and labour. Kumar and Singh (1980) studied the effect of interaction of irrigation and labour on cropping pattern. The study revealed that labour played a dominating role in decision making process. There are several important case studies of linear programming application in various phases of irrigation. For example Hiramath (1973) applied multi period linear programming for temporal and spatial allocation of irrigation water in Krishnarajasagar project of Mysore State, India.

Heady et al. (1973) developed a linear programming model for the optimal land and water allocation to estimate whether there was enough water to meet the food needs of United States of American by the year 2000 AD. Badenhop and Cashloller (1974) employed linear programming technique to choose most profitable crop combination using alternate set of land and water combination in Tungbhadra irrigation project area in India. Singh et al. (1976) formulated a linear programming model for the optimal allocation of land and water for different winter crops in Hissar district. The objective was to maximize the net profit over a given command area and canal discharge.

Agrawal and Agrawal (1982) used linear programming for water budgeting to maximize agricultural production. The study was based on an area under major irrigated winter crops, their yields per hectare, and the total irrigation water actually applied by canals in district Hissar.

2.3.2 Conjunctive Use Management Using Linear Programming

The conjunctive use can be defined as the combined and integrated management of surface water and ground water for optimal utilization of available water resources. In other works it is complementary use of surface and ground water resources to provide enhanced and assured water supplies at minimum cost. The concept of conjunctive use of surface and ground waters is simple in that it tries to take advantage of large free evaporation loss and transportation of water from one point to another based on the head difference at no cost. Thus when excess surface water is available it can be diverted for irrigation purposes which includes recharge of ground water to build up ground water storage so that the same can be utilized in place and time when surface water is in short supply. By maintaining the ground water level at the reasonable depth one can maintain the ecological balance in the region, minimizing the cost of pumping, avail excessive build up of ground water table and minimize the resulting problems of water logging and salinity. Sometimes the shortage of surface water can be made up by mining of ground water temporally; thus this type of conjunctive water supply system offers flexibility in operation and results in water conservation. It increased the total yield reliability of supply and general efficiency of water system. A comprehensive study of the conjunctive water use is given in Todd (1980) and Coe (1990).

Various research workers have extensively used Linear programming (LP) technique. Rogers and Smith (1970) used LP model to arrive at the optimal allocation of ground water and canal water for conjunctive use planning of irrigation. The optimization was constrained by capacities of river, canal wells and drainage and pumping facilities and cropping pattern. The model was deterministic and emphasized on interaction of surface and ground water system.

Lakshminarayana and Rajgopalan (1977) has applied LP model to Buri Doab in Punjab, India. The model determines the extent of allocation of irrigated area to alternative crops and the amount of seasonal water releases from the two sources. Canal and tubewells necessary for seasonal water crop requirements during a one year crop period of operation are determined such that the benefits from the system is maximized. This is a deterministic model in which the response of the ground water was not considered for withdrawals.

Singh and Sirohi (1977) applied linear programming techniques to workout a plan for optimal water distribution among the various crops available from tubewells and upper Ganga Canal in Western UP, India. Sinha and Charyula (1979) developed a linear programming model for the existing irrigation system of Gomati Kalyani Doab, India. Surface water and ground water were planned to be used conjunctively. Various alternative crops were allocated in cultivated areas to determine the optimal cropping pattern.

Yoganarashimhan and Chand (1979) have applied a linear programming model to Gomti Kalayani Doab for maximizing the benefits from irrigation works, subject to a set of constraints. The model select is the cropping pattern from the thirteen crops and gives the allocations of surface and ground waters.

Duggal (1979) suggested an optimization approach for conjunctive use of surface and ground water. Multi period, multi level analysis was carried out by Singh (1981) to optimize land, water, and fertilizer resources for future development.

Both surface and ground water resources were used in LP model for each of the individual river basins and an optimal policy was determined for each of 20 rivers basins and for the country as a whole by Chachadi and Sinha (1988). They have formulated a conjunctive use model based on LP for optimal agricultural production in the sub basin of the Ghataprabha command area in Karanataka State, India. This model has been used to allocate the optimal areas to different crops subject to the water availability constraints from surface and ground water sources.

Vedula (1985) presented a water allocation model for the Upper Cauvery river basin in India. Linear programming is used to determine the reservoir releases, ground water pumping targets, and cropping patterns. The multi objective-planning model maximizes the net benefits and the irrigated areas.

2.4 THE HISTORICAL REVIEW OF INTRA-BASIN/INTER-BASIN WATER TRANSFERS

There are large disparities in rainfall and river flows in different parts of India. In this situation, it was natural for engineers and planners to think in terms of water transfer from better endowed to deficient basins. The concept of intra-basin/inter-basin, i.e., inter-linking of Indian rivers is thus not entirely new and was first thought of in the last century. A historical review of existing inter basin links proposals is given below.

2.4.1 Lt. Cotton's Comprehensive Navigation Plan

Lt. General Sir Arthur Cotton who was the pioneer of water resources development in India, way back in 1839, stated that water in India is more valuable than gold (Cotton, 1885). He considered that besides irrigation, development of water resources for navigation was of utmost importance as this would contribute to increase of production and economic development through improved transportation (Cotton, 1984 and 1985; Rao, 1975). Lt. Cotton accordingly developed a plan to inter link the rivers in India. The aim was to link Karachi to Calcutta via Kanpur and Cuttak to Bhattkal, Mangalore and Madras. But all that then were able to achieve was series of disconnected water ways, like Midnapure Canal, the Orissa High Level Canal and Kurnool-Cudappah Canal. The venture ended in a failure and had to be taken over by the Government (GOI, 1972).

2.4.2 National Water Grid

Dr. K. L. Rao, one of the most eminent engineers of Independent India, and the Union Minister of Irrigation, proposed a National Water Grid for providing navigation and to remove the spatial disparities in the availability of water in different river basins.

It was based on work done earlier in the Central Water and Power Commission, India. It was noted that the general location of regions of surplus water and deficit is such that trans-basin transfer will be necessary from north and east towards west and south.

Accordingly, Ganga-Cauvery link, off taking near Patna, after it has been joined by its major tributaries Ghagra, Gandak and Sone, passing enroute through the basins of the Sone, Narmada, Tapi, Godavari, Krishna and Pennar, was to connect Ganga and Cauvery as shown in Figure 2.1. Other minor links were also proposed. The 2640 Km long Ganga-Cauvery link essentially envisaged the withdrawal of 1680 cumecs (60,000 cusecs) of flood flows near Patna for about 150 days in a year and pumping about 1400 cumecs (50,000 cusecs) of this water over a head of 449 m for transfer to the peninsular region and utilizing the remaining 2800 cumecs (10,000 cusecs) in the Ganga basin itself. The proposal envisaged utilization of 2.59 million-hectare meters of Ganga waters to bring under irrigation an additional area of 4 million hectares. Dr. Rao had also proposed a few additional links like, (a) Brahmaputra-Ganga link to transfer 1800 to 3000 cumecs with a lift of 12 to 15 m, (b) Link transferring 300 cumecs of Mahanadi waters southwards, (c) Canal from Narmada to Gujrat and Western Rajasthan with lift of 275 m and (d) Links from rivers of Western ghats towards east. The National Water Grid was also considered a network for inland navigation. Dr. Rao had estimated his proposals to cost Rs. 12,500 Crores (NWDA, 1998). A UNDP team was invited to study the proposal and it was endorsed (Rao, 1975). However, that study of the National Water Grid by the Central Water Commission, found that the Ganga-Cauvery link alone will cost about Rs. 70,000 crores at 1995 prices. The annual cost including cost of power would be around Rs. 30,000 per hectare, while the NWDA proposal for inter linking rivers between Ganga and Cauvery at 1996 prices has been estimated to cost only around Rs. 15, 000 per hectare annually (NWDA, 1998). Then the scheme has not been pursued.

2.4.3 Garland Canal

Captain Dastur, an air pilot, proposed an impressionistic idea to interconnect the rivers of India. His idea was a form of a Garland around the peninsula and a long canal at the foothills of the Himalayas. The two were proposed to be joined by pipes. The Himalayan canal was to be a 4200 km long, 300m wide at constant bed level between 335m and 457m above mean sea level aligned along the southern slopes of the Himalayas running from Ravi in the west to Brahmaputra and beyond in the east. It was visualized to be fed by the Himalayan river waters stored in 50 integrated lakes to be created by cutting the hills slopes of the Himalayas to the same level as the bed of the canal, with another 40 lakes beyond Brahmaputra. The proposal envisaged a storage capacity of 247 BMC to control and distribute 617 BMC of water. The Central and Southern Garland canal was proposed at a constant elevation of between 244m and 305m above the mean sea level, with about 200 lakes having a storage capacity of about 497 BMC to control and distribute 864 BMC of water. The Himalayan and Garland canals were proposed to be inter connected at two points, Delhi and Patna, by five 3.7m diameter pipes to transfer the water (Figure 2.2). Captain Dastur claimed that all the surplus water in the country will be utilized to irrigate 219 million hectares. About 16.8 million volunteers were expected to complete the work in 3 to 4 years. The proposal was estimated to cost of Rs. 24,095 crores at 1974 prices (NWDA, 1998). The proposal was technologically preposterous and should have been summarily rejected. It is, however, being mentioned to bring out the institutional aspects of scientific policy making. The proposals had the full support of the then Prime Minister and apparently the Ministry could not give sound opinion on its own. Committees were therefore, set up, the proposal was detailed and then estimating that it will cost about Rs.12 million Crores, and the proposal was dropped.

2.4.4 National Perspective

The idea to interlink the rivers in India, to overcome the spatial imbalance persisted. The Ministry of Water Resources, Government of India, framed a National Perspective for Water Resources Development in August 1980. It was discussed at various government levels and a National Water Development Agency (NWDA) was set up as an autonomous society to promote scientific development for optimum utilization of water resources of the country and in particular to carry out detailed studies in the context of the National Perspective.

The development, conservation and use of waters thus form one of the main elements in the country's developmental planning to achieve the total production goals in addition to meeting the industrial and other needs of far projected population for 2050 AD (NWDA, 1998).

On this basis it is imperative that it was proposed to link the Brahmaputra and other rivers with national grid to meet the shortages in the various parts of the country (Mohile et al., 1996).

The broad approach adopted in the National Perspective is as follows: (NWDA, 1998).

(i) Existing uses have been kept undisturbed.

(ii) Normally water development under the existing legal and constitutional framework is assumed to take place fully by the turn of the century.

(iii) The development envisaged is within the framework of all the existing agreements among various co-basin states involved.

(iv) While planning inter-basin and inter-state transfer of water, reasonable needs of the basin states for the foreseeable future have been kept in view and provided for.

(v) Most efficient use of land and water in the existing irrigation and hydropower station has been kept as a principal objective to be achieved.

2.4.5 National Perspective Plan

The National Perspective Plan comprises of two components, namely,

(i) Himalayan River Development, and

(ii) Peninsular Rivers Development.

2.4.5.1 Himalayan river development

The Himalayan River Component envisage construction of storages on the main Ganga and Brahmaputra rivers and their principal tributaries in India and Nepal so as to conserve monsoon flows for flood control, hydro-power generation and irrigation.

Inter-linking canal systems will be provided to transfer surplus flows of the Kosi, Gandak and Ghagra to the west. In addition, Brahmaputra- Ganga link will be constructed for augmenting dry weather flows of the Ganga (Figure 2.3). Surplus flow available on account of inter-linking of Ganga and Yamuna are proposed to be transferred to the drought prone areas of Haryana, Rajasthan and Gujrat. The scheme will also enable large areas in south Uttar Pradesh and South Bihar to obtain irrigation benefits from the Ganga, with a moderate lift at less than 30m. Further, all land in Tarai area of Nepal would also get irrigation apart from generation of about 30 million KW of hydro-power in Nepal and India. It will also provide flood moderation in the Ganga, Brahmaputra system with this proposal, about 140 BCM of additional water would be available from these river systems for irrigation on estimated 22 million hectares in the Ganga, Brahmaputra basin apart from Haryana, Punjab, Rajasthan and Gujarat. It would also provide 1120 cumecs (40,000 cusecs) to Calcutta port and would provide navigation facilities across the country. The scheme will benefit not only parts of India but also neighbours Nepal and Bangladesh (NWDA, 1998).

2.4.5.2 Peninsular river development

Amongst the Peninsular rivers, the Mahanadi and Godavari are considered to have sizable surpluses after meeting the existing and projected needs of the states within these basins. It is therefore, proposed to provide terminal storages on Mahanadi and Godavari rivers to divert surplus flows of Mahanadi and Godavari system and to further transfer surplus flows of Mahanadi to the Godavari system to water short rivers namely, Krishna, Pennar and Cauvery. The link from Mahanadi to Godavari will be along the east coast and will not involve any lift. The link between Godavari and Krishna will be partly by gravity and partly in the ultimate stage, by lifts of the order of 120m (maximum). The transfer of water would enable irrigation in drought prone areas of Maharashtra, Karnataka, Andhra Pradesh and Tamilnadu by successive exchange. The component is shown in Figure 2.4.

The second component of this proposal is to divert a part of the waters of the west flowing rivers of Kerala to the east for irrigating the drought prone areas of Tamilnadu, apart from bringing new areas under irrigation in Kerala.

The third component is to construct storages and inter-link small rivers, flowing along the west coast, north of Mumbai and south of Tapi. This will enable partial release of waters from Tapi and Narmada which will enable extension of irrigation to Saurashtra and Kutch areas. It will also enable provision of extra water to meet the growing needs of metropolitan area of Mumbai as well as providing irrigation to the coastal areas in Maharashtra.

The fourth component envisages inter-linking of the southern tributaries of the Yamuna , the Ken and the Chambal in addition to construction of small storages on intermediate tributaries and a dam on the Yamuna at Panchnad. This will enable irrigation in Ujjan and Indore areas of Madhya Pradesh as well as upper areas in Rajasthan.

The proposal of Peninsular River Development will enable additional use of about 84 BCM of water to benefit the States of Orissa, Andhra Pradesh, Maharashtra, Karnataka, Tamilnadu and Madhya Pradesh etc. This will provide additional irrigation benefit of 13 million hectares. The distinctive feature of the National Perspective is that the transfer of water is essentially by gravity and only in small reaches by lift not exceeding 120 m.

2.4.6 Examples of Some Intra-basin /Inter-basin Transfers Scheme Implemented in India

The Shenbagavalli Anicut built around two centuries ago in the Sivangiri Zamin in the head reaches of Vaippar basin which is a minor river south of Vaigai. A small weir called the Sherbagavalli anicut was built on a small tributary of Periyar river flowing towards the west. A short canal cutting across the ridge was excavated to divert the water to a tributary of Vaippar river flowing eastwards. This scheme serves 4423 hectare under 40 minor irrigation tanks.

The Periyar project is the most notable endeavour of the last century in trans-basin diversion. A masonry gravity dam 47.28 m high has been constructed across a gorge on west flowing Periyar River. A 170 m long tunnel with discharging capacity of

40.75 cumecs has been driven across the mountain barrier to convey the waters eastwards to Vaigai basin. The project was commissioned in 1895 and provided irrigation to 57,923 ha initially which has since been extended to 81,069 ha. Having a power station of 140 MW capacity.

Parambikulam Aliyar project is a complex multi-basin multi-purpose project. Seven streams, five flowing towards the west and two towards the east, have been dammed and their reservoirs inter-linked by tunnels. The water is ultimately delivered to drought prone areas in Coimbatore district of Tamilnadu and the Chittur area of Kerala state. The command area for irrigation is presently 1.62 lakh hectares. There is a total 185 MW power generation capacity at four power houses. This project was built during the second and third five year plans.

Kurnool Cudappa Canal scheme was started by a private company in 1863. A 8.23 m high anicut was built on river Tungbhadra upstream of Kurnool town. A 304 km long canal with a capacity of 84.9 cumecs at its head extends from Krishna to Pennar and irrigates 52.746 ha. The scheme was taken by Government of India in 1982.

The Telgu-Ganga project has been recently implemented primarily to meet the pressing needs of water supply to Chennai metropolitan area. It brings Krishna waters from Srisailam reservoir through an open canal, first to Somasila reservoir in Pennar valley. This involves rock cuts upon 35m deep. From Somasila water is taken through a 45 km canal to Kandaleru and thence to Poondi reservoir in Tamilnadu through another 200km long canal. By mutual agreement 12 TCM or 0.34 BCM of water will be delivered to Tamilnadu at the border from Krishna basin. This will greatly augment the water supply for Chennai city. The canal also irrigates 2.33lakh ha in Andhra Pradesh enroute. The project was made possible by the state of Maharashtra, Karnataka and

Andhra Pradesh voluntarily, foregoing 5TCM each from their entitlement. This project is a fine example of not only of hydraulic engineering but also of inter-state co-operation.

Intra-basin/inter-basin transfers in the Indus basin under the Indus Water Treaty, waters of three eastern rivers, viz, Sutluj, Beas and Ravi were allocated to India. As land to be benefited in India lies mostly to the east and south of these rivers, the rivers had to be inter-linked and waters conveyed to canal systems serving vast tracts in India. The main storage on Sutlaj is at Bhakra, while that on Beas is at Pong. Bhakra system provides irrigation to 26,30,000 ha of new area besides stabilization of existing irrigation on 9 lakh ha. The aggregate generation capacity of Bhakra project is 1354 MW. Direct benefits of Pong include 16 lakh ha irrigation and 360 MW power. A diversion dam at Pandoh, 140 km upstream of Pong on Beas, enables diversion of water from Beas to Bhakra reservoir, and generates 165MW of power on the way. The Beas-Satluj link is 37.25 km long, of which 25.45km is tunnel through difficult rock formations. The capacity of tunnel is 254.7 cumecs. Ranjit Sagar reservoir on Ravi will provide additional water to Beas, and also generate a large block of power. It is no exaggeration to say that the Indus valley water resources development has transformed the entire economy of Punjab, Haryana and Rajasthan. So for as power benefits are concerned, the entire Northern grid shares these.

The projects cited above have been highly benefited and have not resulted in any noticeable environmental damage. The major reservoirs at Bhakra, Pong and Ranjit Sagar dams, did involve considerable rehabilitation problems, which have been largely satisfactorily resolved.

2.4.7 Water Transfers in Other Countries

Many schemes of intra-basin/inter-basin water transfers have been planned, and some of them implemented in other countries.

Sixteen major inter-basin water transfer schemes have been implemented in Canada, mainly for hydropower. In USA the longest and best known schemes implemented so far is California State Water Project.

In United States, The California's State Water Project which diverts 4 cubic km of water from northern California to the drier central and southern parts of the state was completed in 1973. The conveyance system comprises of 869 km California Aqueduct, a complex system of lined and unlined canals, pumping stations, siphons and tunnels involving a lift of 1220m.

The Texas Water Plan envisages redistribution of water in Texas and New Mexico to meet the needs of the year 2020.

The waters of Colorado river which is the international river between USA and Mexico are being supplied outside the basin to the Imperial Valley in the California.

In Canada, the major existing inter-basin transfer projects are Kemano, Churchill, Diversion, Welland Canal, James Bay, Churchill falls and Bayd' Espoir etc. Proposed inter-basin water transfers in Canada are North America Water and Power Alliance (NAWAPA), Canadian Water Magnum Plan, Central North American Water Project (CNAWP), Smith Plan etc. for transfer from Canada to U.S.A.

In Mexico, for the Mexico city water supply, transfer from ground waters from the Lerma basin was completed in 1958.The water plan for the North Western Region (PLHINO) conceived a set of inter basin transfers within the Noroeste region.

In Sri Lanka, the Mahaveli-Ganga project includes several inter basin transfer links.

In USSR the notable scheme executed is the Irtysh Karganda scheme in the Central Kazakhstan.

In China the Lingua canal was completed in 214 BC and Grand Canal was completed in 605 AD. Recently completed project in China is Billuna-Dalian inter-basin water supply system. Trans-basin transfer of Luhana river to Tiajian and Tengshan, inter-basin diversion of Guang Long province and inter-basin diversions in Fujian province. Diversion of Quiantang river water, diversion of Yellow river surpluses and south to north transfer projects with the West route, Middle route and East route are other proposed projects in China.

These schemes give us confidence in planning and executing schemes in our country. At the same time lesson have to be learnt from their actual performance, economical and environmental point of view. The decision and implementations of the intra-basin and inter-basin water transfers in India as per the directives given by the Supreme Court of India should be taken for execution taking into consideration of fast growing population for 2050AD.

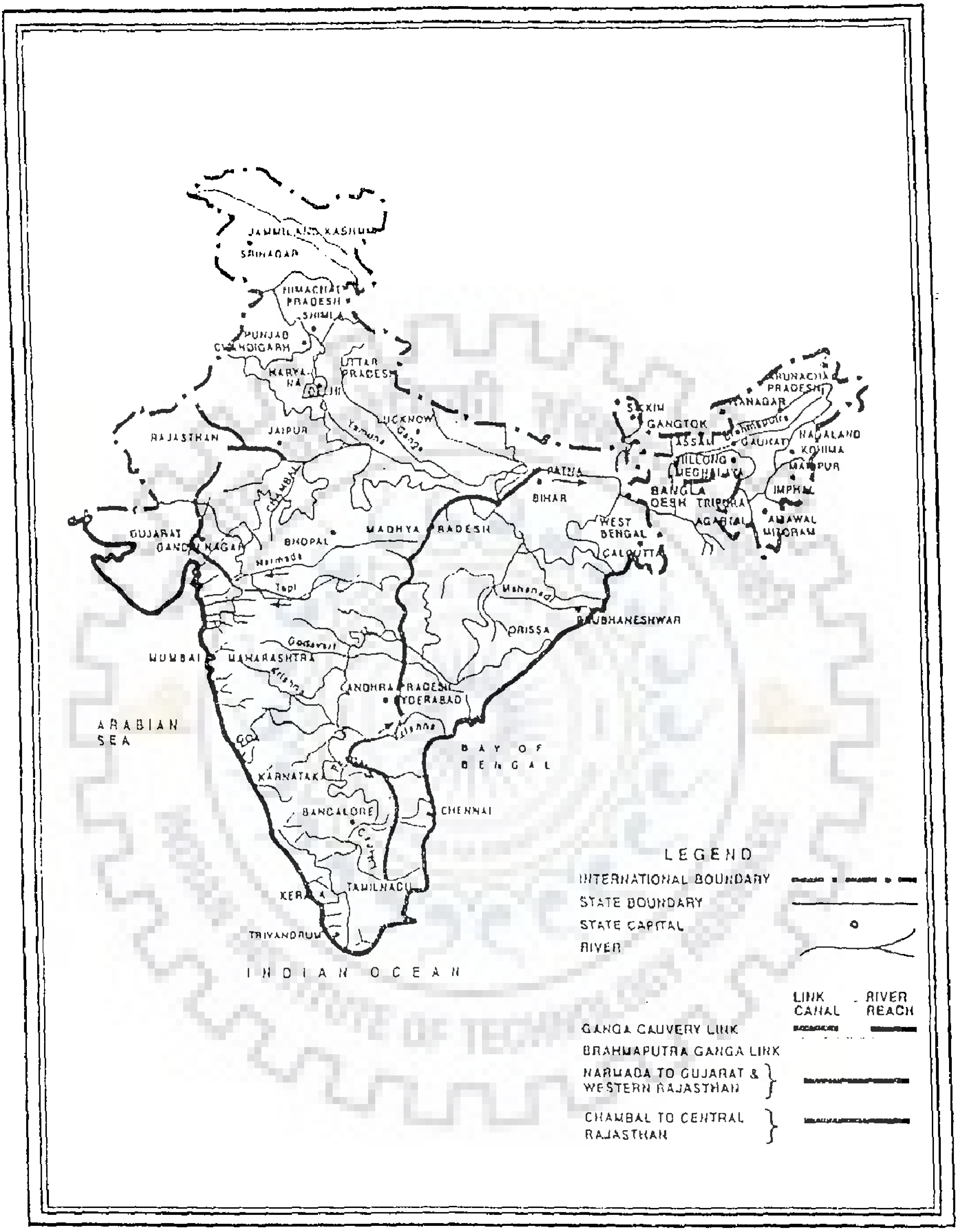

Figure 2.1 : Dr. K. L. Rao's Proposal

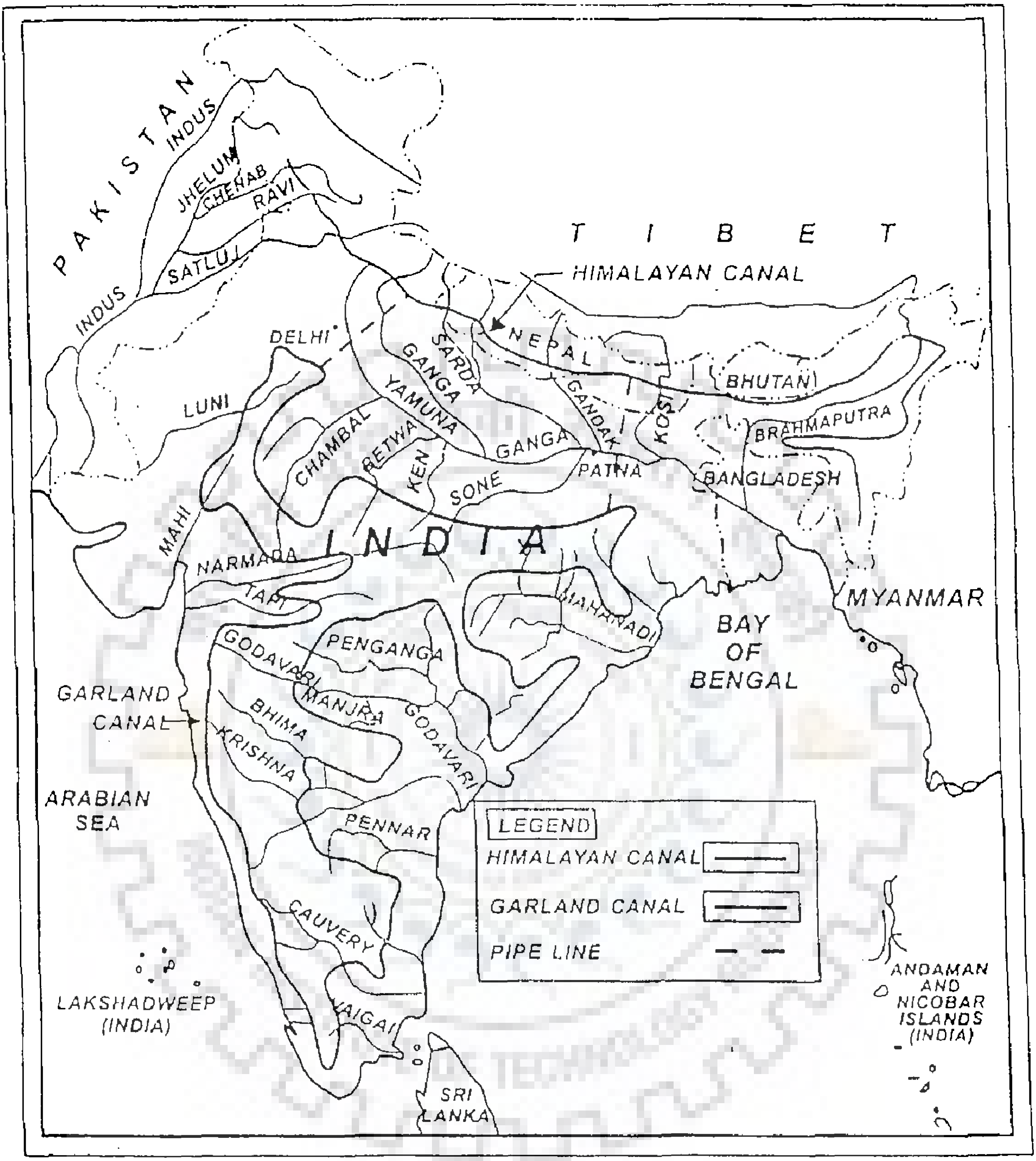

Figure 2.2 : Captain Dastur's Proposal

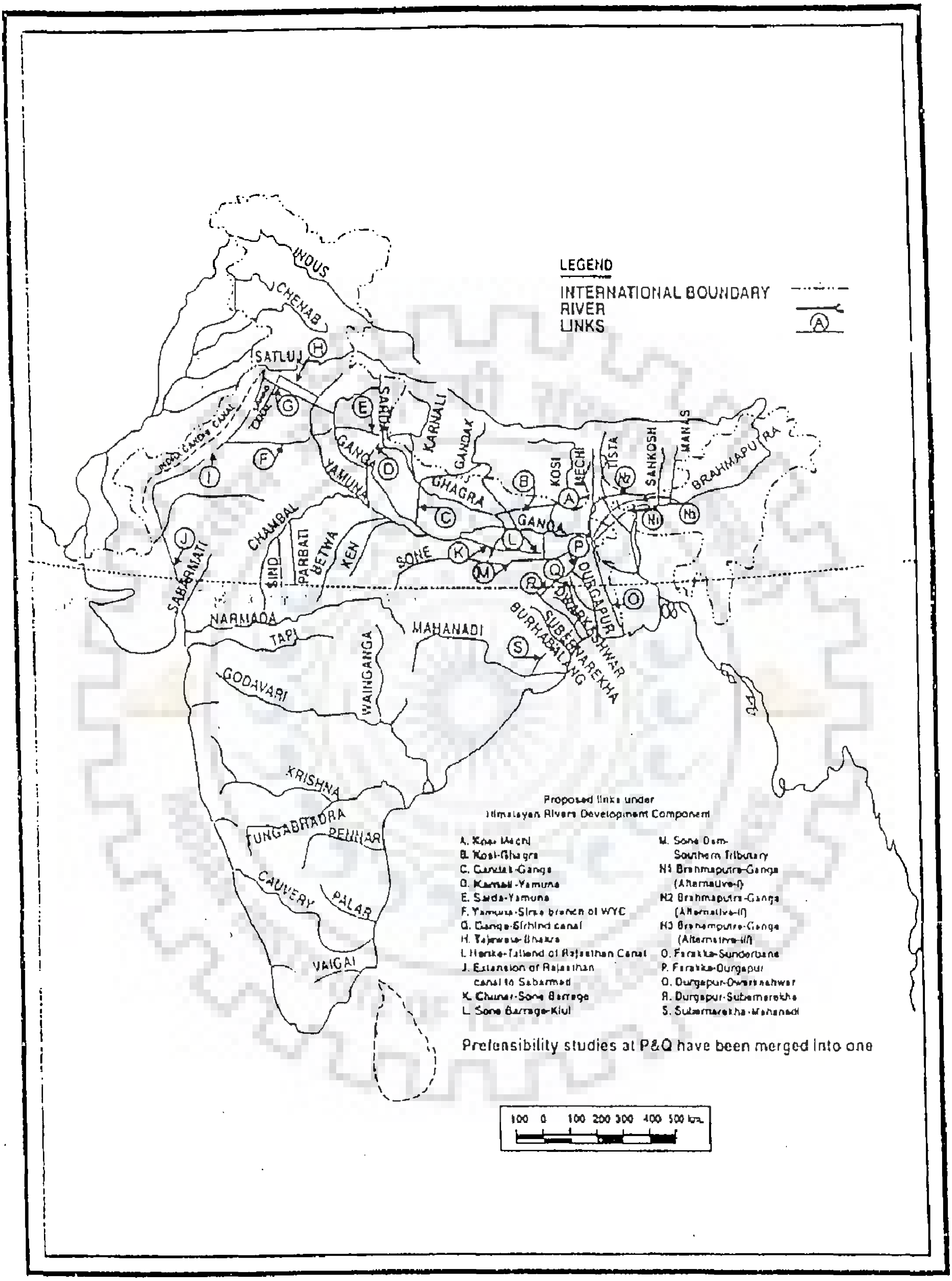

Figure 2.3 : Himalayan Rivers Development Component

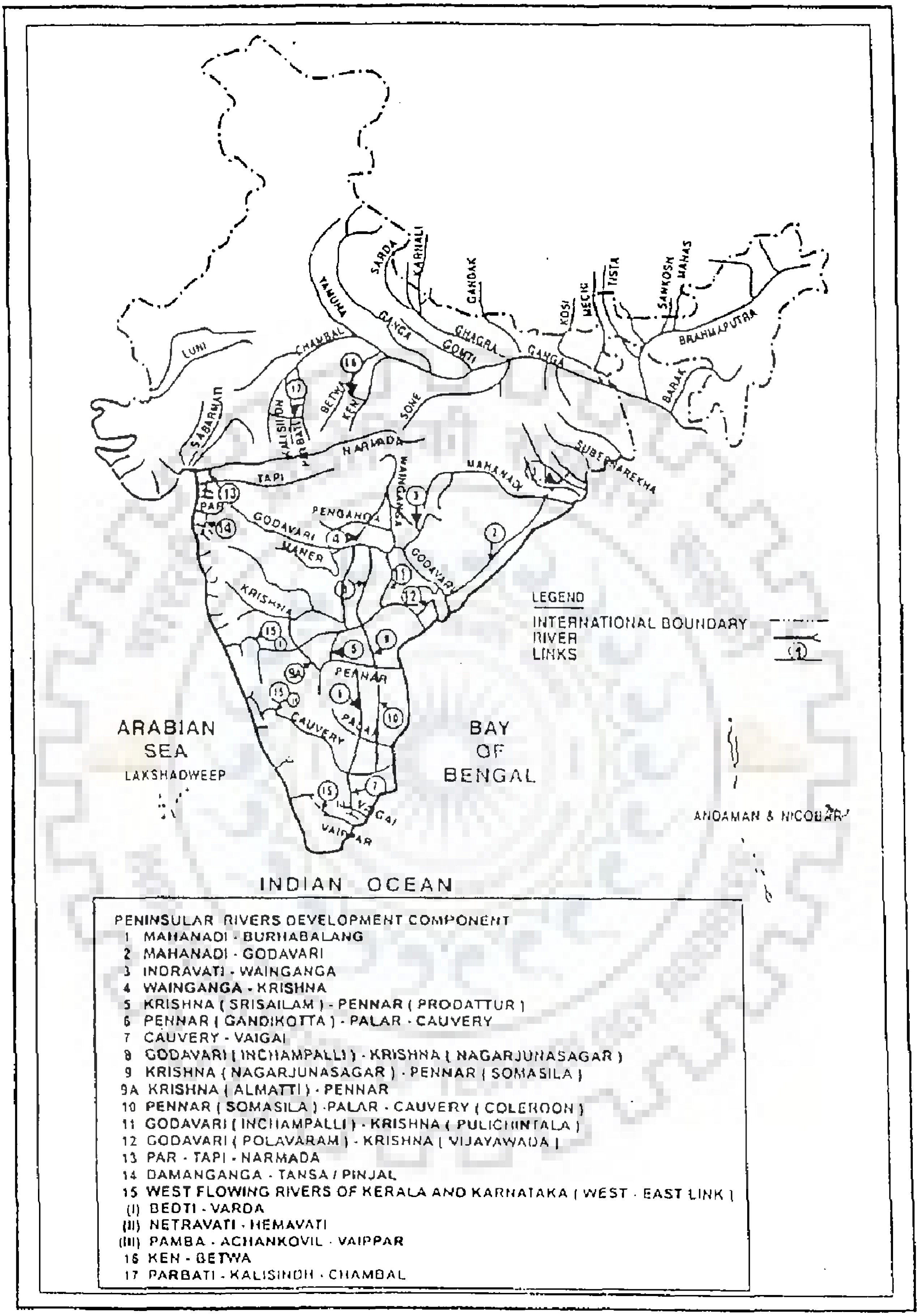

Figure 2.4 : The Peninsular Rivers Development Component

TRANSBOUNDARY CAUVERY RIVER SYSTEM

3.1 CAUVERY RIVER BASIN

The Cauvery River is also known as Dakshin Ganga, or 'Ganga of South' in India. The Cauvery is one of the major interstate rivers of South India and is the fourth largest river in the Indian peninsula next only to Godavari, Mahanadi, and Krishna. It rises in the Western Ghats in the Kodagu district of Karnataka at an altitude of about 1341 m above mean sea level (m.s.l) and flows in eastwardly direction passing through the states of Karnataka, Tamilnadu, Kerala and Pondicherry before it drains into Bay of Bengal. The total length of river from source to its out-fall into Bay of Bengal is about 800 km of which 320 km is in Karnataka, 416 km in Tamilnadu and 64 km fall on the common boundaries between Karnataka, Tamilnadu and Pondicherry. The principal tributaries of river Cauvery are the Lakshmanthirtha, Hemavathi, Harangi, Shimsha, Kabini, (which originates in Kerala), Arkavathi, Suvarnavathi in Karnataka, Bhavani (origin in Kerala), Amaravathi (origin in Kerala), Noyil and Ponnanai Ar in Tamilnadu.

The entire Cauvery basin catchment has been divided into 16 sub-basins, viz., (1) The Upper Cauvery (from the source to the Krishnarajsagar dam, i.e., KRS dam, (2) the Kabini, (3) the Shimsha, (4) the Arkavathi, (5) the Middle Cauvery (from the catchment of main river Cauvery from KRS dam at the upstream end to just below the confluence of Arkavathi river with main river Cauvery), (6) the Suvarnavathi, (7) the Palar, (8) the Chinnar, (9) the Bhavani, (10) the Noyil, (12) the Tirumanimuttar, (11) the Amaravathi, (13) the Ponnanai Ar, (14) the Upper Coleroon, (15) the Lower

Coleroon and (16) the Cauvery Delta. The sub-basin wise drainage area, rainfall, run-off and groundwater potential is given in Table 3.1.

Table 3.1: Sub-basinwise Area, Rainfall, Runoff at 75% Water Year Dependable Flow and Ground Water Potential

Sl. No. (1)	Name of Sub-basin (2)	Area (Km^2) (3)	Rainfall (mm) (4)	Runoff* (MCM) (5)	Ground Water (MCM) (6)
1	Upper Cauvery	10619	1025	5394	578.5
2	Kabini	6810	1097	3641	386.4
3	Shimsha	8469	656	619	506.0
4	Arkavathi	4351	451	287	103.5
5	Middle Cauvery	2676	424	330	205.6
6	Suvarnavathi	1787	38	38	63.9
7	Palar	3214	469	105	139.7
8	Chinnar	4061	653	312	177.6
9	Bhavani	6154	908	1917	187.7
10	Noyil	2999	504	225	54.2
11	Amaravathi	8280	572	898	308.0
12	Tirumanimuttar	8429	536	649	350.1
13	Ponnanai Ar	2050	542	191	207.4
14	Upper Coleroon	3082	656	589	252.6
15	Lower Coleroon	1378	815	224	120.6
16	Cauvery Delta	6566	810.5	1051	224.6

* 75% water year dependable flows.

The Cauvery basin lies between 10^0 and 13^0 N latitudes and 75^0 and 80^0 E longitudes, bounded by the Western ghats at the west, the Bay of Bengal on the east and the river Krishna, Pennar and the basin area covered by the streams between Palar and Cauvery on the north and the area covered by the streams between Cauvery and

Vaigai on the south.

The catchment area of the Cauvery River is 81155 km^2, which is nearly 8% of total geographical area of the country. The statewise drainage area of Cauvery basin is given in Table 3.2.

Table 3.2: Statewise Drainage Area of Cauvery Basin

State	Drainage Area (Km^2)	Total Area of the Basin (%)
(1)	(2)	(3)
Karnataka	34273	42.2
Kerala	2866	3.5
Tamilnadu	43867	54.1
Pondicherry	149	0.2
Total	**81155**	**100.0**

In Karnataka, the basin includes the entire districts of Mysore and Mandya, about three quarters of Hassan district, about two-thirds each of Bangalore and Coorg districts and a part of Tumkur and Chikmagalur districts. In Kerala, the Cauvery basin covers small parts of four districts, i.e., Cannanore, Kozhikode, Iddikki and Palghat. In Tamilnadu, the basin extends over about three-quarters each of the three districts, i.e., Ooty, Coimbatore and Tanjavur, about two-thirds of Tiruchirapalli and small parts of Madurai, Salem, Dharmapuri and South Arcot districts.

3.2 SUB-BASINS

The basin has been divided into 16 sub-basins for planning purposes by National Water Development Agency (NWDA). Refer various reports in the list of References and Bibliography. The list of sub-basins is shown in Figure 3.1.1 and the tributaries of Cauvery river-basin are shown in Figure 3.1.2 (a) and Figure 3.1.2 (b).

3.2.1 Upper Cauvery Sub-basin

The Upper Cauvery Sub-basin lies between latitudes 10^0 54' and 13^0 21' N and longitudes 75^0 30' and 76^0 36' E comprising the catchment of the Hemavathi, the Laxmanthirtha and the main river Cauvery up to Krishnarajsagar (KRS) dam.

Cauvery rises at Talakaveri on the Brahmagiri ranges in the Western Ghats in the Kodagu district of Karnataka at an elevation of about 1341m above mean sea level. The river flows down from hills in a series of rapids and cascades and is joined at the foot of hills by the Kannike stream at Bhagamandala. The banks are high and steep formed of rich clay. At the border of Kodgu and Mysore districts, the river Harangi joins the Cauvery. The river then flows eastward in the Mysore district where the Hemavathi and the Lakshmanthirtha join on the left bank and right bank, respectively, some distance upstream of the KRS dam. The total length of the Cauvery river in the Upper Cauvery sub-basin up to the Krishnarajsagar dam is about 224 km. The length of the Harangi, Hemavathi and Lakshmanthirtha, all tributaries of Cauvery river in the Upper Cauvery sub-basin is 48 km, 245 km, and 131 km, respectively, from their origin to their confluence with the Cauvery.

The Upper Cauvery sub-basin drains an area of 10619 Km^2 which is about 13% of the total catchment area of the Cauvery basin. The catchment of the Upper Cauvery sub-basin lies wholly in Karnataka covering parts of the Chickmaglur, Kodgu, Hassan, Mandya and Mysore districts. The district wise breakup of the catchment area of the sub-basin is given in Table I.1 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.1. The line diagram showing the irrigation projects in the sub-basin is shown in Figure 3.3.1.

3.2.2 Kabini Sub-basin

The Kabini river is one of the tributaries of the river Cauvery in its upper-reach. The Kabini sub-basin lies between latitudes 11^0 29' N and 12^0 20' N and longitudes 75^0 48' E and 75^0 54' E.

The Kabini river rises in the Western Ghats at an elevation of about 2140 m above mean sea level in the Wyand district of Kerala state. The districtwise breakup of the catchment area of the sub-basin is given in Table I.2 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.2. The line diagram showing the irrigation projects in the sub-basin is shown in Figure 3.3.2.

3.2.3 Shimsha Sub-basin

The Shimsha sub-basin lies between the latitudes 12^0 18' N and 13^0 30' N and the longitudes 76^0 15' E and 77^0 19' E.

The river Shimsha, one of the important tributaries of Cauvery, rises in the south of Devarayanadurga hill in Tumkur district. After flowing southwest in the initial reach, it turns to southwards and then to east. Thereafter pursuing a southerly course, the river enters the Mandya district. Further, it finally takes southeasterly course and joins the Cauvery, a few kilometers below the Shivasmudram falls. The total length of the river Shimsha is about 200 km from its origin to confluence with Cauvery.

The Shimsha sub-basin has a catchment area of 8469 km^2, which constitutes 10.4 percent of the Cauvery basin area. The entire catchment area of the sub-basin lies in the Karnataka State. The district wise breakup of the catchment area of the sub-basin is given in Table I.3 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.3. The line diagram showing the irrigation projects in the sub-basin is shown in Figure 3.3.3.

3.2.4 Arkavathi Sub-basin

The Arkavathi sub-basin lies between the latitudes 12^0 16' N to 13^0 23' N and longitudes 77^0 11' E to 77^0 42' E.

The river Arkavathi is one of the important tributaries of the river Cauvery. It rises at Nandidurga hills in Chikballpur taluk of Kolar district. After flowing in the southwest direction at the initial stage, it receives along its course, the drainage waters of Kumudvathi river. From this point, the river Arkavathi flows in a southerly direction up to Ramanagaram and turns towards southeast and flows in the same direction up to the confluence of its tributary Suvarnamukhi on the left bank. Thereafter, it flows southerly direction and receives the water of Kuttlehole from the left near Kanakapura town. Further, it flows down and receives the waters of Doddahalla from the left and then finally joins Cauvery at Kungedoddi. The total length of the river Arkavathi is about 150 km from its origin to its confluence with Cauvery.

The Arkavathi sub-basin has a catchment area of 4651 km^2 that constitutes 5.4 percent of the Cauvery basin area. The major portion, i.e., 4184 km^2 (96%) of the catchment area of the sub-basin lies in Karnataka state and the rest 167 km^2 in Tamilnadu (Dharmapuri district). The district wise breakup of the catchment area of the sub-basin is given in Table I.4 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.4. The line diagram showing the irrigation projects in the sub-basin is shown in Figure 3.3.4.

3.2.5 Middle Cauvery Sub-basin

The Middle Cauvery sub-basin lies between the latitude 11^0 52' N to 12^0 48' N and longitude 76^0 30' E to 77^0 29' E comprising the catchment of main Cauvery from Krishnarajasagar dam to the state boundary just below Mekedatu gorge on river Cauvery.

The river Cauvery below the Krishnarajasagar dam continues to flow eastwards for 15 km up to Srirangapatnam and then changes its course south-east wards. It receives an important tributary, viz., the Kabini on its right bank at Triumakudal Narasipur and another tributary, viz., the Suvarnavathi joins the Cauvery from the right at Talakad about 25 km downstream. The river then takes a north-east direction and receives the Shimsha from the left, below Sivasmudram. It is here that the river starts cutting through the Eastern Ghats, and from a width of one kilometer, narrows considerably and flows in cascades through a gorge. At Sivasmudram, the river divides into two branches and falls through a height of more than 91 m in a series of falls and rapids. The two major falls are the Ganga Chukki and Bhara Chukki. The fall of river at this point is being utilized for the generation of hydro-electricity power. The Sivasmudram power station built here as early as 1902 is one of the earliest of the hydroelectric power stations set up in Asia. The two branches of the river join after the falls and flow through a gorge, almost too narrow to accommodate the fury of the river. At one point, known as Mekedatu (the goat's leap) the channel is so narrow that it is said that a goat could leap across it. After flowing through a gorge, the Cauvery continues its eastward journey and forms the boundary between Karnataka and Tamilnadu states for a distance of about 64 km. Another left bank tributary, viz., the Arkavathi joins the river just before it enters into Tamilnadu state. The total length of river Cauvery is about 130 km from Krishnarajasagar dam to the state boundary below Mekedatu gorge.

Middle Cauvery sub-basin has catchment area of 2676 km^2, which constitutes 3.03 % of the Cauvery basin area. The entire catchment area of the sub-basin lies in Karnataka State. The district wise breakup of the catchment area of the sub-basin is given in Table I.5 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.5.

3.2.6 Suvarnavathi Sub-basin

The Suvarnavathi river is one of the southern tributaries of the Cauvery in its upper reaches. It is the second tributary joining on right bank. The Suvarnavathi sub-basin lies between latitudes 11^0 35' N to 12^0 10' N and longitudes 76^0 46' E to 77^0 12'E.

The Suvarnavathi river rises in the Nasurghat range of hills situated in the south eastern portion of Mysore district near Gajjala hatti valley and flows northwards through Chamrajasagar and Yelandur taluks. Two streams, viz., Niredurgihalla originating at Attikene estate and Araikaduhalla originating at Dimbum join together near Badibadga to form the river Suvarnavathi or Honhole. This river after flowing for a further distance of 11 km is joined by a tributary, the Chikkahole. After flowing for some more distance about 15 km it is joined by another tributary the Yenehole from left side. The Suvarnavathi river finally joins the Cauvery on its right side at Talakad in the Kollegal taluk. The total length of Suvarnavathi river is about 88 km from its origin to its confluence with the Cauvery. The average bed fall of the river is 6.5 m per kilometer.

The Suvarnavathi sub-basin covers an area of 1787 km^2 in the states of Karnataka and Tamilnadu. It forms 2.2% of the area of the Cauvery basin. The district wise breakup of the catchment area of the sub-basin is given in Table I.6 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.6.

3.2.7 Palar Sub-basin

The Palar river is one of the southern tributaries of the Cauvery. The Palar sub-basin lies between the latitudes 11^0 35' N and 12^0 14' N and longitudes 77^0 10' E and 77^0 50' E.

The Palar rises in the hill ranges of Satyamangalam taluk of Periyar district and flows northwards till it receives a small tributary, namely Moranur Halla from west where river turns perpendicularly to the east and finally joins the Cauvery on right side near the upstream and of Mettur reservoir. The river Palar forms the common boundary between Karnataka and Tamilnadu in Mysore and Periyar districts, respectively, for about 45 km.

The Palar sub-basin comprises, the entire catchments of the Uduthorehalla, the Palar and its tributaries plus the direct catchment of the Cauvery on the right bank, east of the Palar catchment up to Mettur dam. The sub-basin covers an area of 3214 km^2 in the states of Karnataka and Tamilnadu. It forms 4.0% of the Cauvery basin. The district wise breakup of the catchment area of the sub-basin is given in Table I.7 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.7. The line diagram showing the irrigation projects in the sub-basin is shown in Figure 3.3.6.

3.2.8 Chinnar Sub-basin

The Chinnar sub-basin covers the catchment area of the Cauvery basin, on the left bank between the beginning of the common border between Karnataka and Tamilnadu along the Cauvery and Mettur dam, on main Cauvery river. It lies between the latitudes 11^0 45' N to 12^0 45' N and longitudes 77^0 25' E to 78^0 20' E. The sub-basin comprises the catchments of four independent streams, namely Chinnar, Doddahalla, Nagavathi and Thoppaiar, the main among them being the Chinnar. The catchment area of the sub-basin as a whole is 4061 km^2, which constitutes 5% of the total catchment of the Cauvery basin. Most of the sub-basin area lies in Dharmapuri district in Tamilnadu at an elevation ranging from 300 to 900 m. above MSL; only small parts of sub-basin lie in Salem district of Tamilnadu and in Bangalore district of

Karnataka. The district wise breakup of the catchment area of the sub-basin is given in Table I.8 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.8. The line diagram showing the irrigation projects in the sub-basin is shown in Figure 3.3.7.

3.2.9 Bhavani Sub-basin

The Bhavani river is one of the tributaries of river Cauvery in its mid-reach. The Bhavani sub-basin lies between latitudes 10^0 56' 3" N and 11^0 46' 14" N and longitudes 76^0 24' 41" E and 77^0 41' 11" E.

The Bhavani river rises at an altitude of about 2634 m in the Billimala range of Nilgiri hills in the Nilgiris district of Tamilnadu. The river flows in the southeast direction up to Makkaliyur and then in the northeast direction up to confluence of the Moyar tributary with the Bhavani. It then runs in the eastward direction up to its confluence with Cauvery.

The length of the river is about 216 km. The Bhavani sub-basin has a catchment area of 6154 km^2, which constitute 7.58% of the Cauvery basin. The district wise breakup of the catchment area of the sub-basin is given in Table I.9 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.9. The line diagram showing the irrigation projects in the sub-basin is shown in Figure 3.3.8.

3.2.10 Noyil Sub-basin

This sub-basin comprises the catchment of Noyil river, which includes the catchment of its small tributaries, viz., Sanganurpallam, Vannattangarai, Nallar and Chinnakarai. The Noyil sub-basin lies between latitudes 10^0 54' N and 11^0 19' N and longitudes 76^0 39' E and 77^0 56' E. The sub-basin area includes a part of the command area of Lower Bhavani project canal, Kalingarayan channel and Perimbikulam main canal. The Noyil sub-basin is bounded on the north by Bhavani sub-basin, on the south by Amaravathi sub-basin, on the east by Cauvery river and Western Ghats on the west. The river flows entirely in Tamilnadu and the basin is spread over the districts of Coimbatore, Periyar and Tiruchirapalli. It has a catchment of 2999 km^2, which constitutes 3.7% of the Cauvery basin. The district wise breakup of the catchment area of the sub-basin is given in Table I.10 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.10.

3.2.11 Amaravathi Sub-basin

The Amaravathi sub-basin lies between latitudes 10^0 6' N and 11^0 2' N and longitudes 77^0 3' E and 78^0 6' E and is bounded by Noyil sub-basin in the north, Vaigai basin in south, the southern part of the Western Ghat in the west and the Cauvery river in the east. Except that part of the upper hilly catchment of the sub-basin, which lies in Kerala, the rest of the sub-basin is spread over Tamilnadu.

The river Amaravathi is one among the main tributaries of the river Cauvery in its mid reach. It is the right bank tributary next to Noyil, downstream of Mettur dam in Tamilnadu. Rising from Naimakad at an elevation of 2300 m in the Southern Ghat (Annamalai) in Devikulam taluk of Iddukki district of Kerala State, named as Pampar, flows northeastwards. A number of streams join the river in Kerala before its entry into Tamilnadu. Amaravathi river flows in the same direction in Tamilnadu till its confluence with the river Cauvery on the right bank. Throughout its course of 256 km, the Amaravathi receives a number of small streams. It has a catchment area of 8280 km^2 which constitutes 10.2% of the Cauvery basin. The district wise breakup of the catchment area of the sub-basin is given in Table I.11 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.11.

3.2.12 Tirumanimuttar Sub-basin

Tirumanimuttar sub-basin comprises the catchment of Cauvery river below Mettur dam on both sides up to Upper Anicut including the sub-catchment of Sarabhanga Nadi, Tirumanimuttar, Pungar and Ayyar, but excluding the catchments of Bhavani, Noyil and Amaravathi rivers.

The Tirumanimuttar sub-basin lies between latitudes 10^0 36' N and 11^0 55' N and 77^0 27" E and 78^0 41' E.

Leaving the Mettur dam, the river Cauvery enters the Tirumanimuttar sub-basin and flows in the southwestern direction along the boundary of Tiruchengode and Bhavani taluka. It receives a small tributary, Chittar river on its right and then the Sarabhanga Nadhi near Kaveripatti on its left. After receiving the Bhavani river on the right at Bhavani opposite to Kumarapalaiyamit, sharply turns south-eastwards and flows along the boundary of the Tiruchengode taluk with the Erode taluk. After Sedarpalaiyam bed regulator, it receives the Kurangupallam stream, a small tributary of main Cauvery and then the Noyil river on its right. By changing its course in the easterly direction for a short distance, again it continues to flow southeastwards upto the Cattalo bed regulator. In this part of its course, it receives the Tirumanimuttar in Namakkal taluk near Velur on its left and the Amaravathi in Karur taluk on its right. The river then continues to flow in the same direction and leaves this sub-basin at Upper anicut. Below Kattalai head regulator, it receives the Pungar on its right near Kulittalai and the Ayyar river on its left near Upper anicut. Throughout its course of about 185 km length from Mettur to Upper anicut, the river Cauvery receives a number of small streams.

The Tirumanimuttar sub-basin has a catchment area of 8429 Km^2, which constitutes 10.39% of the total catchment of Cauvery basin. The sub-basin lies mostly in Salem and Tiruchirapalli districts with only small parts in Periyar and Dindigul Anna districts of Tamilnadu. The district wise breakup of the catchment area of the sub-basin is given in Table I.12 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.12.

3.1.13 Ponnanai Ar Sub-basin

The Ponnanai Ar sub-basin comprises the catchment of the Ponnanai Ar and its tributary on the right side of the river Cauvery between Upper Anicut and Grand Anicut.

The sub-basin area includes the catchment of the Kodingal Ar which also joins river Cauvery along with the Ponnanai Ar (Kodamuruttri-Ar) upstream of Tiruchirapalli town. The sub-basin also covers a part of the command area of Kattalai canal scheme and New Kattalai high-level canal scheme.

The Ponnanai Ar sub-basin is bounded on the north by Upper Coleroon sub-basin, on the west by Tirumanimuttar sub-basin, on east by Cauvery Delta and on the south by the basin covering the area between the Cauvery and Vaigai river basins. The sub-basin lies between North latitudes 10^0 25' 50" and 10^0 53' 25" and East longitudes 78^0 08' 00" and 78^0 50' 00".

The Ponnanai Ar has its origin in the scattered hills near Kadavur in Kulittalai taluk of Tiruchirapalli district and flows in a northeast direction through Kultittala, Manapparai and Tiruchirappali taluks. It empties into the Cauvery river just above Tiruchirapalli town. Along the course of its travel, it receives the Kuraray River on its right near its confluence with Cauvery. The river Ponnanai Ar is also known as Ariyar in the middle reach and Kodamurutti Ar in the lower reach.

The Ponnanai Ar sub-basin has a catchment area of 2050 km^2, which constitutes 2.53% of the total catchment area of the Cauvery basin. The sub-basin lies mostly in Tiruchirapalli and Pudukkottai districts with only small parts in Madurai and Thanjavur districts of Tamilnadu. The district wise breakup of the catchment area of the sub-basin is given in Table I.13 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.13.

3.2.14 Upper Coleroon Sub-basin

The Upper Coleroon sub-basin covers the direct catchment of the Coleroon river, between the Upper Anicut. It lies between the latitudes 10^0 50' N and 11^0 15' N and longitudes 78^0 35' E and 79^0 27' E. The sub-basin also comprises the catchment of a few independent streams such as Upper, Marudaiyar, Nandiyar, Nari Odai, Andi Odai etc. The catchment area of the sub-basin as a whole is 8082 km^2, which constitutes 3.8% of the total catchment of the Cauvery basin. Most of the sub-basin area lies in Tiruchirapalli district and a small part of sub-basin lies in Thanjavur district of Tamilnadu. The district wise breakup of the catchment area of the sub-basin is given in Table I.14 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.14.

3.2.15 Lower Coleroon Sub-basin

The Lower Coleroon sub-basin with a catchment area of 1378 km^2 covers the catchment of the Coleroon river below the lower Coleroon Anicut and extends up to its confluence with the sea. This sub-basin includes the ayacut of the Lower Coleroon Anicut system as well as the catchment of the Veeranam tank situated in the north side of the Coleroon river and its ayacut area. This sub-basin area lies entirely in Tamilnadu state between latitudes 11^0 08' N and 11^0 25' and longitudes 79^0 13' E and 79^0 48' E. The area of this sub-basin constitutes 1.7% of the total catchment of the Cauvery basin. Most of the sub-basin area lies in South Arcot and Tiruchchirappalli districts and a small part of the sub-basin lies in Thanjavur district. The district wise breakup of the catchment area of the sub-basin is given in Table I.15 in Appendix-I. The irrigation projects in the sub-basin are shown in Figure 3.2.15.

3.2.16 Cauvery Delta Sub-basin

The Cauvery delta sub-basin comprises the command area of the Vennar branch, Cauvery branch and part of the Grand Anicut canal irrigation system. The sub-basin also covers a part of the command area of Kattalai canal scheme and New Kattalai high-level canal scheme.

Upper Coleroon and Lower Coleroon bound the Cauvery Delta sub-basin on the north, on the west by Tirumanimuttar sub-basin and Ponnanai Ar Sub-basin, on the south by Palk Strait and the basin area covered by the streams between Cauvery and Vaigai and on the east by the Bay of Bengal. The sub-basin lies between North Latitudes 10^0 17' and 11^0 22' and East Longitudes 78^0 48' and 79^0 53'.

The Cauvery at Grand Anicut (Upper end of Cauvery Delta sub-basin) sub-divides itself into two main branches, viz., Cauvery and Vennar System which get further sub-divided into 36 rivers to feet the delta through a network of main channels and numerous branches, distributaries and sub-distributaries.

The Cauvery delta sub-basin covers a catchment area of 6566 km^2, which constitutes 8.09% of the total catchment of the Cauvery basin. The sub-basin lies mostly in Thanjavur and Nagappattinam Quaid-E-Millad districts with small parts in Tiruchchirappalli and Pudukkottai districts of Tamilnadu and entire Karaikal area of

Pondicherry state. The district wise breakup of the catchment area of the sub-basin is given in Table I.16 in Appendix-I.

The principal features of the irrigation projects in the Cauvery basin are given in Table 3.3. The irrigation projects in the sub-basin are shown in Figure 3.2.16.

3.3 CROPPING PATTERN AND LAND USE COEFFICIENTS

The cropping pattern adopted in the present study, and the cropping pattern used in preliminary water balance studies for the sixteen sub-basins of Cauvery basin is the same as adopted by NWDA. The crop calendar as defined by the time period from preparation and planting the crops up to harvesting the crop was also adopted as per the NWDA reports. The land use coefficients for sixteen sub-basins in Cauvery river basin are computed and presented in Tables 3.4.1(a) to 3.4.16(a).

3.4 CROP WATER REQUIREMENT

The crop water requirement is defined as "The depth of water needed to meet the water loss through evapotranspiration of a disease free crop, growing in large field, under non restricting soil conditions including soil water and fertility and achieving full production potential under given growing environment". The assessment of water requirement for various crops is an important factor in choice of crops and one of the basic necessities for crop planning in a command area. The monthwise crop water requirements at reservoir level are obtained from the various reports of NWDA for various sub-basins in Cauvery river basin and are presented in Tables 3.4.1(b) to 3.4.16(b).

3.5 CLIMATES, RAINFALL AND STREAM FLOW

The catchment area of Cauvery basin experiences tropical climate. The maximum and minimum temperatures, observed are 44^{0}C and 18^{0}C respectively. The basin experiences four distinct seasons. They are:

(i)	South west monsoon	-	June to September
(ii)	North east monsoon	-	October to December
(iii)	Cool, dry weather (winter)	-	January to February
(iv)	Hot, dry weather	-	March to May

Maximum rainfall is received along the western border of the basin from the southwest monsoon. Eastern side of the basin gets most of the rain during the northeast monsoon. Depressions in the Bay of Bengal affect the basin in the monsoon causing cyclones and widespread heavy rains. There are 352 raingauge stations in and around the basin. There are 11 Indian Metrological Department (IMD) observatories situated within the basin. The maximum and minimum temperatures, relative humidity, wind velocity, sunshine, and evapotranspiration (Eto) data is computed and published by IMD titled "Potential Evapotranspiration (PE) over India (Scientific report No. 136, 1971) for different IMD observatories. The normal rainfall in the Cauvery basin varies from sub-basin to sub-basin as shown in Table 3.1. The monthly-observed stream flow data in the Cauvery river basin for all the 16 sub-basins are collected from various reports of NWDA, and is presented in Table 3.5.

3.6 THE GROUND WATER POTENTIAL

The data required for computation of the sub-basinwise ground water potential available in the Cauvery river basin was collected from Central Ground Water Board Faridabad, under the Ministry of Water Resources, Government of India, from the publication Ground Water Resources of India are (1995). The districtwise ground water resources available in the Cauvery river basin are given in the publication. The ground water potential available in each sub-basin is computed in the proportion of the districtwise area lying in the sub-basins. The summation of sub-basinwise ground water of all the 16 sub-basin gives the total ground water potential available in the Cauvery river basin.

The sub-basinwise ground water potential is presented in Tables 3.6(a) to 3.6(d).

3.7 CAUVERY WATER DISPUTES

The important features of the order of the Cauvery Water Disputes Tribunal are presented below:

The state of Tamilnadu filed a civil miscellaneous petition before Cauvery water disputes Tribunal praying that the state of Karnataka be directed not to impound or utilize water of Cauvery river beyond the extent impounded or used by them as on 31.5.1972, as agreed to by the Chief Ministers of Cauvery basin states and the Union Minister for Irrigation and Power. It further seeks passing of an order restraining the state of Karnataka from undertaking any new projects, dams, reservoirs, canals etc. and/or from proceeding further with the construction of projects, dams, reservoirs, canals etc. in the Cauvery basin. Another C.M.P. was subsequently filed by the state of Tamilnadu as an emergent petition to direct as an emergent measure, the state of Karnataka to release at least 20 T.M.C. of water as a first installment as the Samba crop cannot be maintained without additional supplies from Mettur reservoir.

During the year 1892, an agreement had made between the then Princely state of Mysore and the state of Madras regarding irrigation reservoirs over thirteen major rivers flowing through the then state of Mysore including the Cauvery and its five Tributaries, viz., Hemavathi, Laxman Thirtha, Kabini, Suvarnavathi and Yagachi. Another agreement had been made between the state of Mysore and the state of Madras governments during 1924 under which Mysore government became entitled to construct a dam and a reservoir across and over the river Cauvery at Kanambadi, now known as Krishnarajasagar, according to the stipulated specifications. Mysore Government was at liberty to carry out future extensions of irrigation in Mysore under the Cauvery and its tributaries to an extent fixed at 1,10,000 acres in addition to the area of irrigation fixed under the Rules and Regulations. The Madras Government was at liberty to construct on the Bhavani, Amaravathi or Noyil rivers in Madras any new storage reservoir. The agreement also provided that the limitations and arrangements shall be open to reconsideration at the expiry of fifty years from the execution of the agreement. Before expiry of the above period, the Central Government constituted a fact-finding committee to collect all the connected data pertaining to Cauvery water and it had submitted its reports. But no final agreement was arrived at between the states regarding the allocation of waters for the respective states.

The Union Territory of Pondicherry sought an interim order from the Tribunal directing the states of Karnataka and Tamilnadu to release the water already agreed to, that is, 9.355 T.M.C. during the months from September to March.

Undisputedly, Cauvery river is an inter-state river. Therefore, the three states of Kerala, Tamilnadu and the Union Territory of Pondicherry being riparian to the said river are entitled to the release of water of Cauvery river in a reasonable and beneficial manner. In the "Law of International Drainage Basins" edited by A.H.Garreston, R.D.Hayton and C.J.Olmstead, at page 63 it has been pointed out that the equality of right does not give a co-riparian the right to an equal division of water. Rather, equality of right is the equal right of each co-riparian state to a division of water on the basis of its economic and social needs, consistent with the corresponding rights of its co-riparian states, and excluding from consideration factors unrelated to such needs.

The Tribunal made it clear that it will not be appropriate to fix the inflow of water into Mettur dam on the basis of the figures at the time of recording of consensus arrived at the meeting of Chief Ministers of the state of the then Mysore, Tamilnadu and Kerala in the presence of Union Minister of Irrigation and Power, held on 29th May 1972 since more than eighteen years had elapsed as on 1990 and various subsequent events also, including construction of additional dams and reservoirs and other irrigation facilities have taken place. Hence, the Tribunal considered it justifiable to fix the annual releases into Mettur dam by making average of the same for a number of normal years in the immediate past. Besides releases from Krishnarajasagar and Kabini dams of Karnataka, some water from the intermediate catchment area also flows down into Mettur dam. But, the Tribunal decided to fix the releases of water by Karnataka by having regard to the realization made over a span or years in the proximate past after excluding abnormally good and abnormally bad years.

Tamilnadu had furnished before Cauvery Tribunal the following figures for the period of ten years, i.e., 1980-81 to 1989-90 of inflow of water into Mettur dam, as given below:

Year	Inflow to Mettur (TMC)
1980-81	394.01
1981-82	403.20
1982-83	173.20
1983-84	230.37
1984-85	284.36
1985-86	158.28
1986-87	187.36
1987-88	103.90
1988-89	181.37
1989-90	175.64

In considering the above figures, Cauvery Tribunal decided to exclude the figures for the years, 1980-81 and 1981-82, which were described by parties as abnormally good years. Cauvery Tribunal also excluded from consideration the figures for the years 1985-86, 1987-88, which were classified to be bad years. The average flow of the remaining six years work out at 205.3 TMC, which was rounded of to 205 TMC.

Karaikal region of Union Territory of Pondicherry at the tail end of Cauvery delta suffered because of utter dearth of water. The Union Territory of Pondicherry had claimed before Cauvery Tribunal 9.355 TMC of water towards irrigation and water supply etc. Cauvery Tribunal directed to release 6 TMC of water by Tamilnadu for Union Territory of Pondicherry.

The grievance of Tamilnadu broadly was that not only the total volume of water from Karnataka for flowing down to Mettur dam was becoming less and less, but also the said releases were not being made timely to meet the needs of cultivation of crops, particularly in Cauvery delta of Tamilnadu. Cauvery Tribunal felt it fair to direct that annual releases be made in a regulated manner from week to week basis from June to May.

The State of Kerala had not applied for any interim order. Hence, the order of Cauvery Tribunal is without prejudice to the claims and contentions of the state of Kerala about the equitable distribution and release of water of river Cauvery and its tributaries.

Cauvery Tribunal directed the state of Karnataka to releases water from its reservoirs in Karnataka so as to ensure that 205 TMC of water is available in Tamilnadu's Mettur reservoir in a year from June to May with effect from 1st of July

1991. The Tribunal also directed that the state of Karnataka should regulate the releases of water in the following manner:

Month	Releases from Mettur (TMC)
Jun	10.16
Jul	42.76
Aug	54.72
Sep	29.36
Oct	30.17
Nov	16.05
Dec	10.37
Jan	2.51
Feb	2.17
Mar	2.40
Apr	2.32
May	2.01
	205.00 [5800 MCM]

In respect of a particular month, releases are to be made in four weeks in four equal instalments. If in a particular week, it is not possible to release the required quantum of water, the said deficit shall be made good in the subsequent week. An amount of 6 TMC of water for Karaikal region of the Union Territory of Pondicherry will be delivered by the state of Tamilnadu in a regulated manner.

Cauvery Tribunal also directed the state of Karnataka not to increase its area under irrigation by water of river Cauvery beyond existing 11.2 lakh acres.

The above order of the Tribunal will remain operative till the final adjudication of the dispute, referred to the Tribunal.

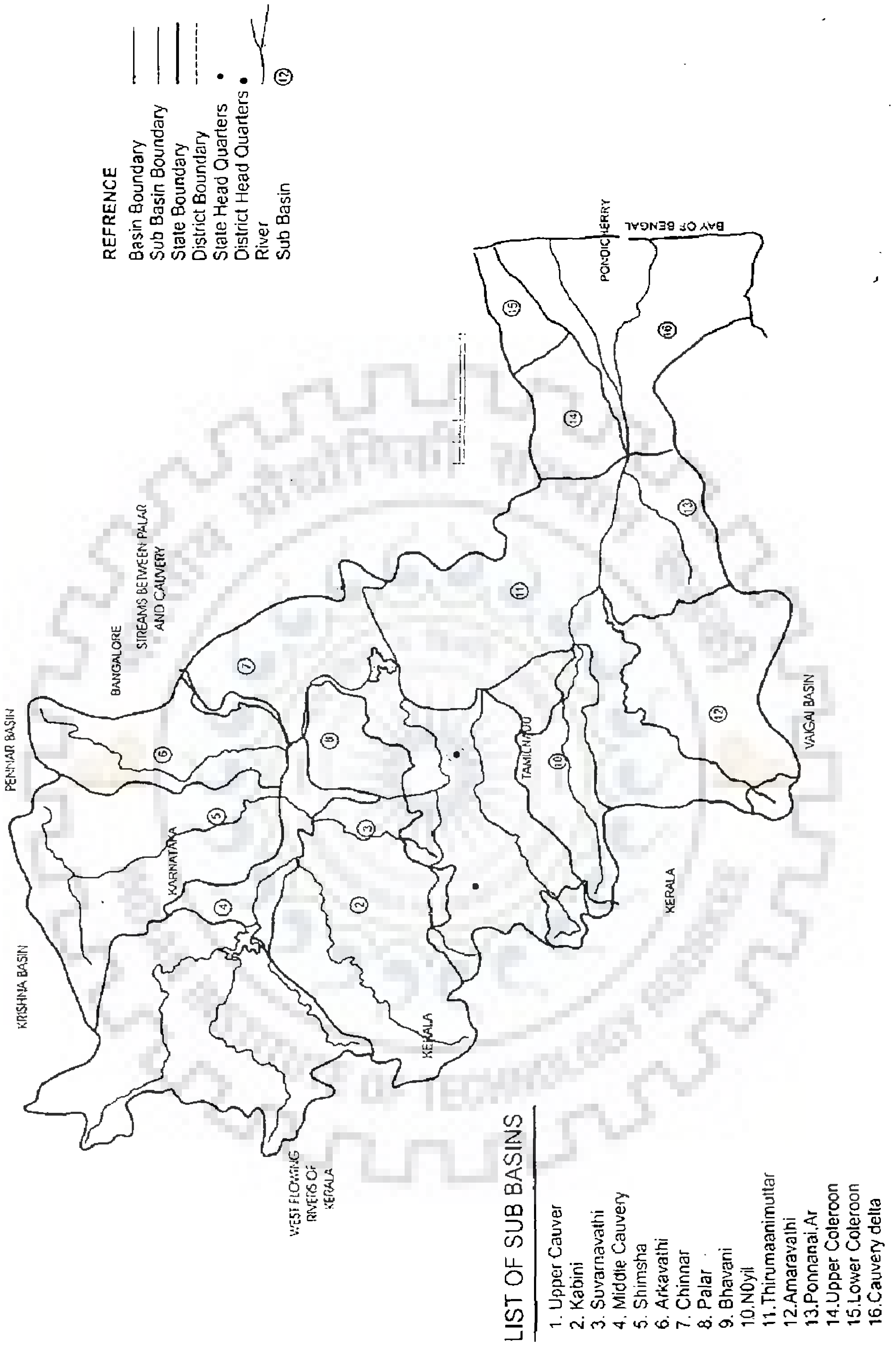

Figure 3.1.1: Map of Different Sub-basins in Cauvery River-basin

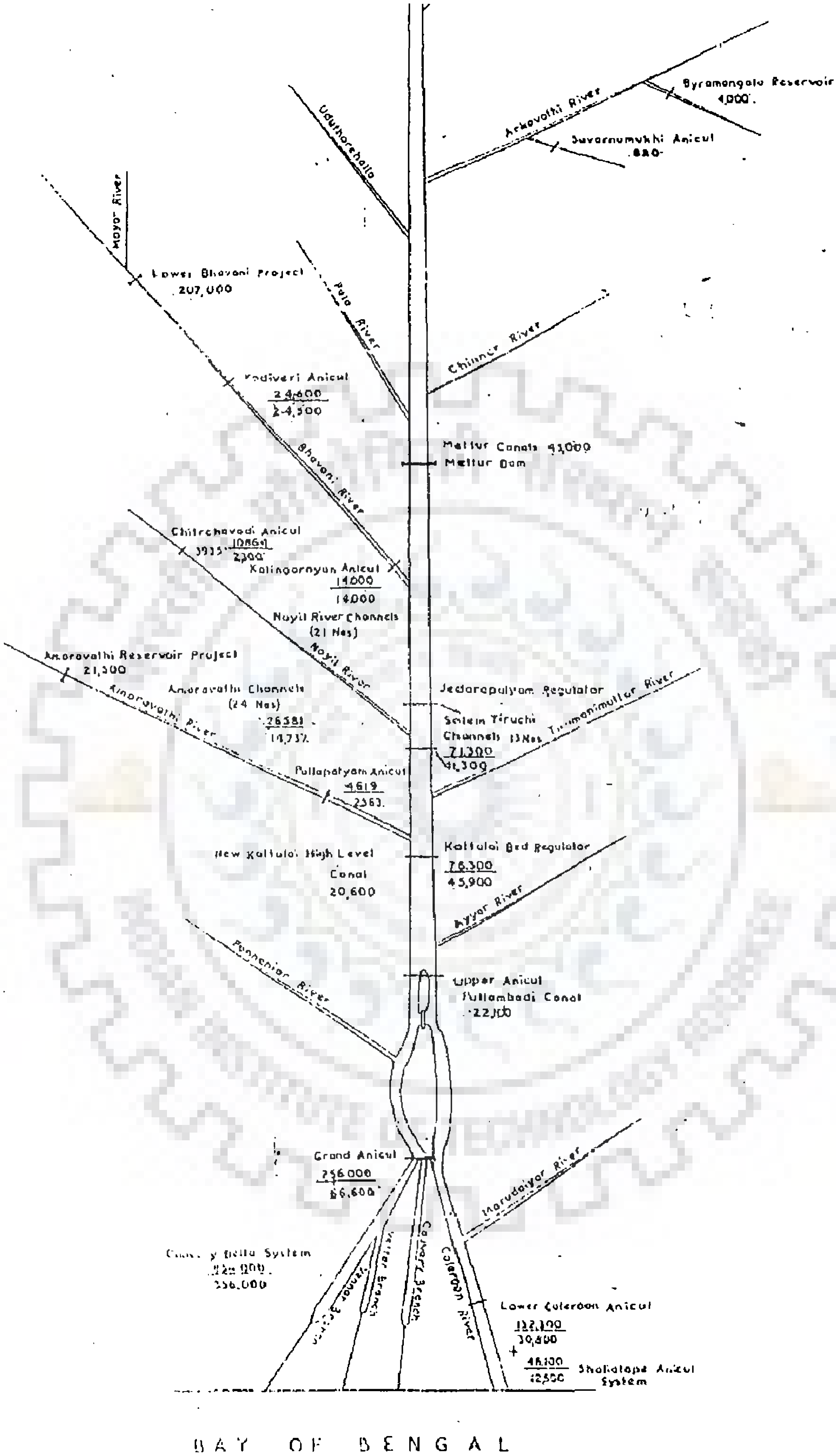

Figure 3.1.2 (a) : Tributaries of Cauvery River-basin

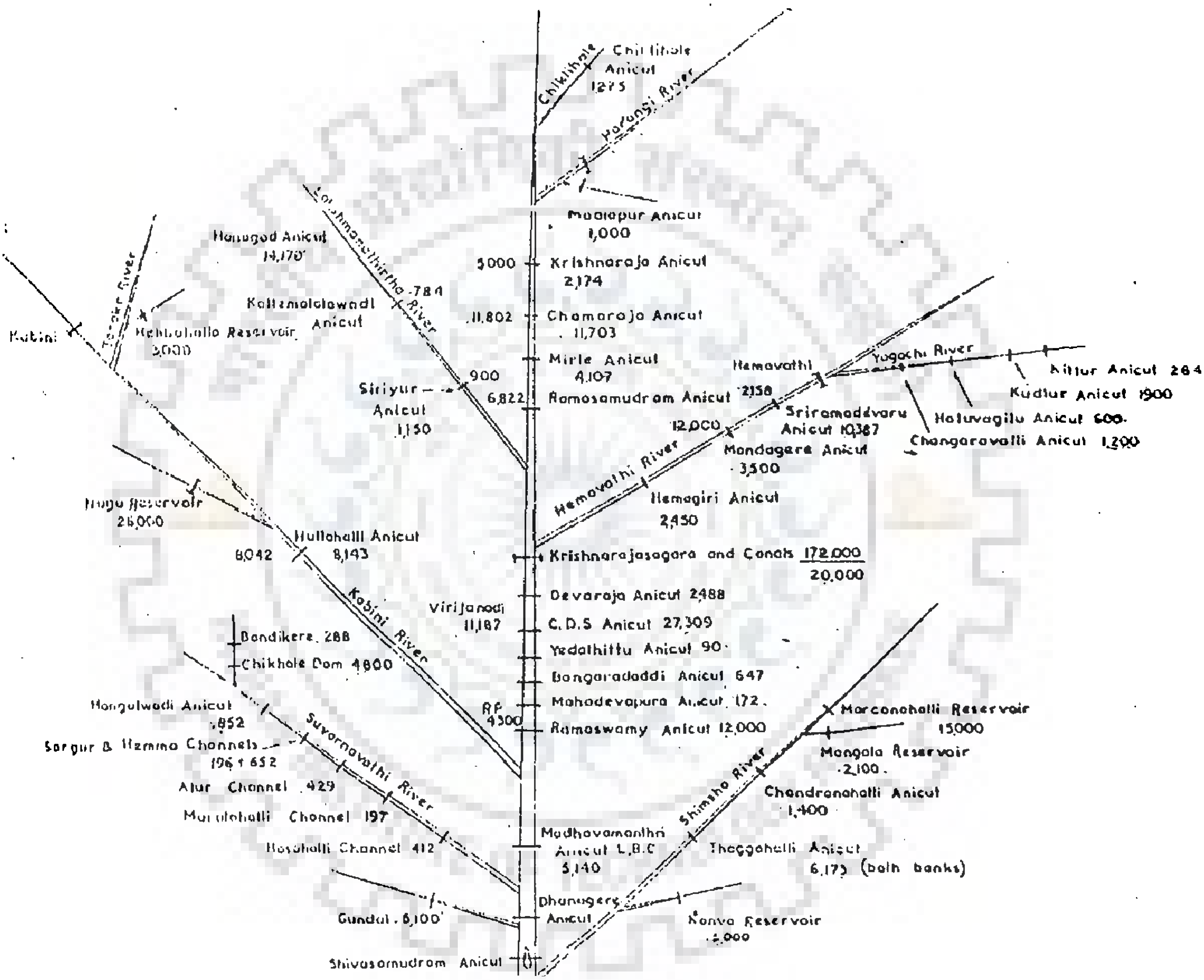

Figure 3.1.2 (b) : Tributaries of Cauvery River-basin

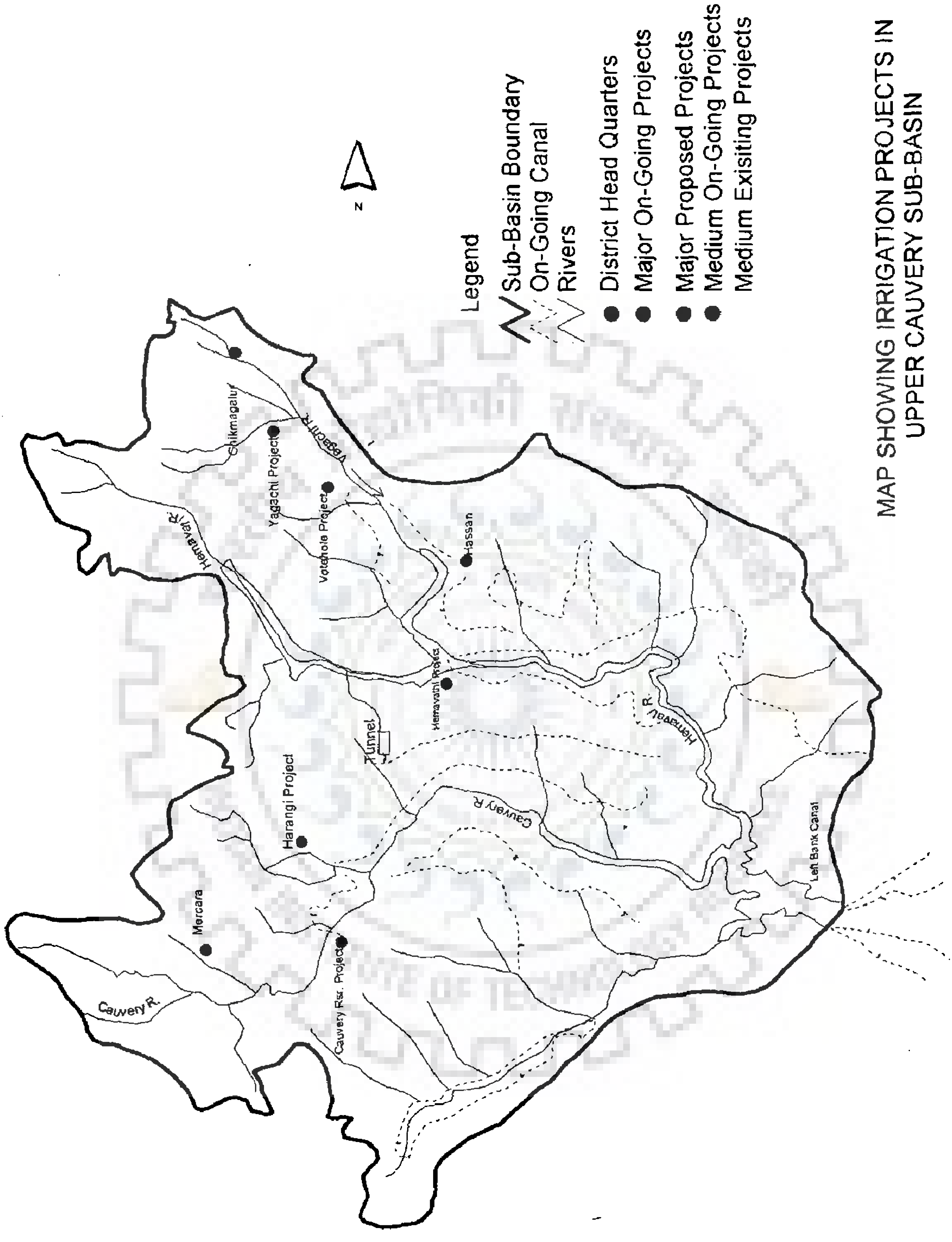

Figure 3.2.1: Map Showing Irrigation Projects in Upper Cauvery Sub-basin

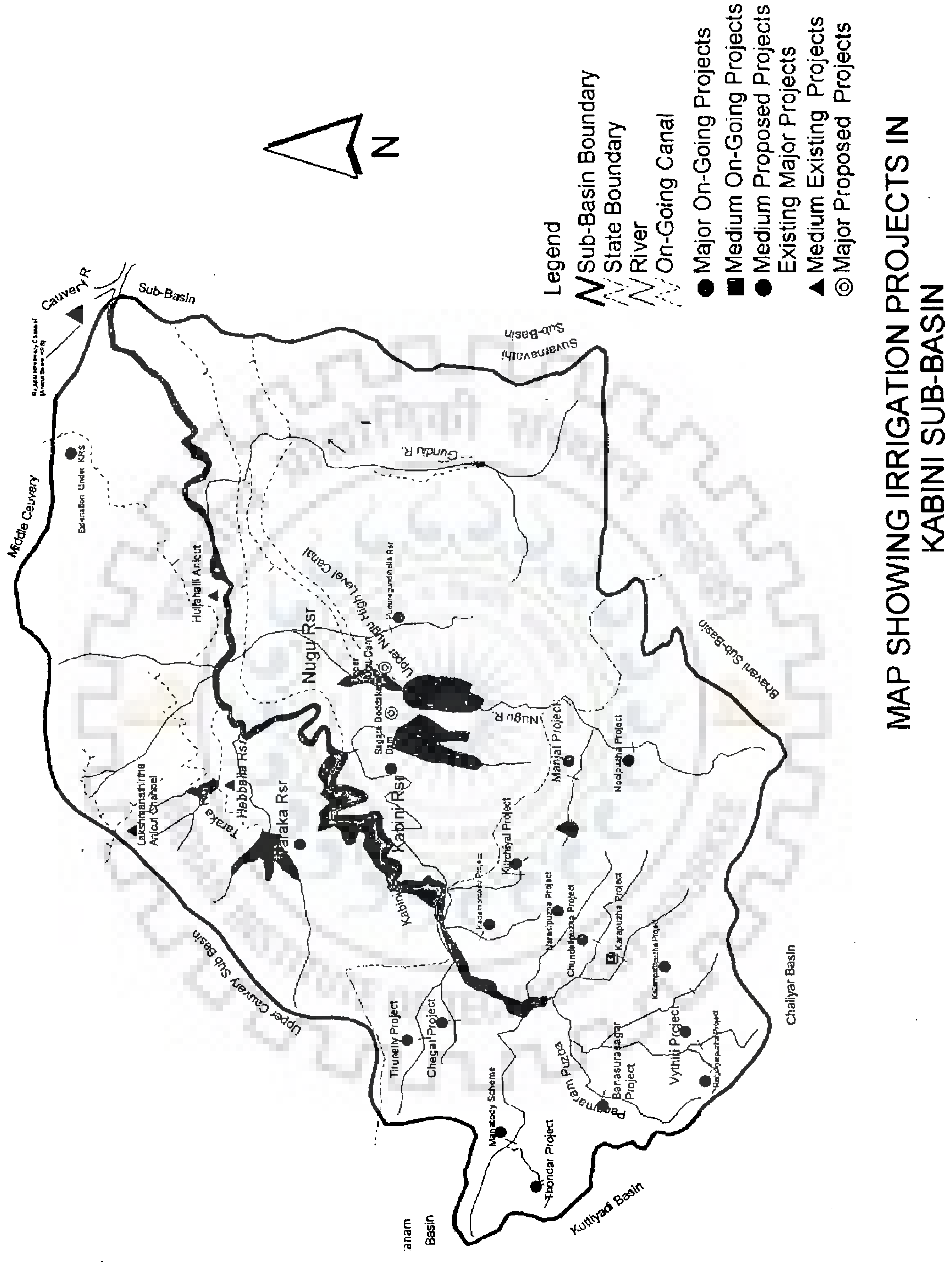

Figure 3.2.2: Map Showing Irrigation Projects in Kabini Sub-basin

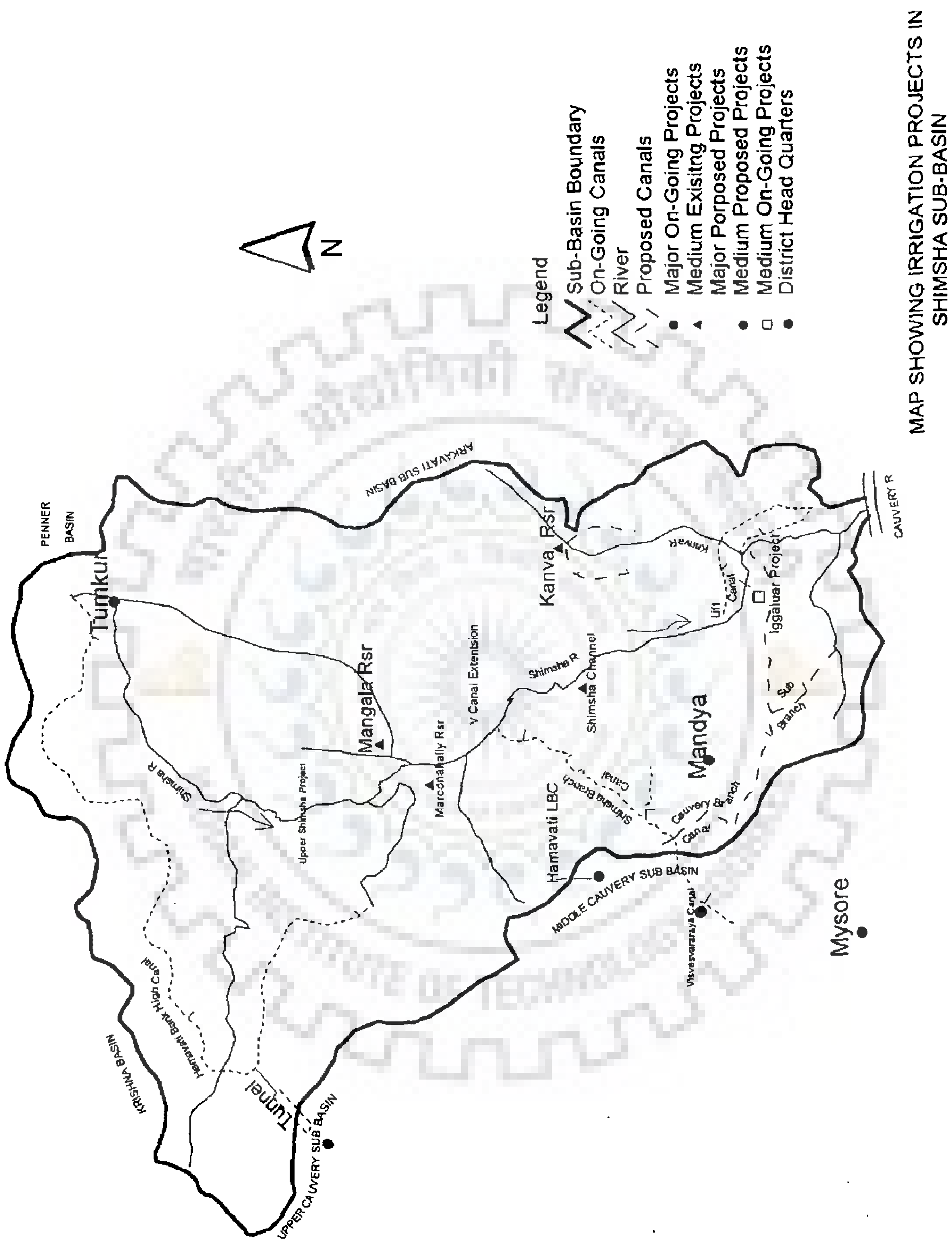

Figure 3.2.3: Map Showing Irrigation Projects in Shimsha Sub-basin

Figure 3.2.4: Map Showing Irrigation Projects in Arkavathi Sub-basin

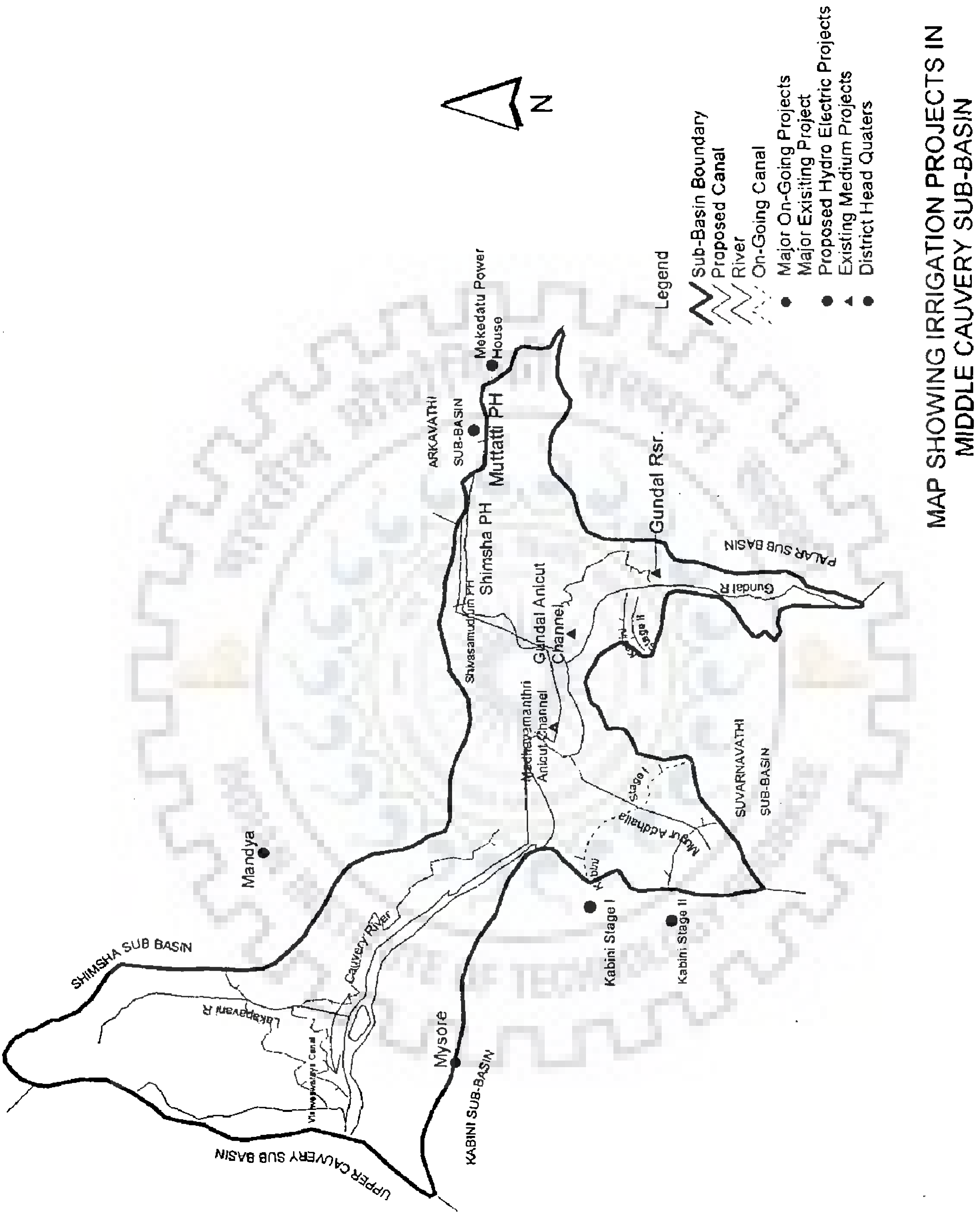

Figure 3.2.5: Map Showing Irrigation Projects in Middle Cauvery Sub-basin

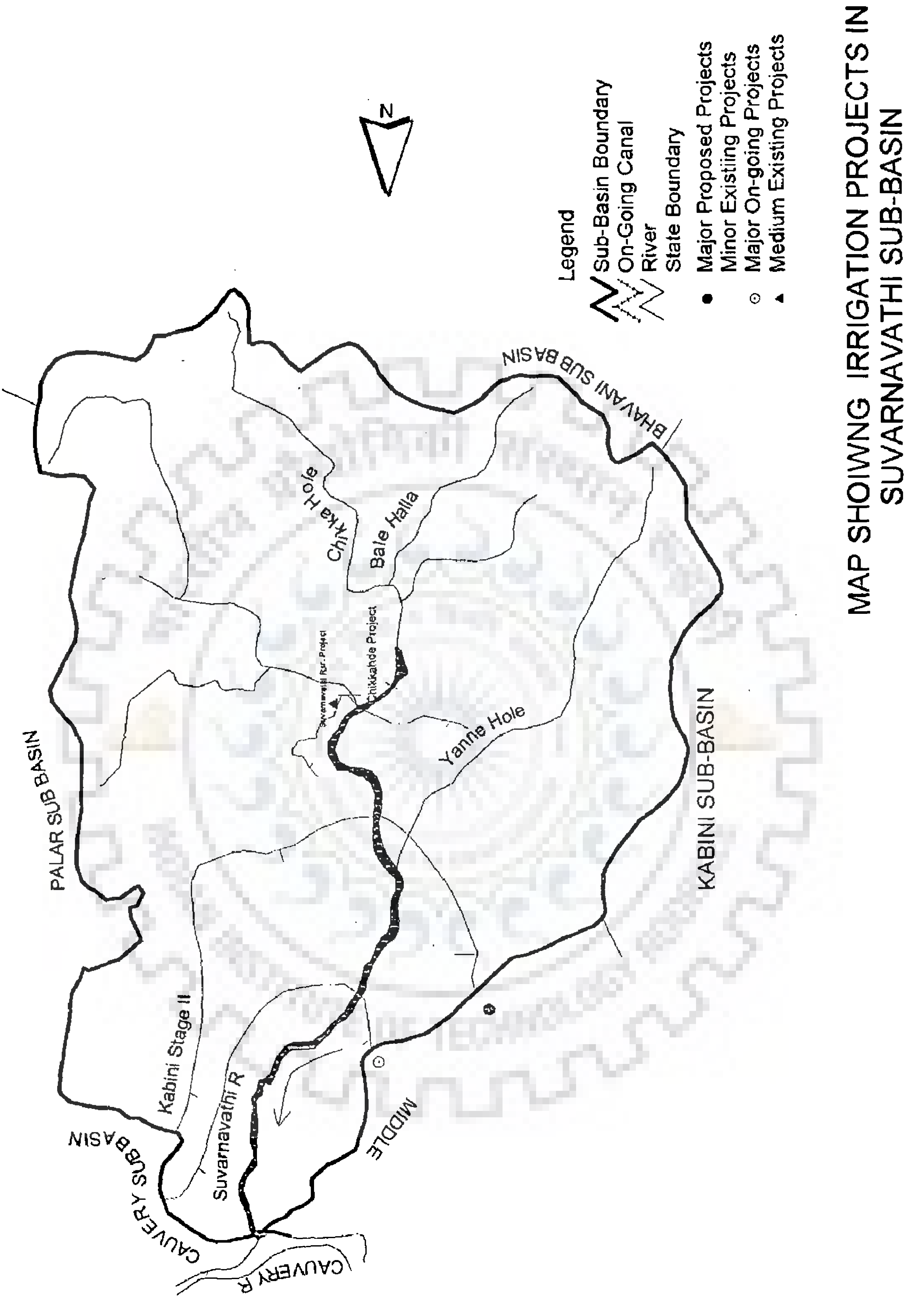

Figure 3.2.6: Map Showing Irrigation Projects in Suvarnavathi Sub-basin

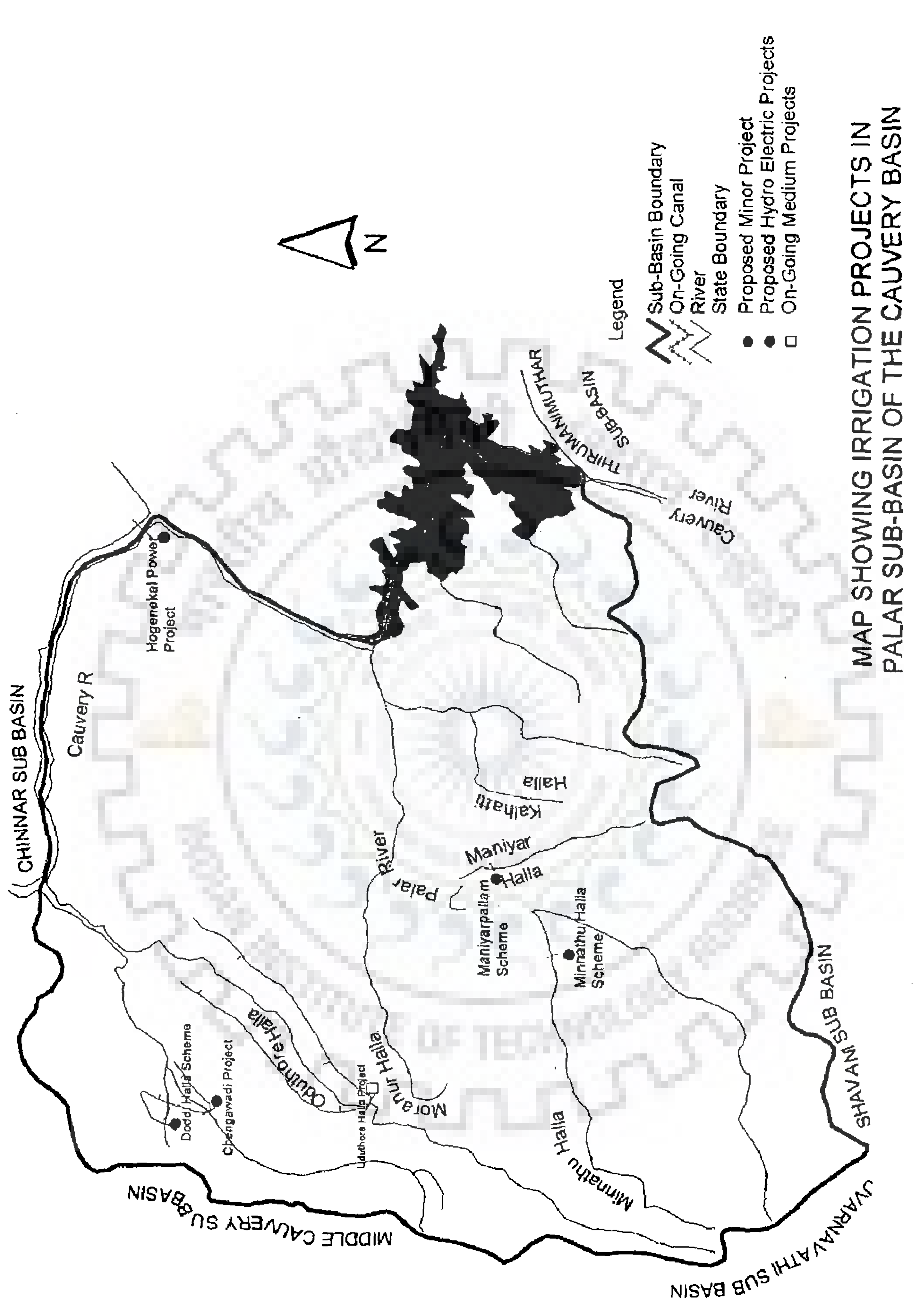

Figure 3.2.7: Map Showing Irrigation Projects in Palar Sub-basin

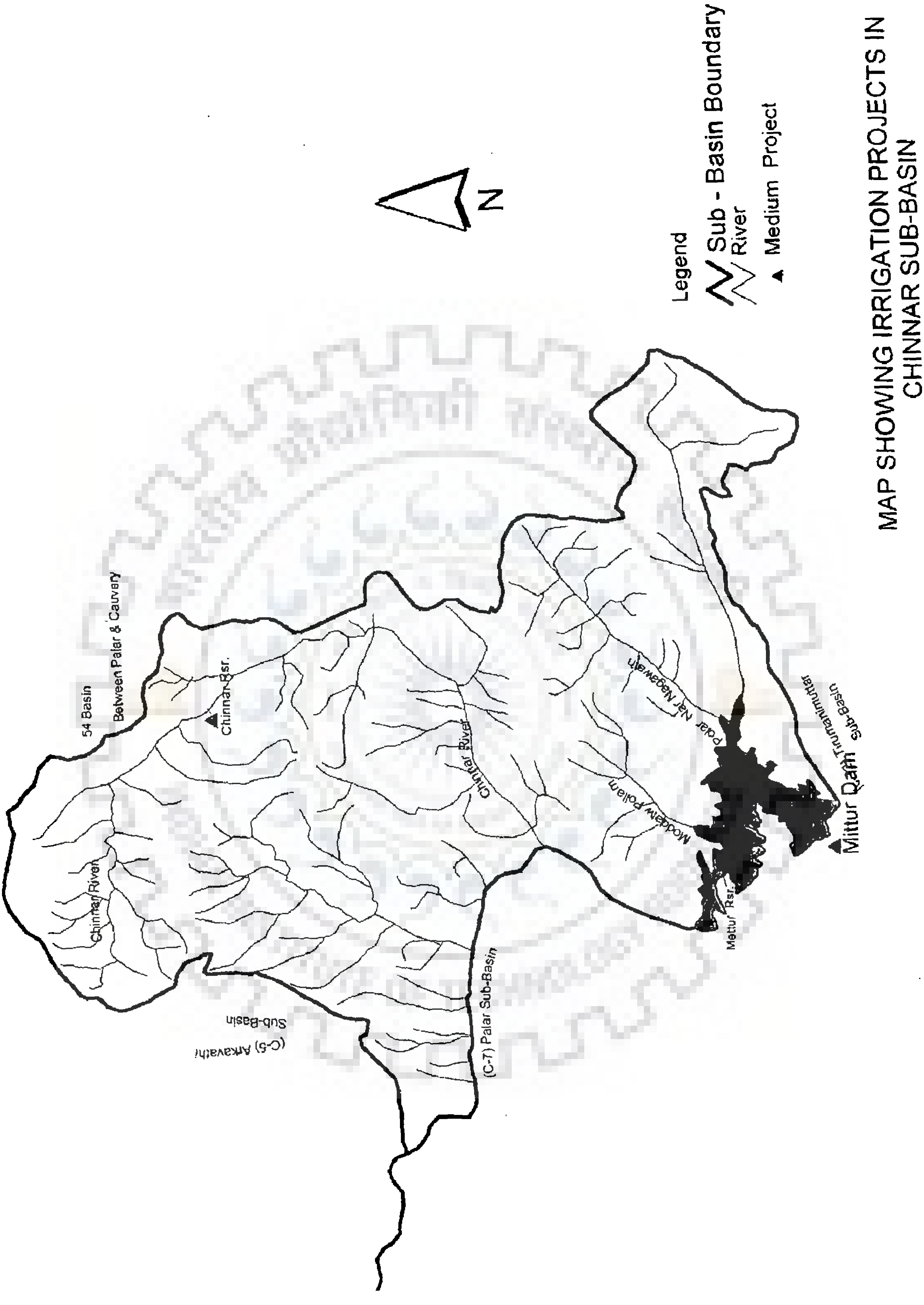

Figure 3.2.8: Map Showing Irrigation Projects in Chinnar Sub-basin

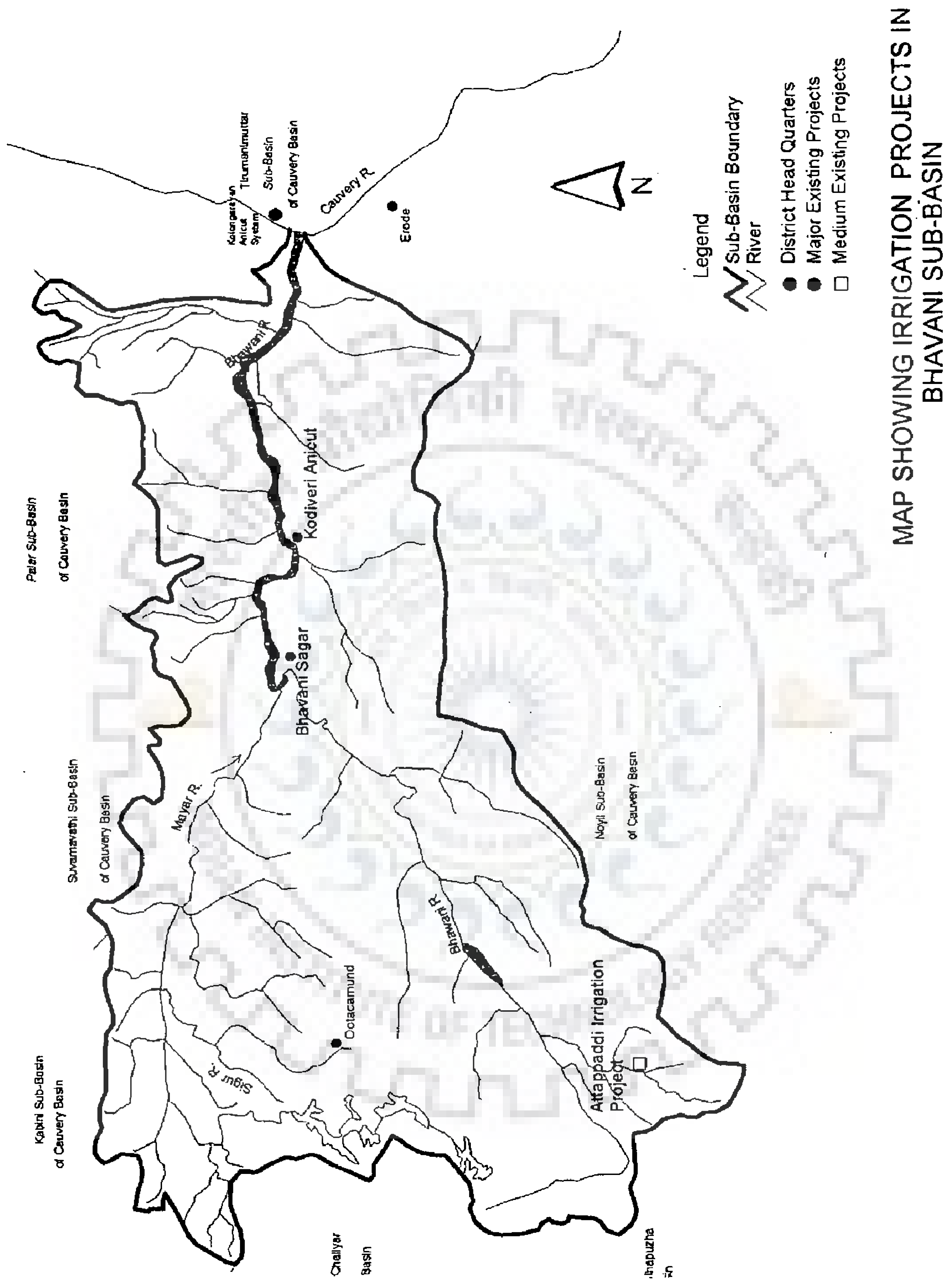

Figure 3.2.9 : Map Showing Irrigation Projects in Bhavani Sub-basin

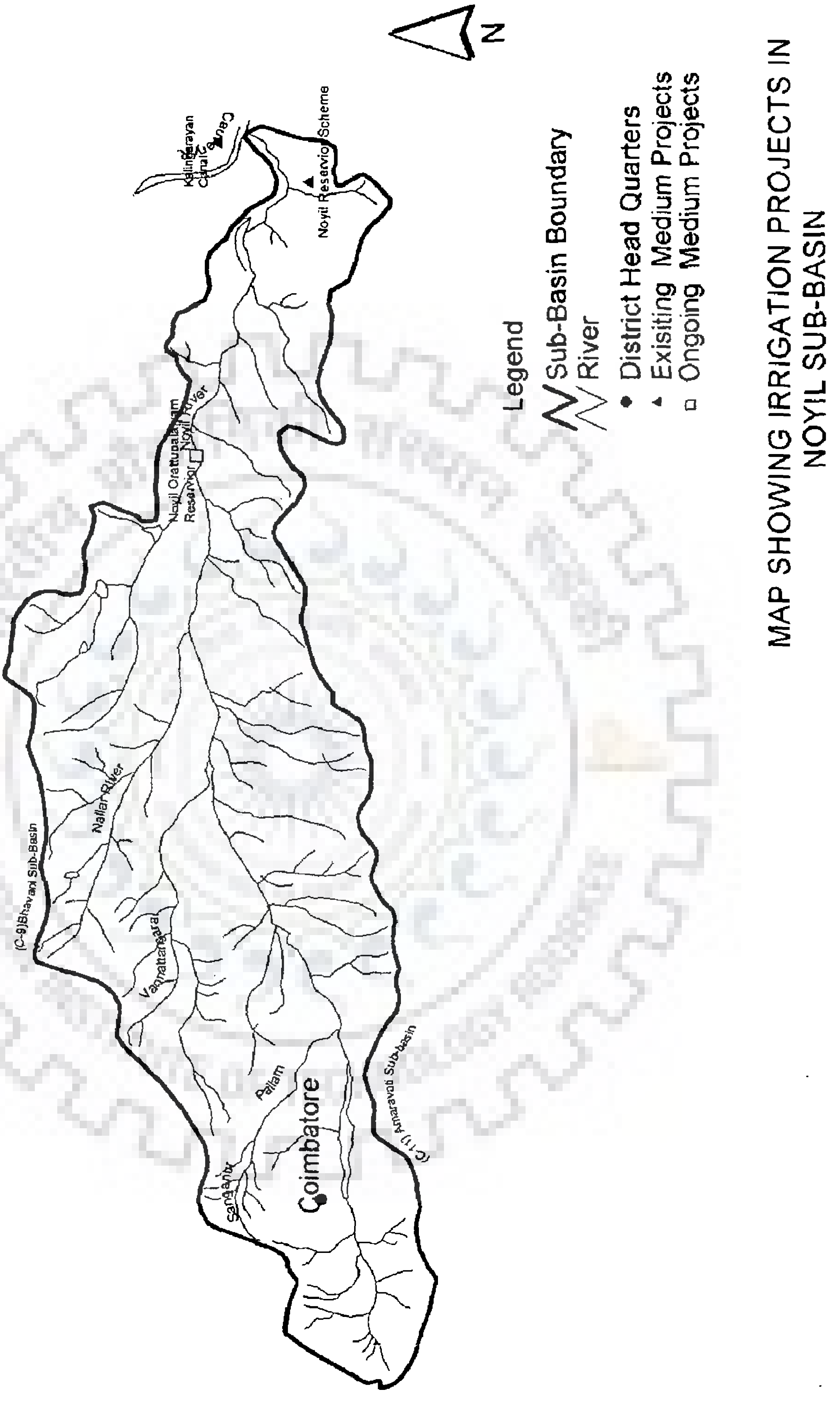

Figure 3.2.10: Map Showing Irrigation Projects in Noyil Sub-basin

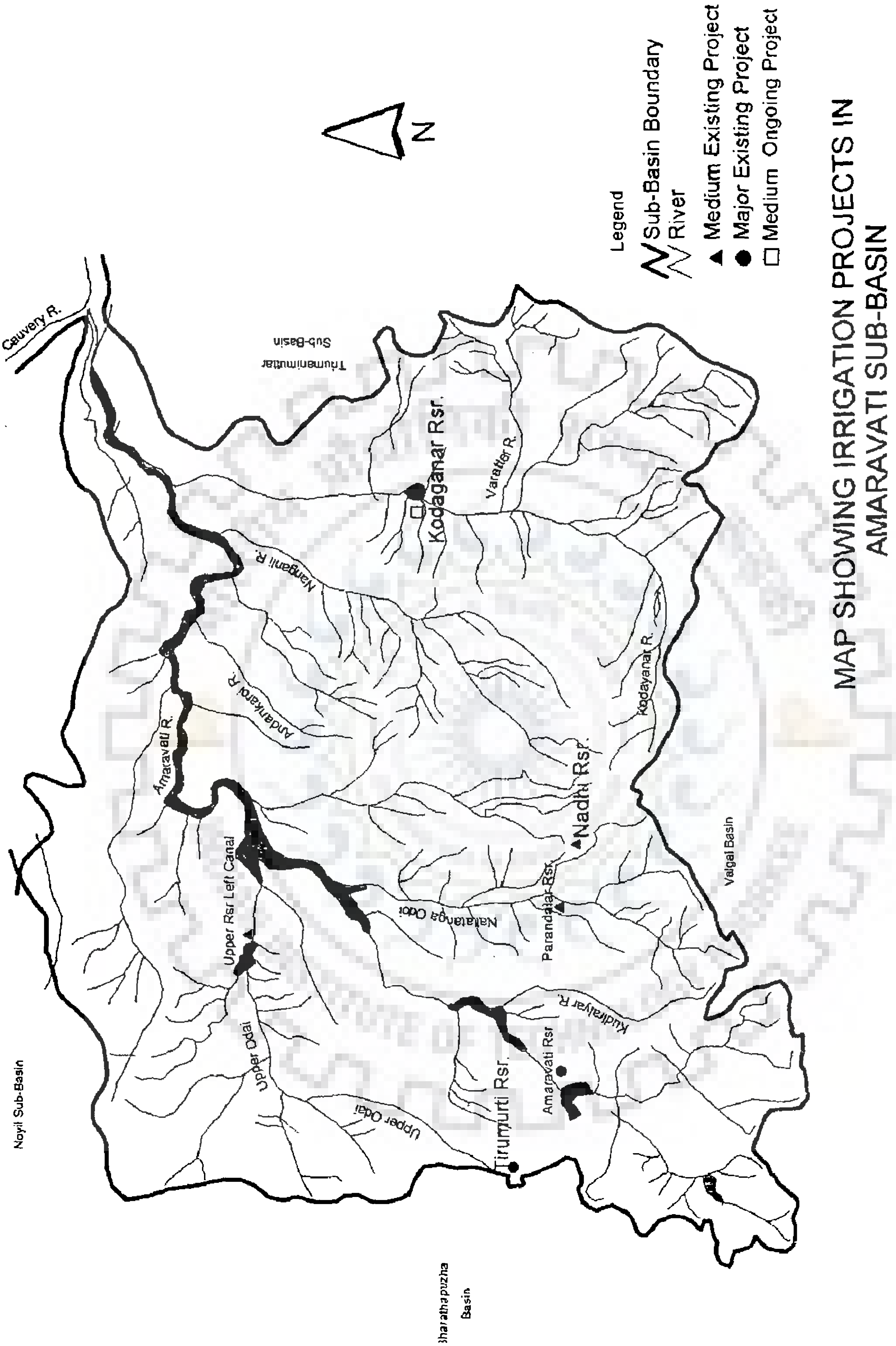

Figure 3.2.11: Map Showing Irrigation Projects in Amaravathi Sub-basin

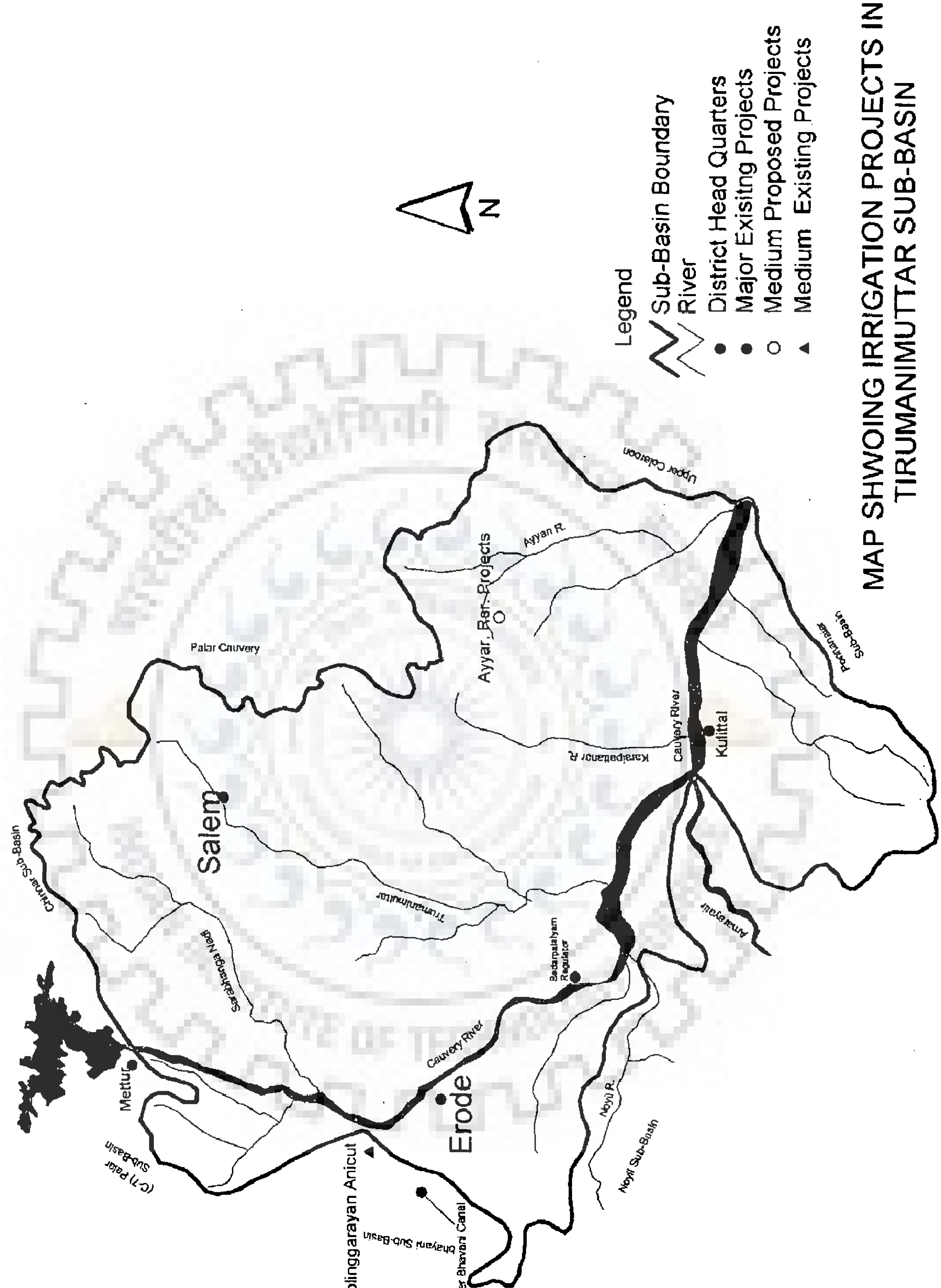

Figure 3.2.12: Map Showing Irrigation Projects in Tirumanimuttar Sub-basin

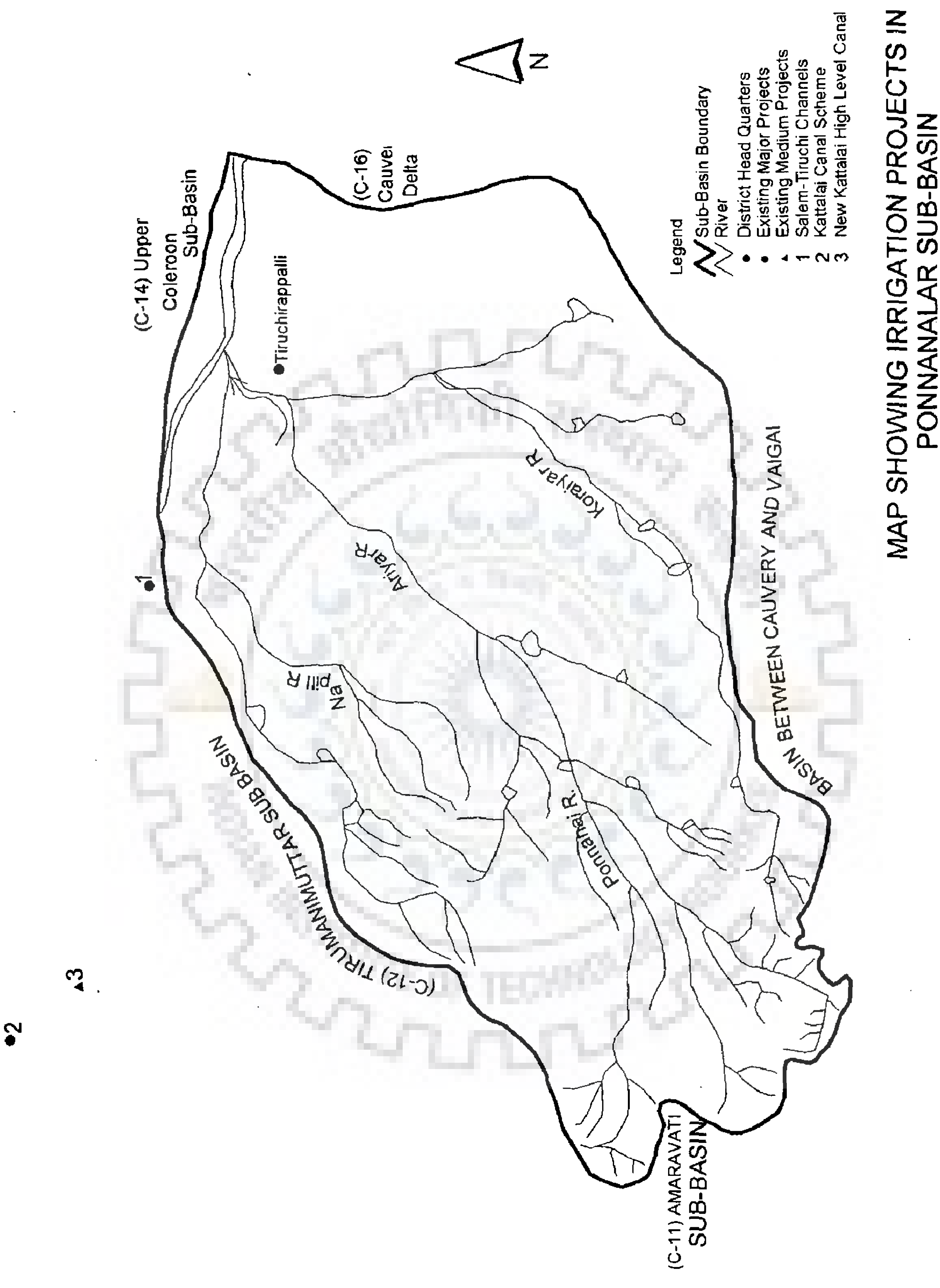

Figure 3.2.13: Map Showing Irrigation Projects in Ponnanai Ar Sub-basin

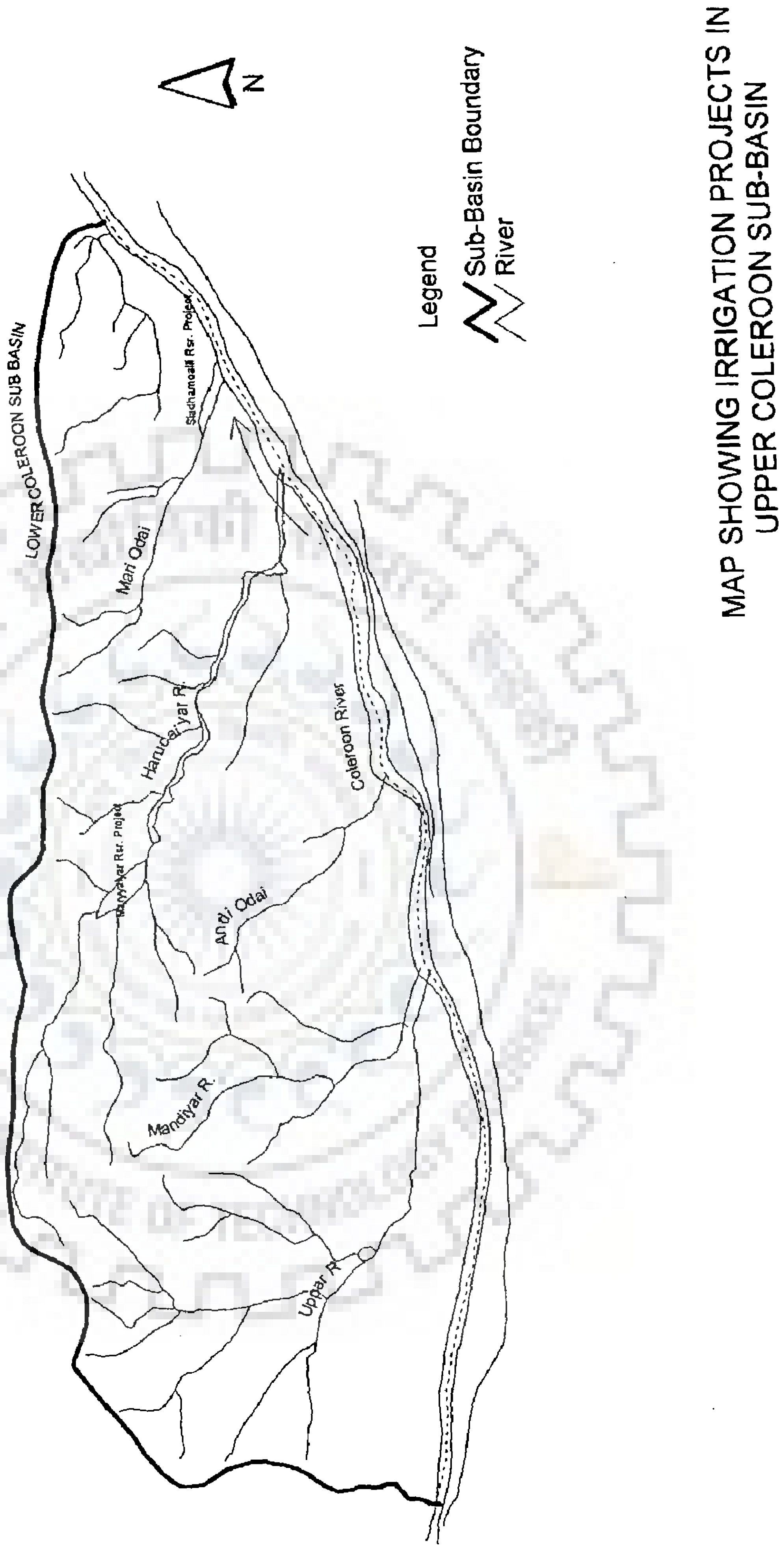

Figure 3.2.14: Map Showing Irrigation Projects in Upper Coleroon Sub-basin

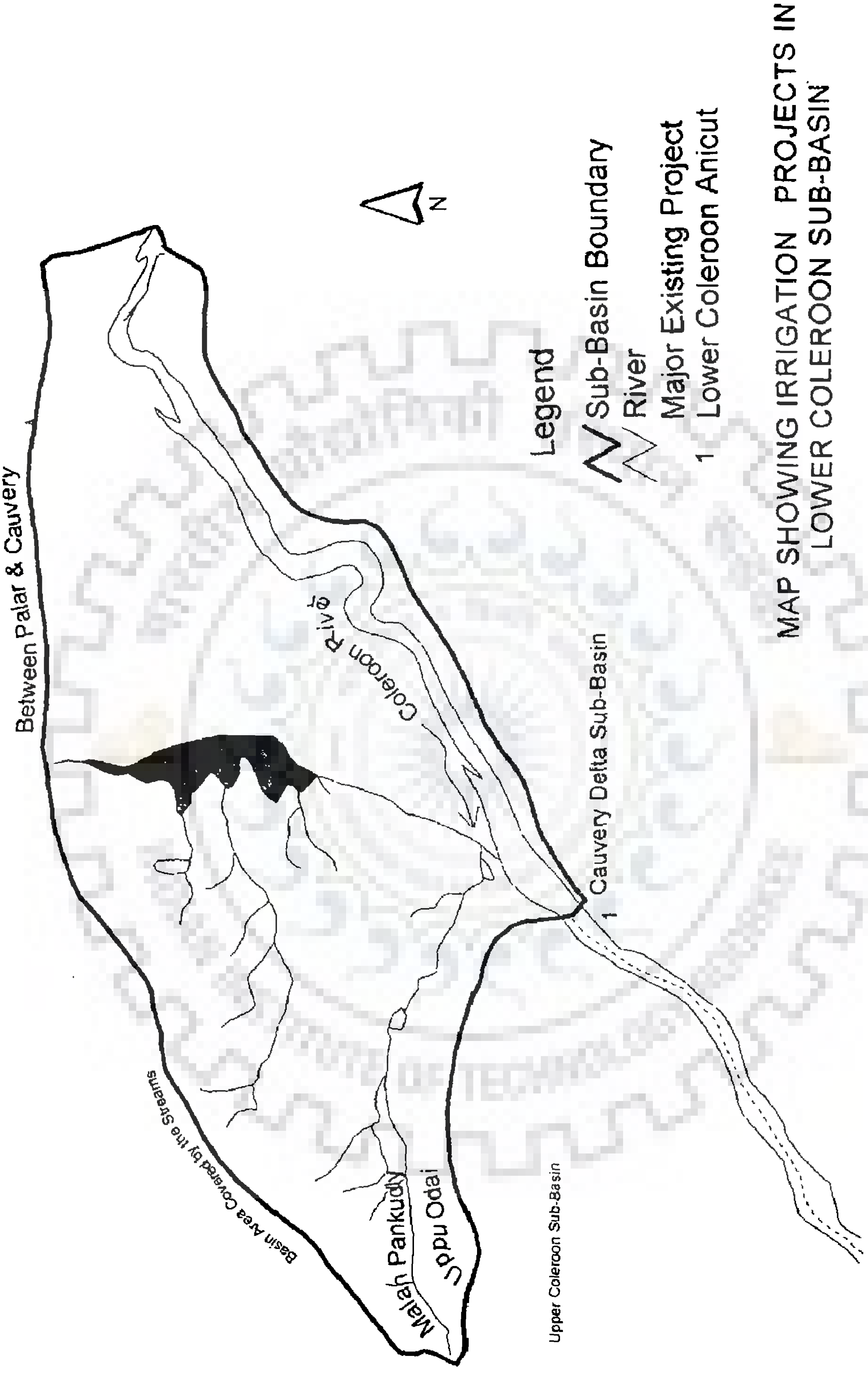

Figure 3.2.15: Map Showing Irrigation Projects in Lower Coleroon Sub-basin

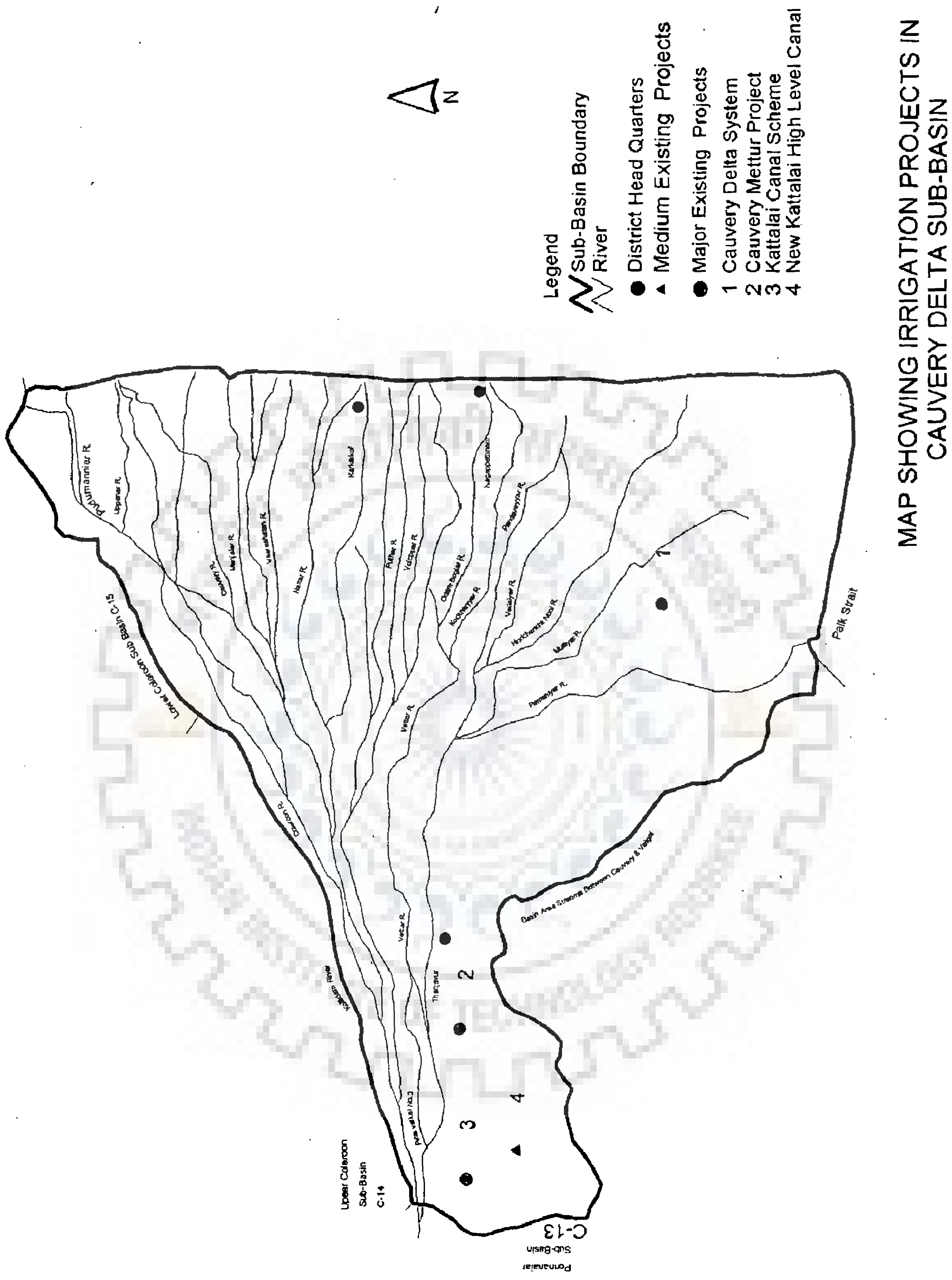

Figure 3.2.16: Map Showing Irrigation Projects in Cauvery Delta Sub-basin

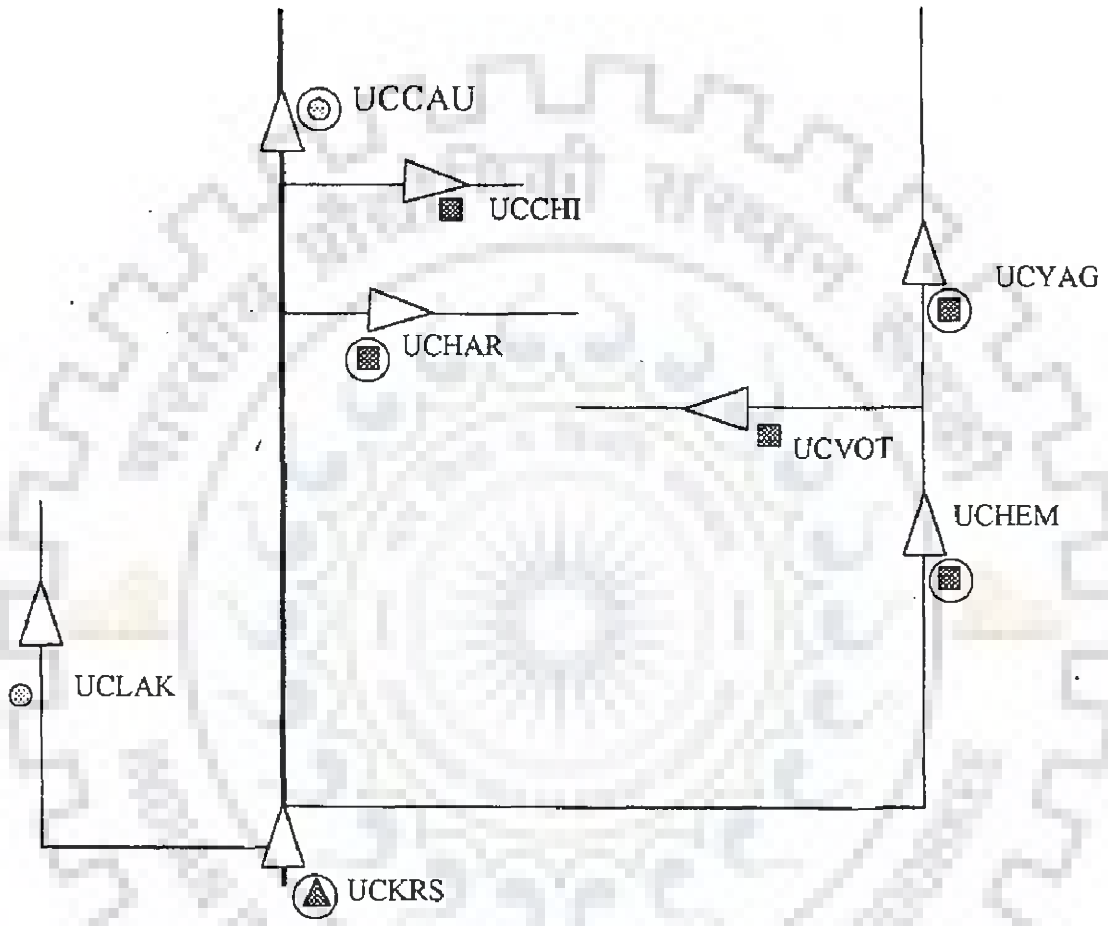

Figure 3.3.1 : Line Diagram Showing Major And Medium Projects in Upper Cauvery Sub-basin

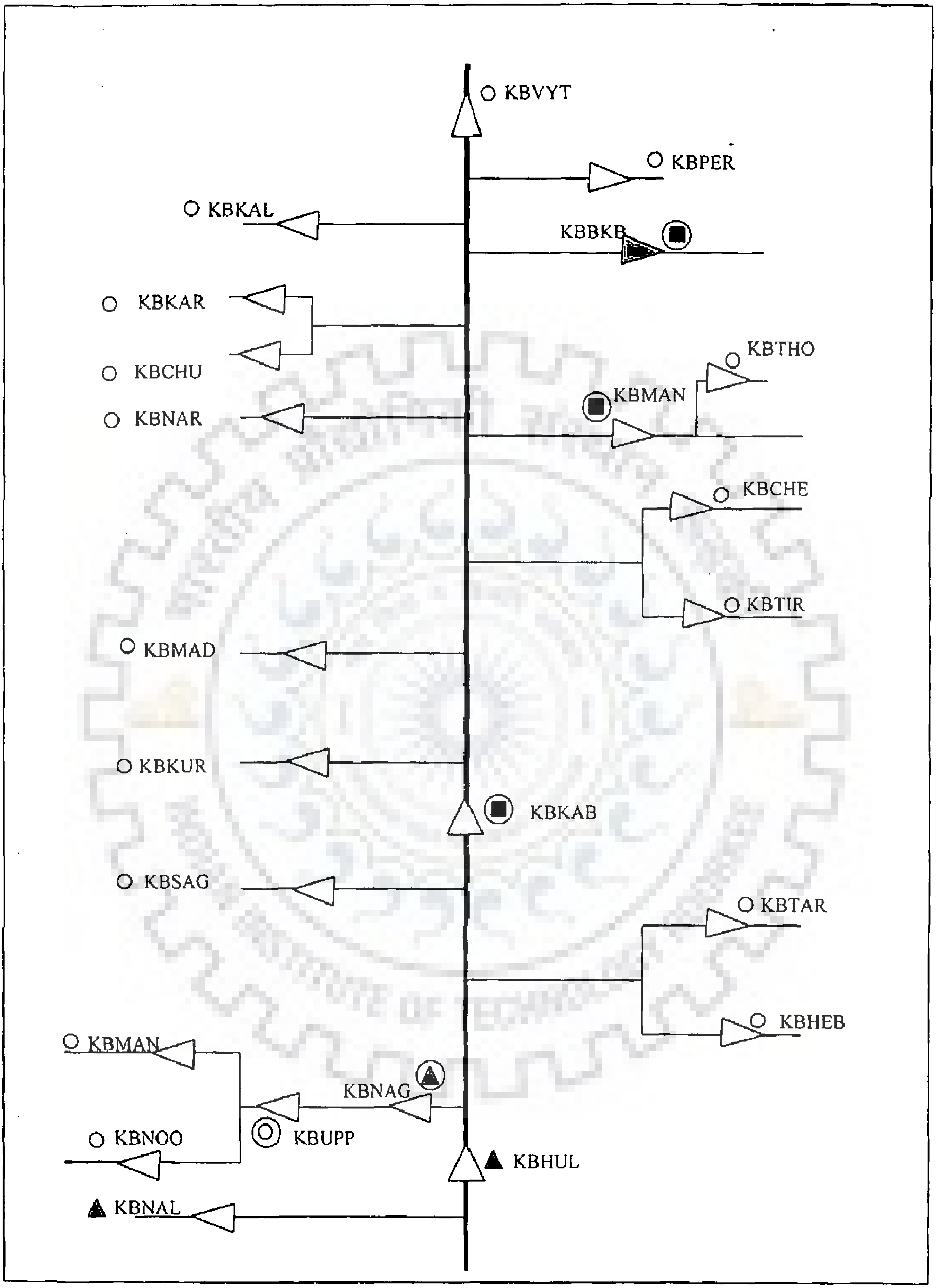

Figure 3.3.2: Line Diagram Showing Major and Medium Projects in Kabini Sub-basin

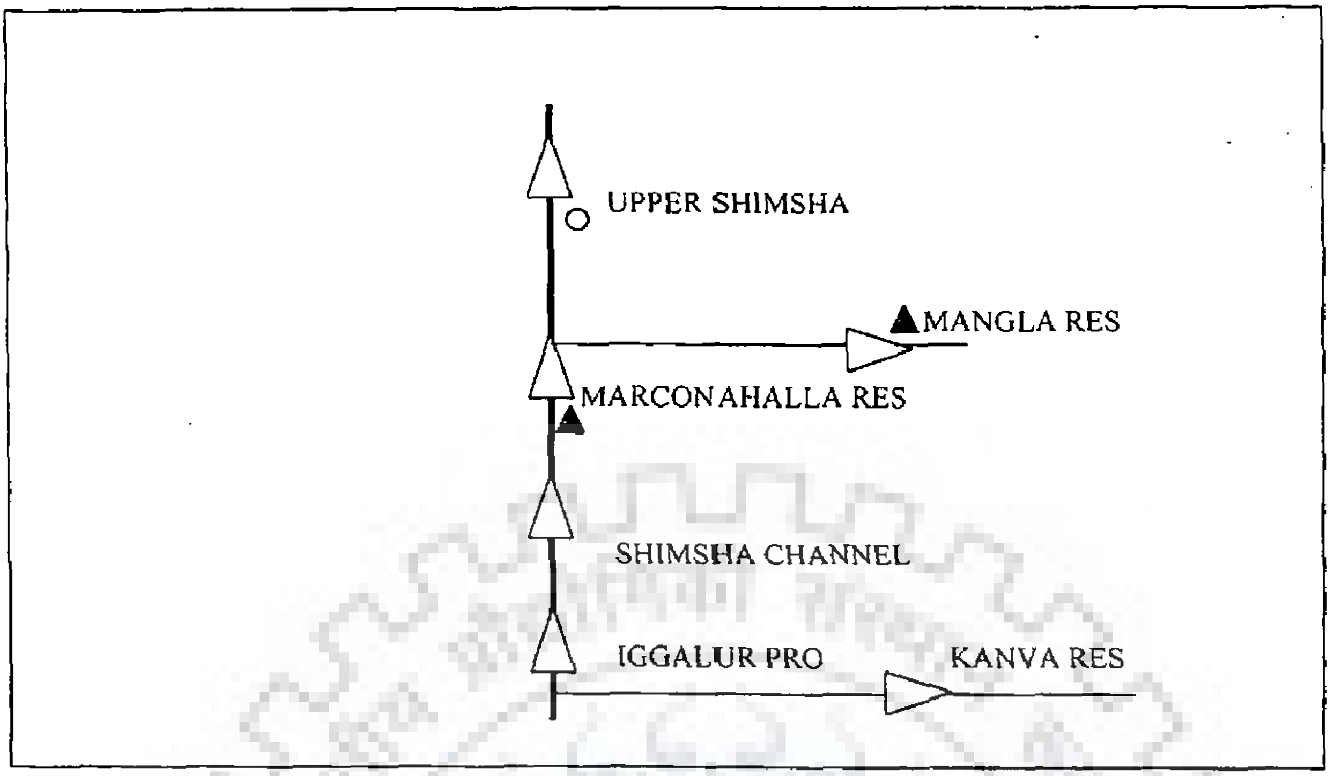

Figure 3.3.3: Line diagram Showing Major and Medium Projects in Shimsha Sub-basin

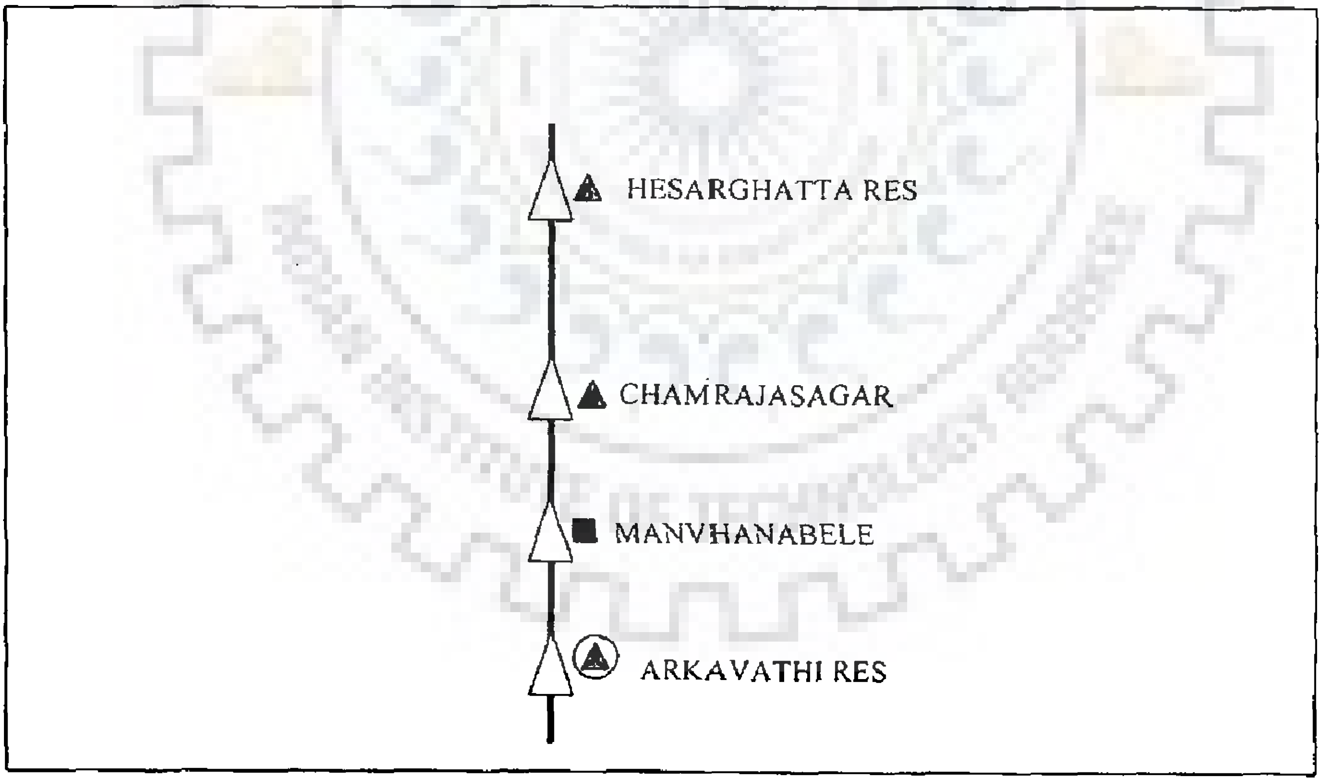

Figure 3.3.4: Line diagram Showing Major and Medium Projects in Arkavathi Sub-basin

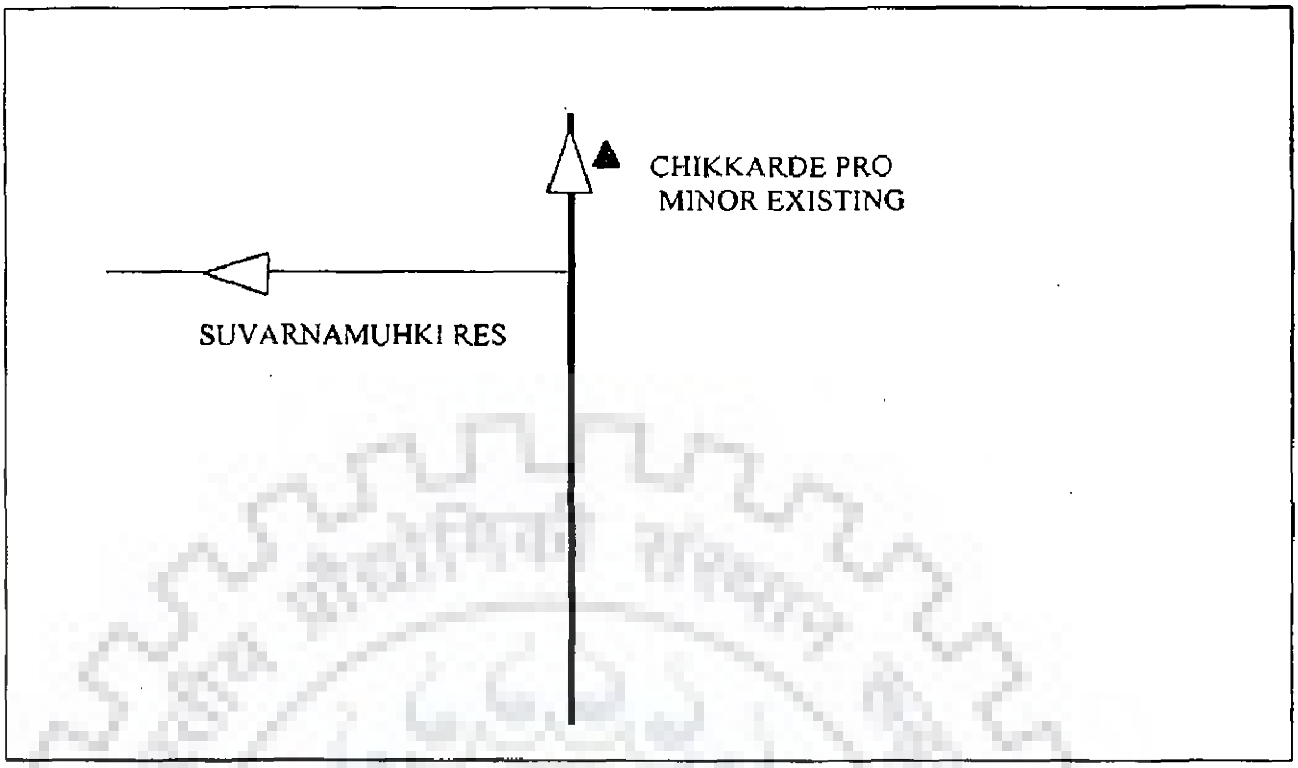

Figure 3.3.5: Line Diagram Showing Major and Medium Projects in Suvarnavathi Sub-basin

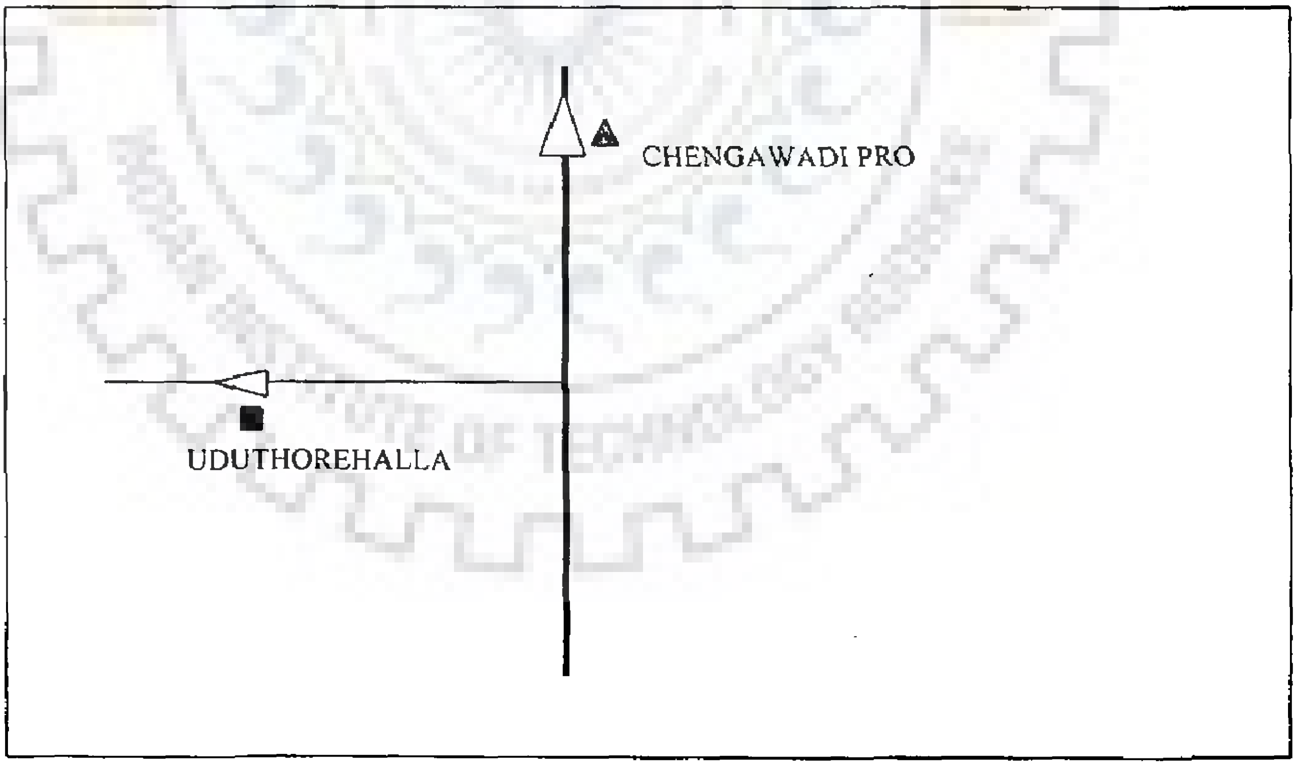

Figure 3.3.6: Line Diagram Showing Major and Medium Projects in Palar Sub-basin

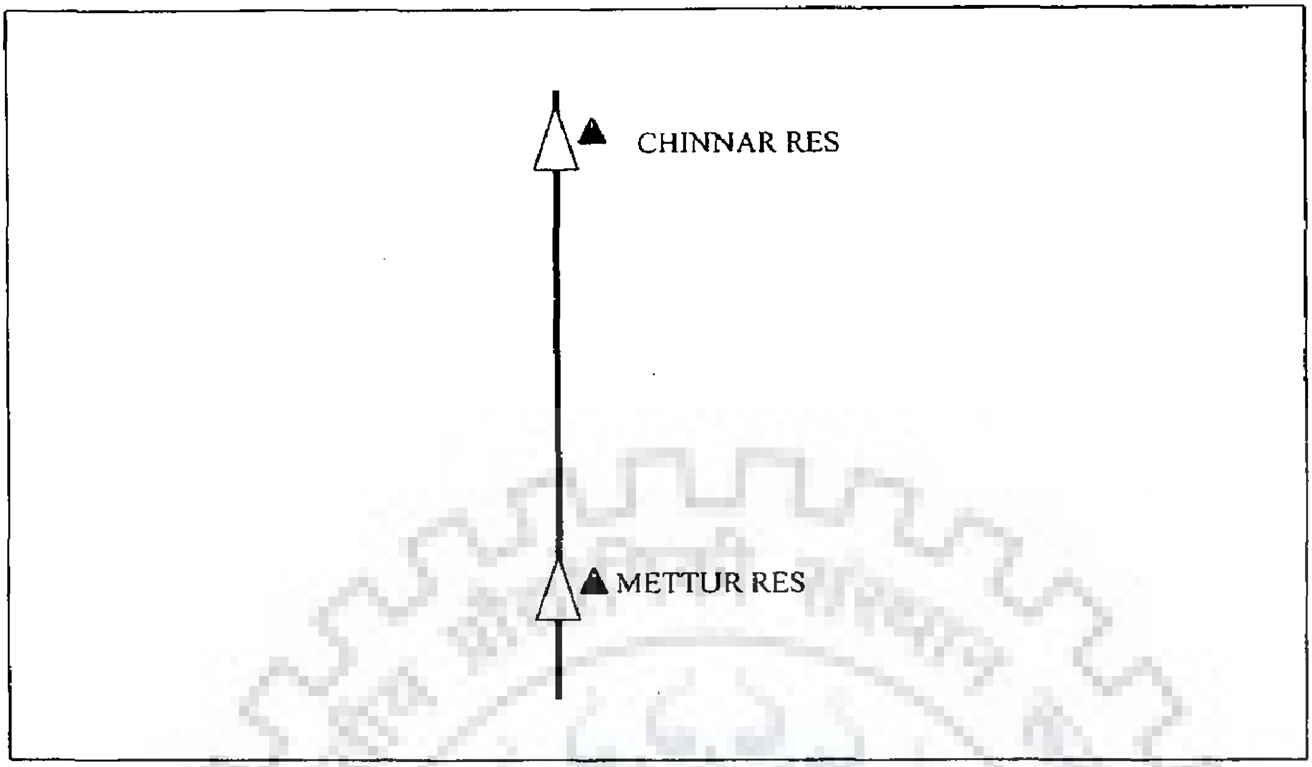

Figure 3.3.7: Line Diagram Showing Major and Medium Projects in Chinnar Sub-basin

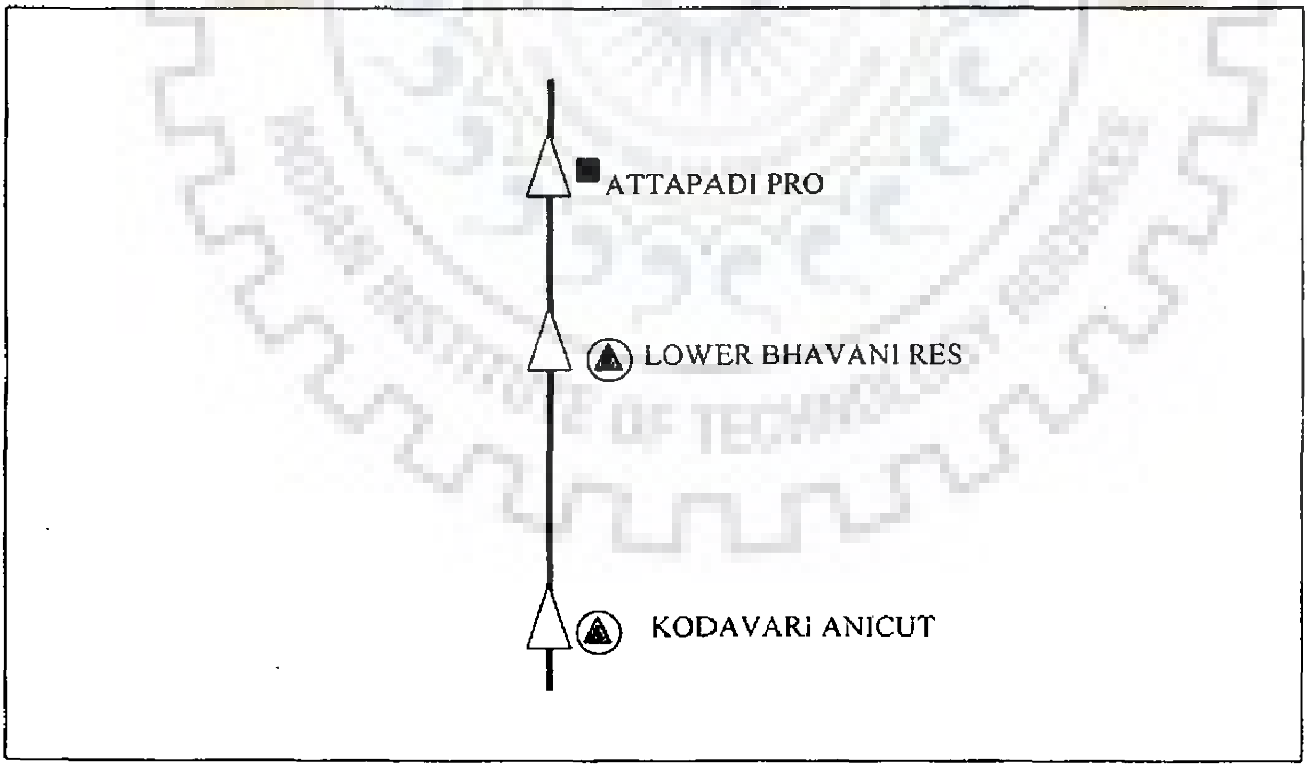

Figure 3.3.8: Line Diagram Showing Major and Medium Projects in Bhavani Sub-basin

Table 3.3: Principal Features of Major Projects/Sites in Cauvery River Basin

Sr.No.	Name of project	Site No.	Notation	Sub-basin	Status	State	District	Catchment area (km^2)	CCA (ha)	Storage (MCM) Live	Dead	Gross	Utilisation (MCM)	Location Longitude	Latitude
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1	Yagachi	1	YCU	Upper Cauvery	Existing	Karnataka	Hassan	557	21,450	70.58	8.89	89.54	162	75^0 11' E	13^0 11' N
2	Hemavathi	2	HCU	Upper Cauvery	Existing	Karnataka	Hassan	2810	2,65,079	915	38	1047	1536.1	76^0 03' E	12^0 45' N
3	Harangi	3	GCU	Upper Cauvery	Existing	Karnataka	Kodagu	420	53,538	216	12	241	509	75^0 54' E	12^0 29' N
4	Cauvery	4	CCU	Upper Cauvery	Proposed	Karnataka	Kodagu	280	44,500	144.43	25	169.43	433.35	NA	NA
5	KRS	5	KCU	Upper Cauvery	Existing	Karnataka	Mandya	10619	1,13,603	1172	125	1408	1483	76^0 33' E	12^0 25' N
6	Banasursagar	6	BKB	Kabini	ongoing	Kerala	Wynad	61.44	9,200	143.11	23.75	166.86	277.5	75^0 57' E	11^0 40' N
7	Mananthvady	7	MKB	Kabini	ongoing	Kerala	Wynad	155.4	22,500	451.63	156.15	607.78	495.5	75^0 54' E	11^0 47' N
8	Kabini	8	KKB	Kabini	Existing	Karnataka	Mysore	2142	45,730	453	99	552	852	76^0 21' E	11^0 55' N
9	Taraka	9	TKB	Kabini	Existing	Karnataka	Mysore	276.6	19,300	82	30	112	193	76^0 15'E	12^0 02'N
10	Sagar doddakere	10	SKB	Kabini	Proposed	Karnataka	Mysore	185	1,700	310	NA	NA	24	NA	NA
11	Upper Nugu	11	UKN	Kabini	proposed	Karnataka	Mysore	950	40,470	280	NA	280	677	76^0 26' E	11^0 54' N
12	Nugu	12	NKB	Kabini	Existing	Karnataka	Mysore	984	10,526	129.85	24.1	153.95	217.91	76^0 27' E	11^0 58' N
13	Mettur	13	MCH	Chinnar	Existing	Tamil Nadu	Salem	42217	18212	2646.8	62.02	2708.8	275	77^0 48' E	11^0 47' N
14	Lower Bhavani	14	BBH	Bhavani	Existing	Tamil Nadu	Periyar	4200	95,175	907.7	21.1	928.79	395.4	77^0 81' E	11^0 28' N
15	Amravathi	15	AAM	Amravathi	Existing	Tamil Nadu	Coimbatore	839.13	10,118	108.14	5.19	113.33	202.26	77^0 16' E	10^0 25' N

Table 3.4.1 (a) : Land Use Coefficients for Upper Cauvery Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
9	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.1 (b): Crop Water Requirements for Upper Cauvery Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.2(a): Land Use Coefficients for Kabini Sub-basin

Sl.No	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Fodder	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Cotton	0.50	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00
6	Rabi Paddy	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00
7	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
8	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
9	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.00	1.00	1.00	S	0.00
10	Sugercane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	Coconut	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.2 (b): Crop Water Requirements for Kabini Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.04	0.64	0.59	0.50	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80
2	kh.Jowar	0.01	0.09	0.15	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
3	kh.Ragi	0.01	0.09	0.15	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
4	Fodder	0.01	0.09	0.15	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32
5	Cotton	0.02	0.09	0.08	0.12	0.06	0.10	0.07	0.00	0.00	0.00	0.00	0.00	0.54
6	Rabi Paddy	0.00	0.00	0.00	0.00	0.00	0.37	0.66	0.72	0.45	0.00	0.00	0.00	2.20
7	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.19	0.30	0.14	0.00	0.00	0.68
8	Fruits & veg.	0.00	0.00	0.00	0.00	0.02	0.08	0.24	0.27	0.00	0.00	0.00	0.00	0.60
9	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.19	0.27	0.25	0.03	0.00	0.77
10	Sugercane	0.06	0.03	0.02	0.05	0.03	0.08	0.22	0.28	0.28	0.34	0.16	0.06	1.62
11	Coconut	0.15	0.12	0.12	0.08	0.04	0.11	0.19	0.23	0.24	0.29	0.20	0.08	1.84

Table 3.4.3 (a) : Land Use Coefficients for Shimsha Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.50	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.50	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.54	1.00	1.00	1.00	0.50	0.00
9	Sugarcane	0.00	0.00	0.00	0.00	0.00		1.00	1.00	1.00	0.00	0.00	0.00

Table 3.4.3 (b): Crop Water Requirements for Shimsha Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.17	0.40	0.40	0.40	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.81
2	kh.Jowar	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
3	kh.Ragi	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06
4	Fodder	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
5	Tobacco	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.19	0.33	0.24	0.00	0.00	0.81
7	Fruits & veg.	0.00	0.00	0.00	0.00	0.01	0.13	0.26	0.11	0.00	0.00	0.00	0.00	0.50
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.39	0.49	0.09	0.00	1.14
9	Sugarcane	0.01	0.01	0.01	0.02	0.03	0.20	0.36	0.26	0.37	0.42	0.26	0.00	1.96

Table 3.4.4 (a) : Land Use Coefficients for Arkavathi Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.50	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.50	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.50	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.54	1.00	1.00	1.00	0.50	0.00
9	Sugarcane	0.00	0.00	0.00	0.00	0.00		1.00	1.00	1.00	0.00	0.00	0.00

Table 3.4.4 (b): Crop Water Requirements for Arkavathi Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.5 (a) : Land Use Coefficients for Middle Cauvery Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	kh. cotton	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Paddy												
7	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
8	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
9	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
10	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.5 (b): Crop Water Requirements for Middle Cauvery Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.6 (a) : Land Use Coefficients for Suvarnavathi Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
9	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.6 (b): Crop Water Requirements for Suvarnavathi Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.7 (a) : Land Use Coefficients for Palar Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
9	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.7 (b): Crop Water Requirements for Palar Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.8(a): Land Use Coefficients for Chinnar Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	Paddy-I	0.00	0.00	0.45	1.00	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00
2	Paddy-II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	1.00	1.00	1.00	1.00
3	kh.Jowar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	1.00	1.00	0.67	0.00
4	kh.Ragi	1.00	1.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.00
5	Fodder	1.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	1.00
6	Bajra	1.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	1.00
7	Pulses	0.70	1.00	1.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Cotton	1.00	1.00	48.00	0.00	0.00	0.00	0.00	0.00	0.54	1.00	1.00	1.00
9	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.55	1.00	1.00	1.00	0.67	0.00
10	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	Coconut	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.8 (b): Crop Water Requirements for Chinnar Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	Paddy-I	0.000	0.000	0.041	0.556	0.481	0.549	0.616	0.123	0.000	0.000	0.000	0.000	2.366
2	Paddy-II	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.051	0.719	0.841	0.681	0.437	2.729
3	kh.Jowar	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.210	0.200	0.137	0.080	0.681
4	kh.Ragi	0.208	0.072	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.139	0.447
5	Fodder	0.208	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.139	0.440
6	Bajra	0.208	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.139	0.440
7	Pulses	0.014	0.079	0.084	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.184
8	Cotton	0.222	0.104	0.019	0.000	0.000	0.000	0.000	0.000	0.060	0.263	0.194	0.257	1.119
9	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.035	0.197	0.293	0.283	0.092	0.000	0.900
10	Sugarcane	0.208	0.156	0.112	0.111	0.034	0.074	0.089	0.106	0.111	0.263	0.193	0.139	1.596
11	Coconut	0.163	0.117	0.075	0.074	0.039	0.095	0.178	0.242	0.260	0.325	0.246	0.191	2.005

Table 3.4.9(a): Land Use Coefficients for Bhavani Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	1.00	1.00	1.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
2	kh.Jowar	1.00	1.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65
3	Fodder	0.90	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Cotton	0.00	0.00	0.52	1.00	1.00	1.00	1.00	1.00	0.54	0.00	0.00	0.00
5	Maize	0.90	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.70	1.00	1.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Paddy(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.16	1.00	1.00	1.00	0.16	0.00
8	Jowar(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
9	Groundnut(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.52	1.00	1.00	1.00	0.40	0.00
10	Sugercane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	Coconut	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.9(b): Crop Water Requirements for Bhavani Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.755	0.570	0.556	0.351	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.082	2.314
2	kh.Jowar	0.172	0.234	0.141	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.568
3	Fodder	0.050	0.191	0.150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.391
4	Cotton	0.000	0.000	0.043	0.077	0.041	0.035	0.211	0.194	0.094	0.000	0.000	0.000	0.695
5	Maize	0.050	0.198	0.165	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.413
6	Pulses	0.039	0.151	0.217	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.428
7	Paddy(s)	0.000	0.000	0.000	0.000	0.000	0.000	0.064	0.605	0.573	0.511	0.034	0.000	1.787
8	Jowar(s)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.074	0.245	0.259	0.132	0.710
9	Groundnut(s)	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.167	0.262	0.264	0.046	0.000	0.770
10	Sugercane	0.260	0.234	0.259	0.251	0.045	0.040	0.088	0.087	0.103	0.245	0.164	0.155	1.931
11	Coconut	0.217	0.193	0.216	0.208	0.054	0.057	0.164	0.207	0.233	0.301	0.212	0.204	2.266

Table 3.4.10 (a) : Land Use Coefficients for Noyil Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
9	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.10 (b): Crop Water Requirements for Noyil Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.11(a): Land Use Coefficients for Amaravathi Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy												
2	kh.Jowar	1.00	1.94	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.00
3	Fodder	0.90	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Cotton	0.00	0.00	0.52	1.00	1.00	1.00	1.00	1.00	0.54	0.00	0.00	0.00
5	Maize	0.90	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.70	1.00	1.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Paddy(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.16	1.00	1.00	1.00	0.17	0.00
8	Jowar(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
9	Groundnut(s)	0.00	0.00	0.00	0.00	0.00	0.00	0.52	1.00	1.00	1.00	0.40	0.00
10	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	Coconut	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.11(b): Crop Water Requirements for Amaravathi Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.814	0.771	0.752	0.485	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.050	2.872
2	kh.Jowar	0.236	0.323	0.223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.813
3	Fodder	0.072	0.268	0.215	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.555
4	Cotton	0.000	0.000	0.065	0.105	0.075	0.045	0.249	0.226	0.108	0.000	0.000	0.000	0.873
5	Maize	0.072	0.276	0.234	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.582
6	Pulses	0.056	0.216	0.303	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.605
7	Paddy(s)	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.586	0.718	0.656	0.047	0.000	2.023
8	Jowar(s)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.089	0.285	0.302	0.176	0.852
9	Groundnut(s)	0.000	0.000	0.000	0.000	0.000	0.000	0.040	0.196	0.296	0.306	0.054	0.000	0.892
10	Sugarcane	0.351	0.323	0.359	0.327	0.087	0.054	0.104	0.107	0.121	0.285	0.192	0.205	2.515
11	Coconut	0.293	0.269	0.301	0.271	0.112	0.072	0.197	0.241	0.265	0.348	0.247	0.264	2.880

Table 3.4.12 (a) : Land Use Coefficients for Tirumanimuttar Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
9	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.12 (b): Crop Water Requirements for Tirumanimuttar Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.13 (a) : Land Use Coefficients for Ponnanai Ar Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
9	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.13 (b): Crop Water Requirements for Ponnanai Ar Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.14 (a) : Land Use Coefficients for Upper Coleroon Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
9	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.14 (b): Crop Water Requirements for Upper Coleroon Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.15 (a) : Land Use Coefficients for Lower Coleroon Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
9	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.15 (b): Crop Water Requirements for Lower Coleroon Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.4.16 (a) : Land Use Coefficients for Cauvery Delta Sub-basin

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	kh.Paddy	0.50	1.00	1.00	1.00	1.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
2	kh.Jowar	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	kh.Ragi	1.00	1.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
4	Fodder	0.53	1.00	1.00	1.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Tobacco	0.53	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Pulses	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00
7	Fruits & veg.	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
8	Ground nut	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00
9	Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 3.4.16 (b): Crop Water Requirements for Cauvery Delta Sub-basin

Unit : Meter

SN	Name of crop	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	kh.Paddy	0.169	0.398	0.402	0.399	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.808
2	kh.Jowar	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
3	kh.Ragi	0.022	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.055
4	Fodder	0.003	0.015	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059
5	Tobacco	0.003	0.012	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.037
6	Pulses	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.194	0.328	0.240	0.000	0.000	0.811
7	Fruits & veg.	0.000	0.000	0.000	0.000	0.010	0.127	0.255	0.106	0.000	0.000	0.000	0.000	0.498
8	Ground nut	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.172	0.390	0.489	0.093	0.000	1.144
9	Sugarcane	0.013	0.012	0.014	0.020	0.027	0.201	0.355	0.263	0.372	0.421	0.262	0.000	1.960

Table 3.5(a): Monthly 75%, 50%, 90%, 100% Dependable Surface Water Yields as per Observed Yields in Upper Cauvery, Kabini and Shimsha Sub-Basins

Month	Upper Cauvery				Kabini				Shimsha			
	75%	50%	90%	100%	75%	50%	90%	100%	75%	50%	90%	100%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Jun	470	607.90	350.4	303.7	407.6	368.2	349.7	120	15.47	19.07	12.64	7.92
Jul	1359.6	2204.70	994	882.7	783.4	231.2	492.1	376.8	9.65	11.89	7.89	4.94
Aug	792.1	479.40	400.9	291.1	388.3	1014.2	541.4	336.6	12.25	15.10	10.01	6.27
Sep	560.6	384.30	551.6	508.7	960.3	1111	244	217.5	89.18	109.93	72.89	45.66
Oct	568.7	955.10	815.7	395.3	1080.9	490	598	191.3	320.33	394.85	261.81	164.02
Nov	216.1	297.10	426.4	161	795.3	122.8	194.1	282.4	127.2	156.79	103.96	65.13
Dec	66.6	24.00	95.4	0	34.6	24.2	44.6	32.1	16.1	19.85	13.16	8.24
Jan	13.6	0.00	26.5	0	41.3	0	12.9	15.1	0.5	0.62	0.41	0.26
Feb	4.8	30.30	7.5	97	8.6	0	10.8	7.1	0.12	0.15	0.10	0.06
Mar	40.9	130.90	0.9	0	41.5	0	94	40.4	0.25	0.31	0.20	0.13
Apr	468.4	568.60	517.6	186.5	284.4	75.4	143.5	89.5	3.65	4.50	2.98	1.87
May	615.8	636.30	640.7	325.9	360.4	938.9	314.5	243.5	24.39	30.06	19.93	12.49
Total	5177	6230.3	4840	3150	5188.6	4376.0	3039.5	1982.3	619.09	763.00	506.0	317

Table 3.5 (b): Monthly 75%, 50%, 90%, 100% Dependable Surface Water Yields as per Observed Yields in Arkavathi, Middle Cauvery and Suvarnavathi Sub-Basins

Month	Arkavathi				Middle Cauvery				Suvarnavathi			
	75%	50%	90%	100%	75%	50%	90%	100%	75%	50%	90%	100%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Jun	10.10	13.69	7.14	4.33	0.96	1.14	0.80	0.55	1.55	3.88	0.41	0.00
Jul	7.49	10.15	5.30	3.21	17.69	21.01	14.74	10.13	3.08	7.70	0.81	0.00
Aug	13.80	18.70	9.76	5.91	46.15	54.82	38.46	26.43	1.67	4.18	0.44	0.00
Sep	99.44	134.78	70.34	42.62	81.78	97.15	68.15	46.84	9.58	23.95	2.52	0.00
Oct	90.23	122.30	63.82	38.67	72.69	86.35	60.58	41.63	9.5	23.75	2.50	0.00
Nov	36.94	50.07	26.13	15.83	71.73	85.21	59.78	41.08	9.62	24.05	2.53	0.00
Dec	9.99	13.54	7.07	4.28	21.86	25.97	18.22	12.52	0.52	1.30	0.14	0.00
Jan	3.93	5.33	2.78	1.68	8.14	9.67	6.78	4.66	0.06	0.15	0.02	0.00
Feb	2.55	3.46	1.80	1.09	4.71	5.60	3.93	2.70	0.2	0.50	0.05	0.00
Mar	1.92	2.60	1.36	0.82	2.06	2.45	1.72	1.18	0.11	0.28	0.03	0.00
Apr	2.81	3.81	1.99	1.20	0.94	1.12	0.78	0.54	0.48	1.20	0.13	0.00
May	7.8	10.57	5.52	3.34	1.28	1.52	1.07	0.73	1.63	4.08	0.43	0.00
Total	287.0	389.00	203.0	123.0	329.99	392.0	275.0	189.0	38	95.00	10.00	0.00

Table 3.5 (c): Monthly 75%, 50%, 90%, 100% Dependable Surface Water Yields as per Observed Yields in Palar, Chinnar and Bhavani Sub-Basins

Month	Palar				Chinnar				Bhavani			
	75%	50%	90%	100%	75%	50%	90%	100%	75%	50%	90%	100%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Jun	9.86	16.06	6.76	1.69	10.28	12.65	7.64	2.93	154.59	247.00	99.38457	53.68981
Jul	20.75	33.80	14.23	3.56	3.21	3.95	2.39	0.92	373.01	214.00	68.0088	79.4668
Aug	26.03	42.40	17.85	4.46	3.75	4.62	2.79	1.07	266.43	223.00	218.0085	135.1451
Sep	28.71	46.76	19.69	4.92	78.95	97.17	58.71	22.52	142.67	252.00	125.6709	94.41746
Oct	7.4	12.05	5.07	1.27	107.38	132.16	79.85	30.63	209.17	387.00	136.9684	79.98234
Nov	0.25	0.41	0.17	0.04	72.39	89.10	53.83	20.65	259.74	207.00	134.6753	157.3133
Dec	3.86	6.29	2.65	0.66	14.65	18.03	10.89	4.18	150.77	166.00	189.0935	52.29048
Jan	2.88	4.69	1.97	0.49	4.55	5.60	3.38	1.30	81.43	101.00	226.2299	264.2511
Feb	1.73	2.82	1.19	0.30	3.05	3.75	2.27	0.87	70.09	133.00	143.1764	46.76684
Mar	1.56	2.54	1.07	0.27	3.3	4.06	2.45	0.94	70.18	221.00	15.82771	40.9486
Apr	0.17	0.28	0.12	0.03	2.45	3.02	1.82	0.70	56.48	97.00	51.0066	26.88173
May	1.79	2.92	1.23	0.31	8.04	9.90	5.98	2.29	80.73	201.00	104.9215	186.2572
Total	104.99	171.0	71.99	18.00	312	384.0	232.0	89.00	1915.3	2444.0	1512.972	1218

Table 3.5 (d): Monthly 75%, 50%, 90%, 100% Dependable Surface Water Yields as per Observed Yields in Noyil, Amaravathi and Tirumanimuttar Sub-Basins

Month	Noyil				Amaravathi				Tirumanimuttar			
	75%	50%	90%	100%	75%	50%	90%	100%	75%	50%	90%	100%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Jun	0.38	0.40	0.36	0.34	63.22	34.40	50.98738	45.65145	1.10	1.88	1.06	0.96
Jul	1.15	1.20	1.09	1.03	119.79	26.60	67.90921	42.0942	3.30	5.63	3.17	2.87
Aug	0.00	0.00	0.00	0.00	138.83	56.30	92.62633	91.85343	0.00	0.00	0.00	0.00
Sep	5.90	6.14	5.59	5.27	76.90	261.50	94.22384	97.27401	17.00	29.02	16.35	14.80
Oct	116.69	121.36	110.46	104.24	108.14	164.00	64.25563	69.70528	336.57	574.61	323.62	293.02
Nov	63.20	65.73	59.83	56.46	147.26	219.60	166.9996	56.40792	182.30	311.23	175.29	158.71
Dec	37.69	39.20	35.68	33.67	103.90	48.70	69.59548	32.43879	108.70	185.58	104.52	94.64
Jan	0.00	0.00	0.00	0.00	35.75	100.90	48.25089	50.18272	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	13.09	4.80	5.236301	34.42916	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.00	9.22	42.60	6.079435	7.961478	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.00	0.00	12.50	49.10	33.607	32.48113	0.00	0.00	0.00	0.00
May	0.00	0.00	0.00	0.00	24.64	99.50	105.229	81.01227	0.00	0.00	0.00	0.00
Total	225.01	234.0	213.00	201.0	853.2	1108.00	805.00	641.4918	648.97	1108.00	624.00	565.00

Table 3.5 (e): Monthly 75%, 50%, 90%, 100% Dependable Surface Water Yields as per Observed Yields in Ponnanai Ar, Upper Cleroon, Lower Coleroon and Cauvery Delta Sub-Basins

	Ponnani Ar				Upper Coleroon				Lower Coleroon				Cauvery Delta			
	75%	50%	90%	100%	75%	50%	90%	100%	75%	50%	90%	100%	75%	50%	90%	100%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Jun	2.31	2.91	1.94	0.77	7.29	9.15	5.86	2.35	5.8	9.87	4.30	1.66	26.86	41.72	15.05858	4.959871
Jul	2.31	2.91	1.94	0.77	35.94	45.09	28.87	11.57	15.2	25.85	11.27	4.36	70.45	109.43	39.49653	13.00904
Aug	3.08	3.89	2.58	1.03	51.05	64.05	41.01	16.44	33.93	57.71	25.17	9.74	157.17	244.14	88.11453	29.02244
Sep	22.33	28.18	18.71	7.48	92.59	116.17	74.39	29.82	41.66	70.86	30.90	11.96	193.02	299.83	108.2132	35.64238
Oct	35.54	44.84	29.77	11.91	82.18	103.11	66.02	26.46	33.89	57.64	25.14	9.73	157	243.88	88.01923	28.99105
Nov	66.03	83.32	55.31	22.13	165.9	208.15	133.3	53.43	28.88	49.12	21.42	8.29	133.78	207.81	75.00135	24.70333
Dec	26.4	33.31	22.12	8.85	93.55	117.37	75.16	30.13	32.64	55.52	24.21	9.37	152.2	236.42	85.32819	28.1047
Jan	9.27	11.70	7.77	3.11	21.63	27.14	17.38	6.97	11.66	19.83	8.65	3.35	54.08	84.01	30.31898	9.986217
Feb	8.53	10.76	7.15	2.86	13.25	16.62	10.64	4.27	5.34	9.08	3.96	1.53	24.77	38.48	13.88686	4.573939
Mar	5.56	7.02	4.66	1.86	10.71	13.44	8.60	3.45	5.42	9.22	4.02	1.56	25.17	39.10	14.11111	4.647801
Apr	2.36	2.98	1.98	0.79	5.78	7.25	4.64	1.86	6.72	11.43	4.98	1.93	31.17	48.42	17.4749	5.75574
May	7.28	9.19	6.10	2.44	10.13	12.71	8.14	3.26	5.38	9.15	3.99	1.54	24.96	38.77	13.99338	4.609023
Total	191	241.0	160.0	64.00	590	739.0	474.0	190.0	226.52	381.0	168.0	65.0	1050.63	1632.0	589	194.0

Table 3. 6(a): Ground Water Potential at Cauvery River Basin in India.

Sl. No.	State/District & Name of sub-basin	Geological area		Factor %	Ground Water								
		whole district	within the sub-basin		Total repleni-shable resource	Provision for dome stic & industrial use	Available resource for irriga-tion	Net draft	Total repleni-shable resource	Provision for dome stic & industrial use	Available resource for irriga-tion	Net draft	Balance for future use
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	***Upper cauvery sub-basin***												
	Karnataka												
	Chikmangalur	7201	714	9.92	590.5	88.6	501.9	31.0	58.5	8.8	49.8	3.1	46.7
	Kodagu	4102	2515	64.12	504.7	75.7	429.0	47.0	323.6	48.5	275.1	30.1	244.9
	Hassan	6814	4369	61.31	165.9	24.9	141.0	11.0	101.7	15.3	86.5	6.7	79.7
	Mandya	4961	965	19.45	790.6	118.6	672.0	78.0	153.8	23.1	130.7	15.2	115.5
	Mysore	11594	2056	17.20	812.9	121.9	691.0	158.0	139.8	21.0	118.8	27.2	91.7
	Total		**10619**						777.5	**116.6**	**660.8**	**82.3**	**578.5**
2	***Kabini sub-basin***												
	Karnataka												
	Kodagu	4102	151	3.68	165.9	24.9	141.0	11.0	6.1	0.9	5.2	0.4	4.8
	Mysore	11954	4757	39.79	812.9	121.9	691.00	158.0	323.5	48.5	275.0	62.9	212.1
	Kerala												
	Cannanore	4958	18	0.36	733.1	110.0	623.1	90.7	2.7	0.4	2.3	0.3	2.0
	kozhikode	2345	29	1.24	423.1	63.5	359.6	118.3	5.2	0.8	4.4	1.5	2.9
	Wyanad	2132	1873	87.85	424.6	63.7	360.9	178.0	373.0	56.0	317.0	156.4	160.6
	Tamilnadu												
	Niligiris	2549	212	8.32	58.0	8.7	49.3	1.6	4.8	0.7	4.1	0.1	4.0
	Total		7040						715.3	107.3	608.0	221.6	386.4
3	***Shimsha sub-basin***												
	Karnataka												
	Bangalore	8005	1344	16.79	763.5	114.5	649.0	475.0	128.2	19.2	109.0	79.8	29.2
	Hassan	6814	527	7.73	504.7	75.7	429.0	47.0	39.0	5.9	33.2	3.0	29.5
	Mandya	4961	2750	55.43	790.6	118.6	672.0	78.0	438.2	65.7	372.5	43.2	329.3
	Mysore	11954	49	0.41	812.9	121.9	691.0	158.0	3.3	0.5	2.8	0.6	2.2
	Tumkur	10598	3799	35.85	895.3	134.3	761.0	438.0	320.9	48.1	272.8	157.0	115.8
	Total		**8469**						929.7	139.5	790.3	284.3	606.0

Table 3.6(b): Ground Water Potential for Cauvery River Basin in India.

Sl. No.	State/District/ & Name of sub-basin	Geological area		Factor %	Ground Water								
		whole district	within the sub-basin		Total repleni-shable resource	Provision for domestic & industrial use	Available resource for irriga--tion	Net draft	Total repleni-shable resource	Provision for domestic & industrial use	Available resource for irriga--tion	Net draft	Balance for future use
1	2	3	4	5	6	7	8	9	10	11	12	13	14
4	*Arkavathi sub-basin*												
	Karnataka												
	Bangalore	8005	4109	51.33	763.5	114.5	649.0	475.0	391.8	58.8	333.1	243.8	89.3
	Kolar	8223	6	0.07	803.6	120.5	683.1	471.0	0.6	1.2	6.6	4.6	2
	Mandya	4961	69	1.39	790.6	118.6	672.0	78.0	11.0	1.7	9.4	1.1	8.3
	Tamilnadu												
	Dharmapuri	9622	167	1.74	1154.7	173.2	981.5	648.5	20.0	3.0	17.0	11.3	5.8
	Total		**4351**						**423.5**	**63.5**	**360**	**256.5**	**103.5**
5	*Middle cauvery sub-basin*												
	Karnataka												
	Mandya	4961	1148	23.14	790.6	118.6	672.0	78.0	182.9	27.4	155.5	18.0	137.5
	Mysore	11954	1528	12.78	812.9	121.9	691.0	158.0	103.9	15.6	88.3	20.2	68.1
	Total		**2676**						**286.9**	**43.0**	**243.8**	**38.2**	**205.6**
6	*Suvarnavathi sub-basin*												
	Karnataka												
	Mysore	11954	1207	10.1	812.9	121.9	691.0	158.0	82.1	12.3	69.8	16.0	53.8
	Tamilnadu												
	Periyar	8209	580.0	7.07	1232.8	184.9	1047.9	904.5	87.1	13.1	74.0	63.9	10.1
	Total		**1787**						**169.2**	**25.4**	**143.8**	**79.9**	**63.9**
7	*Palar sub-basin*												
	Karnataka												
	Mysore	11954	1870	15.64	812.9	121.9	691.0	158.0	127.2	19.1	108.1	24.7	83.4
	Tamilnadu												
	Periyar	8209	1097	13.36	1232.8	184.9	1047.9	904.5	164.7	24.7	140	120.9	19.2
	Salem	8650	247	2.86	1736.7	260.5	1476.2	176.0	49.7	7.4	42.2	5.0	37.1
	Total		**3214**						**341.5**	**51.2**	**290.3**	**150.6**	**139.7**
8	*Chinnar sub-basin*												
	Karnataka												
	Bangalore	8005	100	1.25	763.5	114.5	649	475.0	9.5	1.4	8.1	5.9	2.2
	Tamilnadu												
	Dharmapuri	9622	3630	37.73	1154.7	173.2	981.5	648.5	435.6	65.3	370.3	244.7	125.6
	Salem	8650	331	3.83	1736.7	260.5	1476.2	176.0	66.5	10	56.5	6.7	49.8
	Total		**4061**						**511.6**	**76.7**	**434.9**	**257.3**	**177.6**

Table 3.6(c): Ground Water Potential for Cauvery River Basin in India.

Sl. No.	State/District/ & Name of sub-basin	Geological area			Ground Water								
		whole district	within the sub-basin	Factor %	Total repleni-shable resource	Provision for domestic & industrial use	Available resource for irriga--tion	Net draft	Total repleni-shable resource	Provision for domestic & industrial use	Available resource for irriga--tion	Net draft	Balance for future use
1	2	3	4	5	6	7	8	9	10	11	12	13	14
9	***Bhavani sub-basin***												
	Karnataka												
	Mysore	11954	240	2.01	812.9	121.9	691	158	16.3	2.4	13.9	3.2	10.7
	Kerala												
	Palghat	4480	562	12.54	885.6	132.8	752.8	78.6	111.1	16.7	94.4	9.9	84.6
	Tamilnadu												
	Coimbatore	7491	1002	13.42	941.5	141.2	800.3	695.1	126.3	18.9	107.4	93.3	14.1
	Periyar	8241	2469	30.08	1232.8	184.9	1047.9	904.5	370.8	55.6	315.2	272	43.1
	Niligiris	2549	1881	73.79	58.0	8.7	49.3	1.6	42.8	6.4	36.4	1.2	35.2
	Total		6154						667.3	**100.1**	**567.2**	**379.5**	**187.7**
10	***Noyil sub-basin***												
	Tamilnadu												
	Coimbatore	7469	2117	28.34	941.5	141.2	800.3	695.1	266.9	40.0	226.8	197.0	29.8
	Periyar	8209	742	9.04	1232.8	184.9	1047.9	904.5	111.4	16.7	94.7	81.8	13.0
	Tiruchirappalli	11095	140	1.26	2228	334.2	1893.8	984.6	28.1	4.2	23.9	12.4	11.5
	Total		**2999**						406.4	61.0	**345.4**	**291.2**	**54.2**
11	*Amaravathi sub-basin*												
	Tamilnadu												
	Kerala												
	Idukki	5061	384	7.59	458.0	68.7	389.3	19.2	34.8	5.2	29.5	1.5	28.1
	Tamilnadu												
	Coimbatore	7469	1515	20.28	941.5	141.2	800.3	695.1	191.0	28.6	162.3	141.0	21.3
	Madurai	12624	3888	30.80	1320.0	198.0	1122.0	597.4	406.5	61.0	345.6	184.0	161.6
	Periyar	8209	1663	20.26	1232.8	184.9	1047.9	904.5	249.7	37.5	212.3	183.2	29.0
	Tiruchirappalli	11095	830	7.48	2228.0	334.2	1893.8	984.6	166.7	25.0	141.7	73.7	68.0
	Total		**8280**						**1048.7**	**157.3**	**891.4**	**583.3**	**308.0**
12	***Tirumanimuttar sub-basin***												
	Tamilnadu												
	Dindugal Anna	6051	165	2.73	927.8	139.2	788.6	479.2	25.3	3.8	21.5	13.1	8.4
	Periyar	8209	976	11.89	1232.8	184.9	1047.9	904.5	146.6	22.0	124.6	107.5	17.0
	Salem	8650	5042	58.29	1736.7	260.5	1476.2	1235.1	1012.3	151.8	860.5	719.8	140.5
	Tiruchirappalli	11095	2246	20.24	2228.0	334.2	1893.8	984.6	451.0	67.7	383.4	199.3	184.1
	Total		**8429**						**1635.2**	**245.3**	**1389.9**	**1039.9**	**350.1**

Table 3.6(d) : Ground Water Potential for Cauvery River Basin in India.

Sl. No.	State/District/ & Name of sub-basin	Geological area		Factor %	Ground Water								
		whole district	within the sub-basin		Total repleni-shable resource	Provision for dome stic & industrial use	Available resource for irriga--tion	Net draft	Total repleni-shable resource	Provision for dome stic & industrial use	Available resource for irriga--tion	Net draft	Balance for future use
1	2	3	4	5	6	7	8	9	10	11	12	13	14
13	***Ponnanai Ar sub-basin***												
	Tamilnadu												
	Madurai	12624	24	0.19	1320.0	198.0	1122.0	597.4	2.5	0.4	2.1	1.1	1.0
	Pudukkottai	4661	486	10.43	1181.0	177.2	1003.9	235.0	123.1	18.5	104.7	24.5	80.2
	Thanjavur	8280	3	0.04	1631.6	244.7	1386.9	580.9	0.6	0.1	0.5	0.2	0.3
	Tiruchirappalli	11095	1537	13.85	2228.0	334.2	1893.8	984.6	308.6	46.3	262.3	136.4	126.0
	Total		**2050**						**434.9**	**65.2**	**369.7**	**162.2**	**207.4**
14	***Upper coleroon sub-basin***												
	Tamilnadu												
	Tiruchirappalli	11095	3080	27.76	2228.0	334.2	1893.8	984.6	618.5	92.8	525.7	273.3	252.4
	Thanjavur	8280	2	0.02	1631.6	224.7	1386.9	580.9	0.4	0.1	0.3	0.1	0.2
	Total		**3082**						**618.8**	**92.8**	**526.0**	**273.4**	**252.6**
15	***Lower coleroon sub-basin***												
	Tamilnadu												
	Tiruchirappalli	11095	522	4.70	2228	334.2	1893.8	984.6	104.8	15.7	89.1	46.3	42.8
	Thanjavur	8280	144	1.74	1631.6	244.7	1386.9	580	28.4	4.3	24.1	10.1	14.0
	South Arcot	10895	712	6.54	4218.1	632.7	3585.4	2608.8	275.7	41.3	234.3	170.5	63.8
	Total		**1378**						**408.9**	**61.3**	**347.5**	**226.9**	**120.6**
16	***Cauvery Delta sub-basin***												
	Tamilnadu												
	Pudukkottai	4661	144	3.09	1181.0	177.2	1003.9	235.0	36.5	5.5	31.0	7.3	23.8
	Thanjavur	8280	1915	23.13	1631.6	244.7	1386.9	580.9	377.4	56.6	320.8	134.4	186.4
	Nagappatti	4664	4269	91.53	590.6	88.6	502.0	500.3	540.6	81.1	459.5	457.9	1.6
	nam Quaid-E-Millad												
	Tiruchirappalli	11095	89	0.80	2228.0	334.2	1893.8	984.6	17.9	2.7	15.2	7.9	7.3
	Pondecherry												
	Karaikal	492	149	30.28	28.8	4.3	24.5	6.0	8.7	1.3	7.4	1.8	5.6
	Total		**6566**						981.0	**147.2**	**833.9**	**609.3**	**224.6**
Grand total Cauvery basin:									10356.5	**1553.5**	**8803**	**4936.5**	**3866.5**

Source: Ground Water Resources of India (1995), Central Ground Water Board, Faridabad, Ministry of Water Resources, Government of India.

Chapter - 4

WATER BALANCE STUDIES OF CAUVERY RIVER BASIN

4.1 GENERAL

In India, rainfall is confined to the monsoon season and is unevenly distributed both in space and time even during the monsoon season. As a result, frequent droughts and floods affect the country's economy. It is necessary to harness the water resources in a most scientific and efficient manner. Cauvery river basin often faces shortage of water resulting in a longstanding dispute between the upper riparian state of Karnataka and lower riparian state of Tamilnadu. Therefore the water balance studies for different sub-basins and the Cauvery basin as a whole are necessary to quantify the requirements in the sub-basins and the basin as a whole. The monthly water balance technique includes, the assessment of the water yield in the sub basin/basin, quantification of existing uses, and reasonable requirements of basin states in the foreseeable future and the determination of order of surplus/deficits. Such a study is attempted here and the procedure is given in this chapter for the "Kabini sub-basin of the Cauvery River basin in India" and the same procedure is adopted for all the 16 sub-basins, and by adding all the 16-sub-basins, the order of surplus/deficit for Cauvery river basin as a whole is determined for 75%, 50%. 90%, and 100% water year dependable flows as given in this chapter.

4.2 WATER BALANCE OF A RIVER BASIN

For overall assessment of the water balance of a river basin, availability of both surface water and ground water is required to be assessed. To establish the surplus/deficit in a river basin with reasonable reliability, it is necessary to take into consideration, the total availability of water, the present water utilizations and the utilization, which could possibly be made in the foreseeable future.

The following steps are involved in the surface water and ground water balance of a river basin at the specified site:

(i) Fill in the missing discharge data, if any.

(ii) Check the consistency of discharge data.

(iii) Estimate the regeneration from the upstream water utilisation.

(iv) Then, the virgin flow is given by

Virgin flow = observed flow + upstream water utilizations.

(v) Derive rainfall-runoff relations for the monsoon period on monthly basis and use the relation for finding run-off from the rainfall record.

(vi) Calculate the non-monsoon run-off as a percent of the monsoon run-off.

(vii) Calculate the 75% water year dependable flow/yield from the catchment.

(viii) Estimate ground water availability based on annual replenishment.

(ix) Calculate the future projections of human and live stock populations for the year; for which, the water resources planning is being done.

(x) Estimate the irrigation, domestic, industrial, hydropower and environmental water requirements with the given guidelines as follows, on the basis of guidelines of NWDA, for water balance studies.

(a) Irrigation Water requirements

Existing : As per projects reports, designed,

Ongoing : As per projects reports, designed,

Future : (as per norms of NWDA)

Major projects (irrigation intensity 150 %) water depth in m.

Medium projects (irrigation intensity 125 %) water depth in m.

Minor project (irrigation intensity 100 %) water depth in m.

(b) Domestic water requirements

Urban : 200 liters/day/capita

Rural : 70 liters/day/capita,

Live stock : 50 liters/day/capita

(c) Industrial Water Requirements

As the adequate data is not available about the industries, the water needs are calculated on the same basis as those for domestic. Industrial water is supplied from the surface water.

(d) Hydropower Water Requirements

The evaporation loss from the reservoirs should be estimated and added to the consumptive uses. Evaporation losses from the reservoirs: (i) Existing and ongoing reservoirs: (as per actual); (ii) Proposed: (20% of utilizable water).

(e) Environmental Water Requirements

The monthly/annual environmental water requirements in this study are considered as 1% of the monthly/annual surface water inflows/yields in the sub-basin/basin.

(xi) Determine the import of water from other basins and the export of water to other sub-basins/basins, both with respect to the basin under consideration.

(xii) Finally the water balance at the specified site is done in the following manner: -

Water balance = [(The 75% water year dependable flow/yield + Ground water availability + Regeneration + Imports) -(Export + Total water needs)].

(iii) The water balance will be determined by the surplus or the deficit in the basin/sub-basins at that specified site.

4.3 A SAMPLE WATER BALANCE OF KABINI SUB - BASIN

The Kabini river is one of the tributaries of the river Cauvery in its upper-reach in South India. The Kabini sub-basin lies between north latitudes 11^0 29' and 12^0 20' and east longitudes 75^0 48' and 75^0 54'.The Kabini river rises in the Western Ghats at an elevation of about 2140 m above mean sea level in the Wyand district of Kerala state.

4.3.1 Basin Hydrology

4.3.1.1 Surface water availability

The data of 49-rain gauge stations out of the 52 stations, in and around catchment up to the T. Narsipur G&D site has been considered. The catchment of the sub-basin also being the same as that of the T. Narsipur G&D site, the values of weighted average yearly monsoon rainfall of the sub-basin /up to the T.Narsipur G&D site for the period from 1901-02 to 1985-86 have been computed by Thiessen polygon method.

4.3.1.2 Rainfall and runoff data

For computations of the yield, the rainfall and runoff data is required. As per the Kabini sub-basin NWDA report, there are 18 G&D sites and 1 gauge site in the sub-basin, inflow data of 4 reservoirs and 1 Anicut are also available. The discharge data of

T.Narasipur G&D site has been considered for the hydrological studies as it covers the entire catchment of Kabini sub-basin and also better method of observation is followed at this site. The monthly-observed yield data at T.Narasipur G&D site for the period from 1971-72 to 1985-86 having catchment area 7040 km^2 are given in Table 4.1.

4.3.1.3 Upstream utilizations

The utilization upstream of above G&D site through the existing projects has been added to the observed yields at the G&D site and the regeneration from the major and medium projects has been deducted to arrive at gross monsoon yields up to the G&D site of each year for the period from 1971-72 to 1985-86.

There are 8 major/medium existing irrigation projects in the catchment upstream of T.Narasipur G&D site. Out of these 8 projects, 5 are storage projects and the remaining 3 are Anicut channels. In the absence of actual utilisation data in respect of 2 anicuts, the utilisation for the same has been computed from the designed area by adopting a delta of 1.6m uniformly for all the years. For the other projects, the utilisation has been arrived at from the inflow and outflow data of the respective projects. The regeneration from the utilizations of above projects has been computed, taking 18% for old projects, i.e., Anicut channels and Nugu reservoir and 10% in respect of all the other projects.

4.3.1.4 Computation of surface water yield

Using the gross monsoon yields of the catchment up to T.Narasipur G&D site and the corresponding weighted average monsoon rainfall of each year for the period from 1971-72 to 1985-86 rainfall run-off relationships have been developed by regression analysis considering both the linear and non-linear forms of equations as given below:

Table 4.1: Monthly Observed Yield of Kabini River at T. Narasipur G&D Site

Units: MCM

Year (1)	Jun (2)	Jul (3)	Aug (4)	Sep (5)	Oct (6)	Nov (7)	Dec (8)	Jan (9)	Feb (10)	Mar (11)	Apr (12)	May (13)	Annual Total (14)
1971-72	689.6	920.3	853.4	546.6	470.8	219.6	153.2	53.0	23.3	15.6	21.8	282.6	4249.8
1972-73	101.8	1258.7	536.2	347.7	309.8	141.1	165.0	47.5	25.1	11.7	21.2	151.0	3116.8
1973-74	637.1	1152.1	980.3	375.8	169.8	116.3	65.2	30.8	15.2	7.8	14.14	29.8	3597.1
1974-75	30.0	763.6	1225.	390.5	256.0	93.8	162.3	42.3	50.9	60.8	98.7	120.6	3294.5
1975-76	307.2	775.9	1307.7	508.0	413.4	188.7	99.1	46.4	49.5	96.5	134.6	165.1	4092.1
1976-77	80.2	132.7	706.5	523.6	154.7	91.8	43.2	43.2	54.1	71.6	99.9	215.0	2216.5
1977-78	16.5	875.8	444.5	596.1	452.3	276.0	122.6	49.0	32.5	77.7	172.8	82.6	3198.4
1978-79	473.6	967.8	1239.6	451.1	210.4	231.8	113.3	56.40	46.4	74.2	223.9	266.4	4354.9
1979-80	173.4	1707.1	1711.	312.5	211.5	231.5	102.0	35.2	42.5	58.7	85.1	107.7	4778.2
1980-81	679.9	1989.8	777.9	445.9	317.0	238.8	173.5	90.4	47.5	75.9	64.1	85.5	4986.2
1981-82	479.4	607.5	1319.7	807.0	334.14	251.9	134.4	73.6	93.9	82.1	85.5	121.9	4893.8
1982-83	283.9	471.4	869.7	197.3	204.0	165.2	143.9	82.8	88.0	63.2	69.0	73.8	2712.2
1983-84	62.2	566.3	816.0	415.0	289.6	216.3	121.2	65.7	58.1	87.4	79.7	91.8	2869.3
1984-85	706.3	1252.7	593.3	301.6	511.2	171.0	115.8	37.7	31.3	53.9	77.2	64.7	3916.7
1985-86	419.6	420.8	624.7	287.5	179.3	158.2	200.5	43.8	58.9	58.0	51.6	50.0	2552.9

(a) $Y = ax + b$

(b) $Y = ax^b$

where Y is the gross monsoon yield in mm; X is the weighted average monsoon rainfall in mm; and a and b are regression constants.

The linear equation is found to be the best-fit equation based on the least standard error of estimation and it has been assumed to hold good for the entire sub-basin. The monsoon yields for the period 1901-02 to 1985-86 for sub-basin were computed by substituting the weighted average monsoon rainfall values of each year in the best-fit equation. The percentage of gross non-monsoon yield to the gross monsoon yield is found to be 11.32. Considering this percentage the non-monsoon yields of each year is computed and the same is added to the monsoon yields to arrive at the annual yield of the sub-basin for that year. The annual yield series thus generated is arranged in descending order, from which the 75% water year dependable yield of the sub-basin are found to be 3641 MCM.

4.3.1.5 Ground water availability / assessment

From the gross ground water potential, provision for domestic uses and existing irrigation (uses) draft in the sub basin have been assessed on proportionate area basis from district-wise ground water statistics published by Central Ground Water Board (CGWB), under the Ministry of Water Resources, Government of India, report for 1995. Based on these details, total as well as balance ground water available for irrigation development has been worked out. The urban water requirement in full and 50% of the rural water requirement is proposed to be met from surface water resources and 50% of the rural water requirement is proposed to be met from groundwater sources and the entire livestock water requirement is proposed to be met from groundwater, and for Kabini sub-basin this works out to 225 MCM and 280 MCM for without ground water and with ground water considerations, respectively. The details are given in Tables 3.6(a) to 3.6(d).

4.3.2 Compilation of Land Use Statistics

The areas under different land use and their percentage to the geographical area of the sub-basin for five years were compiled from taluka–wise statistics. The cultivable area was taken to comprise net area sown, land under miscellaneous crops and trees, current fallows, other fallows and cultivable waste. The land use figure for the year in which the cultivable area is maximum has been considered in the study.

4.3.3 Imports and Export

4.3.3.1 Imports

There is an existing import of 28.44 MCM of water through Anicut channels from Upper Cauvery sub-basin. Further a quantity of 31.42 MCM of Upper Cauvery water is being used for water supply to Mysore City through right bank low level canal of KRS.

A quantity of 297.33 MCM is envisaged to be imported from Upper Cauvery sub-basin through an ongoing project namely extension under Krishnarajasagar stage-I.

Apart from the above, a small quantity of 2.05 MCM is also proposed to be imported from Upper Cauvery sub-basin through Middle Cauvery sub-basin for Anicut channels under Rabi crops. The total import works out to 359 MCM.

4.3.3.2 Exports

There is no export of water from the existing projects.

As regards ongoing projects, Kabini project stage-I envisages an export of 425.48 MCM and 201.87 MCM to Middle Cauvery and Suvarnavathi sub-basins, respectively. Other two projects namely Mananthvady multi purpose scheme and Banasursagar Sagar project located in Kerala portion of the sub-basin also envisage an export of 495.50 MCM and 189.00 MCM to Valapattanam and Kuttiyadi basins, respectively, of west flowing rivers of Kerala .The Cauvery water supply scheme stage-III to Bangalore city (Arkavathi sub-basin) which is under construction at present also receives water from Kabini sub-basin to the extent of 98.55 MCM.The export from the proposed Kabini sub-basin project stage-II is estimated to be 95 MCM and 289.63 MCM of water to Middle Cauvery and Suvarnavathi sub-basin, respectively. Thus the total export from Kabini sub-basin is 1795 MCM.

4.3.4 Water Requirements / Water Needs

4.3.4.1 General

While planning for water resources development in any basin, an assessment of reasonable needs of the basin in the foreseeable future for various purposes like domestic, irrigation, hydropower and industries is essential. These needs are to be met either from the surface flows or from ground water sources or from a combination of both. Assessment of the reasonable requirements of water in the Kabini sub-basin by the end of 2050 AD under each category has been attempted in the following paragraphs.

The requirement of water for various uses, viz., domestic, irrigation, industrial and hydro-power generation was determined as under.

4.3.4.2 Domestic water needs

The requirement of domestic consumption in the rural and urban areas as well as for the livestock has been obtained by projecting the rural, urban and live stock population of the Kabini sub-basin to the 2050 AD. The requirement of water per capita per day for rural and urban and live stock populations is considered as 70 liters, 200 liters and 50 liters, respectively.

The population as per census 1981 for states of Karnataka, Kerala and Tamilnadu are available (NWDA Report of Kabini Sub-basin, 1992).

The population and livestock have been projected from 1981 to the year 2050 AD using the formula.

$$P_{2050} = P_{1981}\left[1+\frac{R}{100}\right]^{N}$$

where P_{2050} = Population in 2050 AD.

P_{1981} = Population (known) in the year 1981 AD,

R = Compound rate of growth of population, and

N = Number of years.

4.3.4.3 Population

For Human population projections, the growth rates assumed are as given in Table 4.2. (Guidelines of NWDA for preparation of preliminary water balance study, 1998):

Table 4.2: Growth Rates for Projecting Human Population

Period (Years) (1)	Growth rate in % (2)
1981-1985	2.06
1985-1990	2.06
1990-1995	1.93
1995-2000	1.78
2000-2010	1.53
2010-2020	1.10
2020-2030	0.92
2030-2040	0.72
2040-2050	0.48

The human population and live stock population for Karnataka, Kerala and Tamilnadu for Kabini sub-basin are as given in Table 4.3.

Table 4.3: Kabini Sub-basin: Projected Human and Livestock Population by 2050 AD

Population (1)	Karnataka (2)	Tamilnadu (3)	Kerala (4)	Total (5)
Urban human	2770894	0	0	2770894
Rural human	1041194	23027	729785	1794006
Total human	3812088	23027	729785	4564900
Livestock	711434	8777	1818490	902060

The live stock population as per the senses (1982-83) in Kabini sub-basin is projected for 2050 AD as given in Table 4.3. The growth rate for calculating projected live stock population is considered 1% per year. The urban water requirement in full and 50% of the rural water requirement is proposed to be met from surface water resources and this works out to 225.0 MCM. The entire live stock water requirement and 50% of the rural water requirement is proposed to be met from ground water sources and 50% of the domestic water requirement to be met from surface water resources is considered to be available as regeneration.

4.3.4.4 Irrigation needs

The modified Penman method was used to compute the crop water requirement.

The annual irrigation under future major, medium and minor schemes is assessed considering irrigation intensity of 150%, 125% and 100%, respectively, as per NWDA norms and the annual utilisation has been determined on climatological approach.

The designed annual irrigation and utilisation in respect of all the existing and ongoing projects have been kept undisturbed in assessing surface water needs. For assessing the surface water needs for irrigation, an estimate has been made of the area that can be brought under irrigation by 2050 AD and the reasonable requirement for irrigating the area. The area that can be brought under irrigation by surface water is taken to comprise the area under irrigation from the existing major, medium and minor projects and the area that would be brought under irrigation from the ongoing and identified future major, medium and minor projects. The water needs for irrigating the crops under future projects including the additional area to be brought under irrigation has been computed on climatological approach. Normal monthly values of potential evapo-transpiration of Mysore observatory computed by modified Penmen's method are given in the IMD publication "Potential Evapo-transpiration (PE) over India" (Scientific Report No. 136, February 1971) and these values are used for computing the net irrigation requirement of different crops.

The potential evapo-transpiration, humidity, temperature, sunshine hours, normal monthly rainfall for Mysore observatory are given in Table 4.4.

The gross irrigation requirement of different crops have been worked out considering an irrigation efficiency of 65% for paddy and 55% for other crops under major and medium projects and an irrigation efficiency of 80% for paddy and 70% for other crops under minor projects. The computations of net and gross irrigation water requirement for different crops are done to find out the irrigation requirements. Considering evaporation losses at 20% of the gross irrigation water requirement for the crops, values of weighted average gross delta have been computed and found to be 1.14 m for major projects, 1.14 m for medium projects and 0.88 m for minor projects. Details of the computation are given in Tables 4.5, 4.6 and 4.7, respectively.

Table 4.4: Metrological Data for Kabini Sub-basin Observed at Mysore I.M.D. Station

Month	Temperature (° C)		Relative Humidity (%)		Wind Speed		Cloud Cover of Sky (Oktas)		Normal Rainfall	Monthly Evapo-transpiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	28.3	16.4	75	30	11.3	225	3.0	2.9	2.8	128.4
Feb	31.2	18.2	69	25	9.1	181	2.8	2.9	5.5	133.5
Mar	33.5	20.2	71	21	8.8	175	2.3	3.2	12.0	165.9
Apr	34.0	21.4	75	34	8.4	167	3.7	5.1	67.6	154.2
May	32.6	21.2	79	51	10.2	203	4.9	5.5	156.9	147.6
Jun	28.9	20.2	81	66	13.9	277	5.9	6.4	60.5	123.5
Jul	27.3	19.7	84	70	14.1	281	6.4	6.8	71.9	115.5
Aug	27.9	19.6	84	67	12.5	249	6.2	6.7	80.1	117.2
Sep	28.7	19.3	83	61	10.7	213	5.7	6.1	116.3	116.9
Oct	28.4	19.6	85	61	7.9	157	5.6	5.9	179.9	110.5
Nov	27.4	18.3	80	54	9.3	185	4.7	4.9	66.6	106.0
Dec	27.0	16.5	78	43	11.3	225	3.6	3.9	14.7	114.3

Table 4.5: Computation of Weighted Average Delta for Proposed Major Projects

CCA = 100 ha, Annual Irrigation = 150 ha.

Name of Crop (1)	Area (%) (2)	GIR (m) (3)	Water Requirement (ham) (4)
Kharif			
Paddy	42	1.494	62.75
Jowar	6	0.268	1.61
Ragi	12	0.268	3.22
Fodder	6	0.268	1.61
Cotton	6	0.445	2.67
Rabi			
Paddy	12	1.835	22.02
Pulses	24	0.566	13.58
Fruits & Vegetables	12	0.503	6.03
Ground nut	18	0.664	11.95
Perennial			
Sugarcane	6	1.349	8.09
Coconut	6	1.535	9.21
Total	**150**		**142.74**

Add 20% evaporation losses = 28.55

Total water requirement = 171.29

Weighted average delta =171.20/150

= 1.14 m.

Table 4.6: Computation of Weighted Average Delta for Proposed Medium Projects

CCA = 100 ha.   Annual Irrigation = 125 ha.

Name of Crop (1)	Area (%) (2)	GIR (m) (3)	Water Requirement (ham) (4)
Kharif			
Paddy	35	1.494	52.29
Jowar	5	0.268	1.34
Ragi	10	0.268	2.68
Fodder	5	0.268	1.34
Cotton	5	0.445	2.23
Rabi			
Paddy	10	1.835	18.35
Pulses	20	0.566	11.32
Fruits & Vegetables	10	0.503	5.03
Ground nut	15	0.664	9.96
Perennial			
Sugarcane	5	1.349	6.75
Coconut	5	1.535	7.68
Total	**125**		**118.97**

Add 20% evaporation losses = 23.79

Total water requirement = 142.76

Weighted average delta = 142.76/125

= 1.14 m.

Table 4.7: Computation of Weighted Average Delta for Proposed Minor Projects

CCA = 100 ha.   Annual Irrigation = 100 ha.

Name of Crop (1)	Area (%) (2)	GIR (m) (3)	Water Requirement (ham) (4)
Kharif			
Paddy	30	1.174	35.22
Jowar	5	0.211	1.06
Ragi	10	0.211	2.11
Fodder	5	0.211	1.06
Cotton	5	0.350	1.75
Rabi			
Paddy	5	1.441	7.21
Pulses	15	0.445	6.68
Fruits & Vegetables	8	0.395	3.16
Ground nut	7	0.522	3.65
Perennial			
Sugarcane	5	1.060	5.30
Coconut	5	1.206	6.03
Total	**100**		**73.23**

Add 20% evaporation losses = 14.64

Total water requirement = 87.87

Weighted average delta = 87.87/100

= 0.88 m.

The ultimate annual irrigation water requirements for the existing ongoing and future irrigation schemes are given in the Table 4.8.

Table 4.8: Ultimate Surface Water Requirement for Irrigation

Category	Annual Irrigation (ha)			Annual Utilization (MCM)		
	In basin	From import	Total	In basin	From import	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Existing Projects	36346	1580	37926	637.77	28.44	666.21
Ongoing Projects	49288	41700	90988	574.63	297.33	871.96
Identified Future Projects	92876	180	93056	1033.06	2.05	1035.11
Total	**178510**	**43460**	**221970**	**2245.46**	**327.82**	**2573.28**

Thus the ultimate annual irrigation water requirement will be 2573 MCM including import of 12 MCM. The climatic data of Mysore IMD station is used for calculating monthly ETo values.

4.3.4.5 *Industrial Needs*

In the absence of actual data on the existing, ongoing and future industries, the industrial water requirement was assumed to be of the same order as that of ultimate domestic water requirements by 2050 AD. The entire industrial water requirement is proposed to be met from surface water source, which is 280 MCM, and 80% of this requirement is considered to be available as regeneration to the stream. This works out to 224 MCM.

4.3.4.6 Hydropower Needs

There are no existing, ongoing or proposed hydroelectric projects in the sub–basin. As such, the requirement of water for hydropower generation is taken as nil.

4.3.4.6.1 Environmental Needs

Environmental needs are considered to maintain the minimum flow required in the river to keep quality of the water to a designed standard which is taken as 1% of the surface water available in the sub basin / basin.

4.3.4.7 Regeneration

The quantum of return flows to the stream has been considered as10% of gross utilization for irrigation from ongoing and future major and medium projects and 18% of the gross water utilized for irrigation from the existing major and medium irrigation projects; and 80% of domestic and industrial needs to be met from surface water resources is considered as regeneration to the stream. The total regeneration works out to 651 MCM.

4.3.4.8 Ultimate Surface Water Requirements

The ultimate surface water requirement for irrigation, domestic, hydropower and industrial needs and environmental needs works out to 2577 MCM, 225 MCM, 9 MCM and 280 MCM, respectively. Thus, the total surface waters requirement for all uses in the Kabini sub–basin will be 3127 MCM including 36 MCM for environmental releases.

4.3.5 Water Balance

The water balance taking into account, the water availability, import, export, requirements (water needs) and regeneration is given in Table 4.9 below:

Table 4.9: Water Balance for Kabini Sub-basin

Sl. No.	Item		Amount (MCM)
1.	Surface water availability @ 75% dependability		3641
2.	Regeneration		651
3.	Surface water import (+)		359
4.	Overall availability		4651
5.	Surface water export (-)		1795
6.	Surface water requirement for		
	(i)	Irrigation by in-basin and imported water	2577
	(ii)	Domestic use	225
	(iii)	Industrial use	280
	(iv)	Hydro power	9
	(v)	Environmental use	36
		Sub total	3127
7.	Regeneration		
	(i)	Domestic use 80 %	180
	(ii)	Irrigation use 10%	247
	(iii)	Industrial use 80%	224
		Sub total	651
8.	Surface water yield		3641
9.	Ground water		
	(a)	Gross ground water potential	716
	(b)	Provision for domestic and industrial use	108
	(c)	Total ground water available for irrigation (a-b)	608
	(d)	Existing irrigation draft	222
	(e)	Balance ground water available for additional irrigation (c-d)	386
10.	Overall water balance of the sub-basin		
	(i)	With consideration of ground water: (Overall availability) – (export + total water needs) (4651 + 386 = 5037) – (1795 + 3127) =	115
	(ii)	Without consideration of ground water: (4651 – 1795 - 3127) =	-271

4.4 DETAILED SUB-BASINWISE WATER BALANCE STUDY OF CAUVERY

4.4.1 Methodology Used For Water Balance Study

The data required for water balance study, i.e., the total annual irrigation requirements of ongoing, existing and proposed major, medium and minor irrigation projects, exports and imports, rural, urban, livestock population, regenerations from irrigation projects, hydropower use etc. were collected from the various reports of preliminary water balance studies and basic data reports of Cauvery basin from National Water Development Authority, under the Ministry of Water Resources, Government of India, New Delhi.

The following steps were used for computation of water balance on monthly basis for all the sixteen sub-basins in Cauvery basin and Cauvery basin as a whole.

Column 1: Months starting from June to May (i.e. water year).

Column 2: The monthly net irrigation requirements for the proposed major, medium and minor irrigation projects are calculated by climatological approach by using modified Penman method. The gross irrigation requirements were calculated by adding 20 percent to the net irrigation requirements for accounting for the reservoir evaporation losses.

Column 3: The monthly gross irrigation requirements for the existing major, medium and minor irrigation projects are calculated by distributing the annual irrigation requirements of the projects in the same proportion as of the monthly gross irrigation requirements of the proposed irrigation projects.

Column 4: The monthly gross irrigation requirements for the ongoing projects are calculated by distributing the annual irrigation requirements of projects in the same proportion of monthly irrigation requirements of the proposed irrigation projects.

Column 5: The total monthly irrigation requirement of the system is computed by summing the columns 2, 3 and 4.

Column 6: The requirement of domestic consumption in the rural and urban as well as for the livestock has been obtained by projecting the rural, urban and live stock population of a sub-basin/basin to the 2050 AD. The requirement of water per capita per day for rural and urban and live stock population is considered as 70 liters, 200 liters and 50 liters respectively.

Column 7: Due to the non-availability of the data, the monthly and total water requirements of industrial water use are taken equal to the water requirements for domestic purposes.

suchas

Column 8: The annual hydropower requirement is taken as per the practice adopted by NWDA. The storage products which are used purely for generation of hydropower as single purpose, the water stored throughout the year for electricity generation and after utilization for electricity generation, the water is released in the parent river. Hence, annual evaporation losses in the single purpose hydropower projects are taken as hydropower requirement and annual hydropower requirement is distributed on the monthly basis in the proportion of the number of days.

Column 9: The monthly environmental water requirements are taken equal to 1 percent of the monthly surface water available in the sub-basin.

Column 10: The monthly water requirement in a sub-basin is computed by summing the water utilizations for irrigation, domestic, industrial, hydropower and environmental purposes.

Column 11: The monthly exports are calculated by distributing the total annual exports in a sub-basin in the proportion of the monthly availability of the surface water in that sub-basin.

Column 12: The monthly gross water requirements are computed by summing all the monthly water requirements for irrigation, domestic, industrial, hydropower, environmental and exports.

Column 13: The monthly imports are computed by distributing of total annual import in the proportion of the monthly irrigation requirements of the importing sub-basin.

Column 14: The monthly regeneration from irrigation water use is assumed as 10 percent to 20 percent of the monthly irrigation water requirements.

Column 15: Regeneration from domestic purposes is computed as 80 percent of the domestic water use.

Column 16: The monthly regeneration from industrial water use is taken as 80 percent of the monthly industrial water use.

Column 17: The total monthly regeneration is computed by summing of monthly regenerations from irrigation, domestic and industrial water uses.

Column 18: The monthly surface water yield in the sub-basin is taken in the proportion of the monthly-observed run-off in the sub-basin.

Column 19: The monthly ground water yield in a basin is computed by distributing the annual ground water yield in the proportion of the monthly irrigation water requirements.

Column 20: The total monthly water availability in a basin is computed summing monthly imports from other basins; monthly regenerations from irrigation, domestic and industrial uses; monthly surface water and ground water yields.

Column 21: The monthly water balance of a basin is the difference between the total monthly water available and the total monthly water utilizations.

If the monthly water availability is more than the monthly utilization in a basin then it is known as water surplus basin; and if the monthly utilization is more than the monthly water availability, then it is known as water deficit basin.

4.4.2 Results of Sub-basinwise Water Balance Study

The detailed water balance studies carried out monthly on annual basis for all the 16 sub-basins in the Cauvery river basin for 75%, 50%, 90%, and 100% water year dependable flows, with and without considerations of ground water are presented in the

Tables 4.10.1(a) to Table 4.10.4(h). The abstracts of the sub-basinwise annual water balance studies for Cauvery basin for 75%, 50%, 90% and 100% water year dependable flows, are presented in Table 4.11.1 to Table 4.11.5. The sub-basin wise annual water balance for 75%, 50%, 90% and 100% water year dependable flows without and with ground water are presented in Table 4.12.1 to Table 4.12.4. The sub-basinwise monthly deficits/surpluses for 75%, 50%, 90%, and 100% water year dependable flows, with and without considerations of ground water are presented in the Table 4.13.1 to Table 4.13.4. The sub-basinwise monthly deficits or surpluses in descending order with percent of deficit or surplus for 75%, 50%, 90%, and 100% water year dependable flows, with and without considerations of ground water are presented in the Table 4.14.1 to Table 4.14.16. The graphical presentations of monthly water deficits surplus without groundwater and with groundwater considerations for all the 16 sub-basins are shown in Figures 4.1 to Figure 4.16.

4.5 ANALYSIS OF WATER BALANCE STUDIES FOR THE 75% WATER YEAR DEPENDABLE FLOW

The water balance studies are carried out monthly on an annual basis, for with and without considerations of ground water for a normal year, i.e., the 75% water year dependable flow.

4.5.1 The sub-basin wise analysis of the water balance studies for the 75% water year dependable flows, without ground water considerations, for the Cauvery river basin is as follows:

4.5.1.1 Upper Cauvery Sub-basin

In the case of water balance studies of Upper Cauvery sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.1(a)], the sub-basin was found short of water in the months of June and September to April, where as the sub-basin is surplus in its water resources in the months of July, August and May. The maximum deficit of 391.3 MCM (8%) occurred in the sub-basin in the month of October, while the minimum deficit of 17.62 MCM (0.40 %) occurred in the sub-basin in the month of November. The maximum surplus of 598.37 MCM (12%) occurred in the month of July, while the minimum surplus of 18.00 MCM (0.40%) occurred in the month of May. The annual deficit in the sub-basin is 274.4 MCM (6%).

4.5.1.2 Kabini Sub-basin

For the water balance studies carried out monthly on an annual basis for Kabini sub-basin for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.2(a)], it was found that in the sub-basin deficits occurred in the months of September and December to April, while the surpluses occurred in the months of June, July, August, October and May. The maximum deficit of 253.1 MCM (5.2%) occurred in the sub-basin in the month of January, while minimum deficit of 5.67 MCM (0.10 %) occurred in the sub-basin in the month of April. The maximum surplus of 132.86 MCM (2.71%) occurred in the month of June, while the minimum surplus of 4.46 MCM (0.09%) occurred in the month of November. The annual deficit in the sub-basin is 267.8 MCM (5.5%).

4.5.1.3 Shimsha Sub-basin

For the water balance studies carried out monthly on an annual basis for Shimsha sub-basin for the 75% water year dependable flow, without ground water consideration [refer Table 4.10.3(a)], it was found that in the sub-basin deficits occurred in the months of June to August and December to April, while the surpluses occurred in the months of September to November and May. The maximum deficit of 68.87 MCM (2%) occurred in the sub-basin in the month of January, while minimum deficit of 0.25 MCM (0.02 %) occurred in the sub-basin in the month of June. The maximum surplus of 294.72 MCM (8%) occurred in the month of October, while the minimum surplus of 8.86 MCM (0.2%) occurred in the month of May. The annual deficit in the sub-basin is 150.81 MCM (4%).

4.5.1.4 Arkavathi Sub-basin

In the case of water balance studies of Arkavathi sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.4(a)], the sub-basin was found short of water through out the year. The maximum deficit of 205.2 MCM (10.9%) occurred in the sub-basin in the month of September, while the minimum deficit of 24.56 MCM (1.30 %) occurred in the sub-basin in the month of April. The annual deficit in the sub-basin is 799.2 MCM (42.4%).

4.5.1.5 Middle Cauvery Sub-basin

For the water balance studies carried out monthly on an annual basis for Middle Cauvery sub-basin for the 75% water year dependable flow, without ground water consideration [refer Table 4.10.5(a)], it was found that in the sub-basin deficits occurred in the months of January to June, while the surpluses occurred in the months of July to December. The maximum deficit of 3.31 MCM (0.2%) occurred in the sub-basin in the month of March, while minimum deficit of 1.63 MCM (0.01 %) occurred in the sub-basin in the month of January. The maximum surplus of 24.14 MCM (1.1%)

occurred in the month of September, while the minimum surplus of 3.54 MCM (0.20%) occurred in the month of December. The annual surplus in the sub-basin is 67.40 MCM (3.1%).

4.5.1.6 Suvarnavathi Sub-basin

. In the case of water balance studies of Suvarnavathi sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.6(a)], the sub-basin was found short of water in the months of June to September and December to May, where as the sub-basin is surplus in its water resources in the months of October and November. The maximum deficit of 17.01 MCM (2.3%) occurred in the sub-basin in the month of July, while the minimum deficit of 0.55 MCM (0.10 %) occurred in the sub-basin in the month of May. The maximum surplus of 6.52 MCM (0.88%) occurred in the month of October, while the minimum surplus of 3.83 MCM (0.52%) occurred in the month of November. The annual deficit in the sub-basin is 80.00 MCM (11%).

4.5.1.7 Palar Sub-basin

For the water balance studies carried out monthly on an annual basis for Palar sub-basin for the 75% water year dependable flow, without ground water consideration [refer Table 4.10.7(a)], it was found that in the sub-basin deficits occurred throughout the year except the months of June and October. The maximum deficit of 30.75 MCM (9.5%) occurred in the sub-basin in the month of July, while minimum deficit of 0.59 MCM (0.20 %) occurred in the sub-basin in the month of May. The maximum surplus of 6.00 MCM (1.9%) occurred in the month of June, while the minimum surplus of 1.84 MCM (0.60%) occurred in the month of October. The annual deficit in the sub-basin is 161 MCM (50%).

4.5.1.8 Chinnar Sub-basin

In the case of water balance studies of Chinnar sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.8(a)], the sub-basin was found short of water throughout the year. The maximum deficit of 4322.6 MCM (32%) occurred in the sub-basin in the month of October, while the minimum deficit of 156.75 MCM (1.20 %) occurred in the sub-basin in the month of July. The annual deficit in the sub-basin is 13103 MCM (96%).

4.5.1.9 Bhavani Sub-basin

In the case of water balance studies of Bhavani sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.9(a)], the sub-basin was found short of water in the months of June to September and January to May, where as the sub-basin is surplus in its water resources in the months of October, November and December. The maximum deficit of 164.53 MCM (5.8%) occurred in the sub-basin in the month of March, while the minimum deficit of 8.84 MCM (0.30 %) occurred in the sub-basin in the month of July. The maximum surplus of 98.8 MCM (3.50%) occurred in the month of November, while the minimum surplus of 35.44 MCM (1.30%) occurred in the month of December. The annual deficit in the sub-basin is 424.90 MCM (15%).

4.5.1.10 Noyil Sub-basin

For the water balance studies carried out monthly on an annual basis for Noyil sub-basin for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.10(a)], it was found that in the sub-basin deficits occurred in the months of June to September and January to May, while the surpluses occurred in the months of October, November and December. The maximum deficit of 49.75 MCM (4.3%) occurred in the sub-basin in the month of June, while minimum deficit of 11.19 MCM (1.0 %) occurred in the sub-basin in the month of September. The maximum surplus of 106.39 MCM (9.2%) occurred in the month of October, while the minimum surplus of 23.26 MCM (2.0%) occurred in the month of December. The annual deficit in the sub-basin is 66.4 MCM (5.7%).

4.5.1.11 Amaravathi Sub-basin

For the water balance studies carried out monthly on an annual basis for Amaravathi sub-basin for the 75% water year dependable flow, without ground water consideration [refer Table 4.10.11(a)], the sub-basin was found short of water in the months of June to September and January to May, where as the sub-basin is surplus in its water resources in the months of October, November and December. The maximum deficit of 207.3 MCM (7.7%) occurred in the sub-basin in the month of March, while minimum deficit of 40.31 MCM (1.50 %) occurred in the sub-basin in the month of September. The maximum surplus of 189.8 MCM (7.1%) occurred in the month of November, while the minimum surplus of 124.3 MCM (4.60%) occurred in the month of October. The annual deficit in the sub-basin is 744.14 MCM (28%).

4.5.1.12 Tirumanimuttar Sub-basin

In the case of water balance studies of Tirumanimuttar sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.12(a)], the sub-basin was found short of water in the months of June to September and January to May, where as the sub-basin is surplus in its water resources in the months of October, November and December. The maximum deficit of 147.3 MCM (4%) occurred in the sub-basin in the month of March, while the minimum deficit of 37.17 MCM (1.0 %) occurred in the sub-basin in the month of January. The maximum surplus of 267.5 MCM (7.3%) occurred in the month of October, while the minimum surplus of 50.49 MCM (1.4%) occurred in the month of December. The annual deficit in the sub-basin is 225.54 MCM (6%).

4.5.1.13 Ponnanai Ar Sub-basin

For the water balance studies carried out monthly on an annual basis for Ponnanai sub-basin for the 75% water year dependable flow, without ground water consideration [refer Table 4.10.13(a)], the sub-basin was found short of water in the months of June to September and January to May, where as the sub-basin is surplus in its water resources in the months of October, November and December. The maximum deficit of 18.84 MCM (1.9%) occurred in the sub-basin in the month of July, while minimum deficit of 1.59 MCM (0.20 %) occurred in the sub-basin in the month of December. The maximum surplus of 43.78 MCM (4.5%) occurred in the month of November, while the minimum surplus of 0.19 MCM (0.02%) occurred in the month of February. The annual deficit in the sub-basin is 13.54 MCM (1.4%).

4.5.1.14 Upper Coleroon Sub-basin

In the case of water balance studies of Upper Coleroon sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.14(a)], the sub-basin was found short of water in the months of June to September and February to April, where as the sub-basin is surplus in its water resources in the months of October to January. The maximum deficit of 69.07 MCM (1.9%) occurred in the sub-basin in the month of July, while the minimum deficit of 2.80 MCM (0.20 %) occurred in the sub-basin in the month of June. The maximum surplus of 132.5 MCM (9.8%) occurred in the month of November, while the minimum surplus of 4.80 MCM (0.40%) occurred in the month of May. The annual surplus in the sub-basin is 86.64 MCM (6%).

4.5.1.15 Lower Coleroon Sub-basin

For the water balance studies carried out monthly on an annual basis for Lower Coleroon sub-basin for the 75% water year dependable flow, without ground water consideration [refer Table 4.10.15(a)], it was found that the sub-basin is surplus in its water resources throughout the year. The maximum surplus of 46.01 MCM (0.38%) occurred in the month of September, while the minimum surplus of 2.80 MCM (0.02%) occurred in the month of May. The annual surplus in the sub-basin is 222.2 MCM (2%).

4.5.1.16 Cauvery Delta Sub-basin

In the case of water balance studies of Cauvery Delta sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, without ground water considerations [refer Table 4.10.16(a)], it was found that the sub-basin is surplus in its water resources throughout the year. The maximum surplus of 256.40 MCM (2.6%) occurred in the month of September, while the minimum surplus of 10.45 MCM (0.10%) occurred in the month of May. The annual surplus in the sub-basin is 1203.1 MCM (12%).

4.5.2 The sub-basin wise analysis of the water balance studies for the 75% water year dependable flows, with ground water considerations, for the Cauvery river basin is as follows:

4.5.2.1 Upper Cauvery Sub-basin

In the case of water balance studies of Upper Cauvery sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.1(b)], the sub-basin was found short of water in the months of June and September to April, where as the sub-basin is surplus in its water resources in the months of July, August and May. The maximum deficit of 276.1 MCM (6%) occurred in the sub-basin in the month of October, while the minimum deficit of 9.87 MCM (0.20 %) occurred in the sub-basin in the month of November. The maximum surplus of 705.08 MCM (14%) occurred in the month of July, while the minimum surplus of 18.00 MCM (0.40%) occurred in the month of May. The annual surplus in the sub-basin is 304.05 MCM (6%).

4.5.2.2 Kabini Sub-basin

For the water balance studies carried out monthly on an annual basis for Kabini sub-basin for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.2(b)], it was found that in the sub-basin deficits occurred in the months of September and December to March, while the surpluses occurred in the months of June, July, August, October, November, April and May. The maximum deficit of 201.6 MCM (4.1%) occurred in the sub-basin in the month of January, while minimum deficit of 0.47 MCM (0.02 %) occurred in the sub-basin in the month of September. The maximum surplus of 193.24 MCM (3.9%) occurred in the month of August, while the minimum surplus of 0.05 MCM (0.01%) occurred in the month of April. The annual surplus in the sub-basin is 118.62 MCM (2.4%).

4.5.2.3 Shimsha Sub-basin

For the water balance studies carried out monthly on an annual basis for Shimsha sub-basin for the 75% water year dependable flow, with ground water consideration [refer Table 4.10.3(b)], it was found that in the sub-basin deficits occurred in the months of April, while the surpluses occurred in the remaining months throughout the year. The maximum deficit of 1.03 MCM (0.01%) occurred in the sub-basin in the month of April. The maximum surplus of 301.47 MCM (7.8%) occurred in the month of October, while the minimum surplus of 3.94 MCM (0.1%) occurred in the month of March. The annual surplus in the sub-basin is 657.95 MCM (17%).

4.5.2.4 Arkavathi Sub-basin

In the case of water balance studies of Arkavathi sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.4(b)], the sub-basin was found short of water through out the year except the months of September and October. The maximum deficit of 149.2 MCM (7.6%) occurred in the sub-basin in the month of January, while the minimum deficit of 24.58 MCM (1.30 %) occurred in the sub-basin in the month of May. The maximum surplus of 16.73 MCM (0.9%) occurred in the month of October, while the minimum surplus of 5.11 MCM (0.3%) occurred in the month of September. The annual deficit in the sub-basin is 695.7 MCM (35%).

4.5.2.5 Middle Cauvery Sub-basin

For the water balance studies carried out monthly on an annual basis for Middle Cauvery sub-basin for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.5(b)], it was found that in the sub-basin deficits occurred in the months of May and June, while the surpluses occurred in the months of July to April. The maximum deficit of 1.83 MCM (0.1%) occurred in the sub-basin in the month of May, while minimum deficit of 0.85 MCM (0.003 %) occurred in the sub-basin in the month of June. The maximum surplus of 52.90 MCM (2.4%) occurred in the month of September, while the minimum surplus of 2.54 MCM (0.10%) occurred in the month of April. The annual surplus in the sub-basin is 274 MCM (12%).

4.5.2.6 Suvarnavathi Sub-basin

In the case of water balance studies of Suvarnavathi sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.6(b)], the sub-basin was found short of water in the months of June to August and December to May, where as the sub-basin is surplus in its water resources in the months of September, October and November. The maximum deficit of 6.05 MCM (0.8%) occurred in the sub-basin in the month of January, while the minimum deficit of 0.22 MCM (0.01 %) occurred in the sub-basin in the month of May. The maximum surplus of 7.32 MCM (1.0%) occurred in the month of October, while the minimum surplus of 3.13 MCM (0.40%) occurred in the month of September. The annual deficit in the sub-basin is 17 MCM (2%).

4.5.2.7 Palar Sub-basin

For the water balance studies carried out monthly on an annual basis for Palar sub-basin for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.7(b)], the sub-basin was found short of water in the months of July and November to April, where as the sub-basin is surplus in its water resources in the months of June, August, September, and October. The maximum deficit of 11.86 MCM

(3.3%) occurred in the sub-basin in the month of February, while minimum deficit of 2.88 MCM (0.80 %) occurred in the sub-basin in the month of April. The maximum surplus of 10.59 MCM (3.0%) occurred in the month of September, while the minimum surplus of 0.19 MCM (0.10%) occurred in the month of May. The annual deficit in the sub-basin is 22 MCM (6%).

4.5.2.8 Chinnar Sub-basin

In the case of water balance studies of Chinnar sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.8(b)], the sub-basin was found short of water throughout the year. The maximum deficit of 4309.00 MCM (32%) occurred in the sub-basin in the month of October, while the minimum deficit of 150.00 MCM (1.0 %) occurred in the sub-basin in the month of July. The annual deficit in the sub-basin is 12925 MCM (95%).

4.5.2.9 Bhavani Sub-basin

In the case of water balance studies of Bhavani sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.9(b)], the sub-basin was found short of water in the months of June, August, September and January to May, where as the sub-basin is surplus in its water resources in the months of July, October, November and December. The maximum deficit of 137.4 MCM (4.8%) occurred in the sub-basin in the month of March, while the minimum deficit of 7.69 MCM (0.30 %) occurred in the sub-basin in the month of September. The maximum surplus of 99.72 MCM (3.50%) occurred in the month of November, while the minimum surplus of 22.65 MCM (0.8%) occurred in the month of July. The annual deficit in the sub-basin is 237.39 MCM (8%).

4.5.2.10 Noyil Sub-basin

For the water balance studies carried out monthly on an annual basis for Noyil sub-basin for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.10(b)], it was found that in the sub-basin deficits occurred in the months of June to September and January to May, while the surpluses occurred in the months of October, November and December. The maximum deficit of 41.33 MCM (3.4%) occurred in the sub-basin in the month of June, while minimum deficit of 9.54 MCM (0.8 %) occurred in the sub-basin in the month of September. The maximum surplus of 106.6 MCM (8.7%) occurred in the month of October, while the minimum surplus of 24.17 MCM (2.0%) occurred in the month of December. The annual deficit in the sub-basin is 31.52 MCM (3%).

4.5.2.11 Amaravathi Sub-basin

For the water balance studies carried out monthly on an annual basis for Amaravathi sub-basin for the 75% water year dependable flow, with ground water consideration [refer Table 4.10.11(b)], the sub-basin was found short of water in the months of June to September and January to May, where as the sub-basin is surplus in its water resources in the months of October, November and December. The maximum deficit of 170.7 MCM (6.2%) occurred in the sub-basin in the month of March, while minimum deficit of 18.6 MCM (0.7 %) occurred in the sub-basin in the month of September. The maximum surplus of 191.4 MCM (7.1%) occurred in the month of November, while the minimum surplus of 126.6 MCM (4.60%) occurred in the month of October. The annual deficit in the sub-basin is 438.6 MCM (16%).

4.5.2.12 Tirumanimuttar Sub-basin

In the case of water balance studies of Tirumanimuttar sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.12(b)], the sub-basin was found short of water in the months of June to September and January to May, where as the sub-basin is surplus in its water resources in the months of October, November and December. The maximum deficit of 79.73 MCM (2.1%) occurred in the sub-basin in the month of March, while the minimum deficit of 26.28 MCM (0.7 %) occurred in the sub-basin in the month of January. The maximum surplus of 293.1 MCM (7.7%) occurred in the month of October, while the minimum surplus of 71.65 MCM (1.9%) occurred in the month of December. The annual surplus in the sub-basin is 124.24 MCM (3%).

4.5.2.13 Ponnanai Ar Sub-basin

For the water balance studies carried out monthly on an annual basis for Ponnanai sub-basin for the 75% water year dependable flow, with ground water consideration [refer Table 4.10.13(b)], the sub-basin was found that the sub-basin is surplus in its water resources throughout the year. The sub-basin has been changed from water deficit for some months to water surplus throughout the year. The maximum surplus of 67.79 MCM (6.75%) occurred in the month of November, while the minimum surplus of 0 MCM (0.0%) occurred in the month of April. The annual surplus in the sub-basin is 193.69 MCM (19%).

4.5.2.14 Upper Coleroon Sub-basin

In the case of water balance studies of Upper Coleroon sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.14(b)], the sub-basin was found short of water in the months of July, August, March and April, where as the sub-basin is surplus in its water resources in the months of June, September to February. The maximum deficit of 12.36 MCM (0.9%) occurred in the sub-basin in the month of July, while the minimum deficit of 0.47 MCM (0.01 %) occurred in the sub-basin in the month of August. The maximum surplus of 148.1 MCM (10.8%) occurred in the month of November, while the minimum surplus of 0.59 MCM (0.40%) occurred in the month of June. The annual surplus in the sub-basin is 339.2 MCM (25%).

4.5.2.15 Lower Coleroon Sub-basin

For the water balance studies carried out monthly on an annual basis for Lower Coleroon sub-basin for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.15(b)], it was found that the sub-basin is surplus in its water resources throughout the year. The maximum surplus of 74.34 MCM (5.7%) occurred in the month of September, while the minimum surplus of 3.1 MCM (0.02%) occurred in the month of May. The annual surplus in the sub-basin is 342.76 MCM (26%).

4.5.2.16 Cauvery Delta Sub-basin

In the case of water balance studies of Cauvery Delta sub-basin, carried out monthly on an annual basis for the 75% water year dependable flow, with ground water considerations [refer Table 4.10.16(b)], it was found that the sub-basin is surplus in its water resources throughout the year. The maximum surplus of 352.2 MCM (3.5%) occurred in the month of September, while the minimum surplus of 11.44 MCM (0.10%) occurred in the month of May. The annual surplus in the sub-basin is 1611 MCM (16%).

4.6 ANALYSIS OF WATER BALANCE STUDIES FOR THE 75%, 50%, 90% AND 100% WATER YEAR DEPENDABLE FLOWS

The water balance studies are carried out on the monthly basis, for with and without considerations of ground water for a normal year, i.e., the 75% water year dependable flow.

The water balance studies for two water deficit years and one water surplus year, i.e., 90% and 100%, and 50% water year dependable flows, respectively, are also carried out.

The water balances of each sub-basin were compared with and without consideration of ground water. The sub-basinwise analysis of the water balance studies for the 75%, 50%, 90% and 100% water year dependable flows for the Cauvery river basin is as follows:

4.6.1 Upper Cauvery Sub-basin

By comparing monthly water balances in the various water year dependable flows in the Upper Cauvery sub-basin [Refer Table 4.10.1(a) to Table 4.10.1(h)], it is found that the months of July and May are surplus, in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability in all the four water year dependable flows and it is water deficit in the months of September, December and February in all four water year dependable flows. The maximum water surplus of 704 MCM (40%) is in the month of July for a normal year, i.e., the 75% water year dependable flow and the maximum water deficit of 291 MCM is in the month of August for the 100% water year dependable flow with the ground water availability considerations. The sub-basin has become water deficit from water surplus sub-basin in the month of August from 75% water year dependable to other water year dependable flows.

The amount of annual surplus and annual deficit water has decreased from 3940 MCM and 286 MCM to -262 MCM and –1935 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.2 Kabini Sub-basin

In the Kabini sub-basin [Refer Table 4.10.2(a) to Table 4.10.2(h)], it is found that the months of June, October and May are surplus in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability and in months of December, January, February and March are water deficit with the ground water availability considerations in all four water year dependable flows. The maximum water surplus is 446 MCM in the month of May for 100% water year dependable flow and the maximum water deficit is 203 MCM in the month of January for 75% water year dependable flow.

The sub-basin has become water deficit sub-basin from water surplus sub-basin in the month of August from 192 MCM, 219 MCM to -16 MCM and –103 MCM for 75%, 50%, 90% and 100% water year dependable flows, respectively.

The amount of annual surplus and annual deficit water has decreased from 835 MCM and 108 MCM to -487 MCM and –1535 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.3 Shimsha Sub-basin

In the Shimsha sub-basin [Refer Table 4.10.3(a) to Table 4.10.3(h)], it is found that in all the months the water availability is excess than water requirements, very few months are deficit in the water availability in comparison to the water needs in the sub-basin with the consideration of ground water availability. The maximum water surplus of 372 MCM is in the month of October for 50% water year dependable flow and maximum water deficit of 4 MCM is in the month of April for 100% water year dependable flow with the ground water availability considerations.

The amount of annual surplus water has decreased from 783 MCM to 640 MCM, 628 MCM and 341 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.4 Arkavathi Sub-basin

In the Arkavathi sub-basin [Refer Table 4.10.4(a) to Table 4.10.4(h)], it is found that in all the months of are deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability. The maximum water deficit of 226 MCM is in the month of September for 90% water year dependable flow.

The amount of annual deficit water is 594 MCM, 713 MCM, 796 MCM and 415 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.5 Middle Cauvery Sub-basin

In the Middle Cauvery sub-basin [Refer Table 4.10.5(a) to Table 4.10.5(h)], it is found that the months of June and May are deficit in the water availability in comparison to the water needs in the sub-basin, and other months are surplus in the water availability in comparison to the water needs in the sub-basin with the consideration of ground water availability for all the four water year dependable flows. The maximum water surplus 58 MCM is in the month of September for 50% water year dependable flow.

The amount of annual surplus water is 331 MCM, 269 MCM, 215 MCM and 128 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.6 Suvarnavathi Sub-basin

In the Suvarnavathi sub-basin [Refer Table 4.10.6(a) to Table 4.10.6(h)], it is found that the months of September, October and November are surplus for 75% and 50% water year dependable flows and other months are deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability. The maximum water surplus 19 MCM is in the month of October in 50% water year dependable flow and for 90% and 100% water year dependable flows sub-basin is water deficit throughout the year.

The amount of annual surplus and annual deficit water has decreased from 12 MCM to -22 MCM, -50 MCM and –60 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.7 Palar Sub-basin

In the Palar sub-basin [Refer Table 4.10.7(a) to Table 4.10.7(h)], it is found that the months of November to May are deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability in all the four water year dependable flows. The maximum water surplus 29 MCM is in the month of September in 50%water year dependable flow and maximum water deficit of 18 MCM is in the month of August in 100%water year dependable flow. In the moth of August the sub-basin becomes water deficit in 90% and 100% water year dependable flow from water surplus in 75% and 50% water year dependable flows.

The amount of annual surplus and annual deficit water has decreased from 44 MCM to -28 MCM, -61 MCM and –115 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.8 Chinnar Sub-basin

In the Chinnar sub-basin [Refer Table 4.10.8(a) to Table 4.10.8(h)], it is found that all the months are deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability in all four water year dependable flows. The maximum water deficit of 5294 MCM is in the month of October in 50% water year dependable flow.

The amount of annual deficit water is -15787 MCM, -12932 MCM, -13012 MCM and –13155 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.9 Bhavani Sub-basin

In the Bhavani sub-basin [Refer Table 4.10.9(a) to Table 4.10.9(h)], it is found that the months of October, November and December are surplus and the months of June, August, February, March and April are deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability in all the four water year dependable flows. The maximum water surplus

157 MCM is in the month of October in 50% water year dependable flow and maximum water deficit of 144 MCM is in the month of August in 100% water year dependable flow with the ground water availability considerations.

The amount of annual surplus and annual deficit water has decreased from 239 MCM to -247 MCM, -652 MCM and –947 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.10 Noyil Sub-basin

In the Noyil sub-basin [Refer Table 4.10.10(a) to Table 4.10.10(h)], it is found that the months of October, November and December are surplus and the months of June, July, August, September, January, February, March, April and May are deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability in all the four water year dependable flows. The maximum water surplus 108 MCM is in the month of October in 50% water year dependable flow and maximum water deficit of 45 MCM is in the month of June in 50% water year dependable flow with the ground water availability considerations.

The amount of annual deficit water is -65 MCM, -40 MCM, -52 MCM and –64 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.11 Amaravathi Sub-basin

In the Amaravathi sub-basin [Refer Table 4.10.11(a) to Table 4.10.11(h)], it is found that the months of October and November are surplus and the months of June, July, August, January, February, March and April are deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability in all the four water year dependable flows. The maximum water surplus 195 MCM is in the month of November in 50% water year dependable flow and maximum water deficit of 172 MCM is in the month of March in 50% water year dependable flow with the ground water availability considerations. In the month of December the sub-basin becomes water deficit in 90% and 100% water year dependable flows from water surplus in 50% and 75% water year dependable flows.

The amount of annual deficit water is -304 MCM, -454 MCM, -547 MCM and –711 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.12 Tirumanimuttar Sub-basin

In the Tirumanimuttar sub-basin [Refer Table 4.10.12(a) to Table 4.10.12(h)], it is found that in the months of October, November and December are surplus in the water availability in comparison to the water needs in the sub-basin, and other months are deficit in the water availability in comparison to the water needs in the sub-basin with the consideration of ground water availability for all the four water year dependable flows. The maximum water surplus 531 MCM is in the month of October for 50% water year dependable flow and in the month of March deficit 82 MCM for 90% water year dependable flow is in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability.

The amount of annual surplus water has decreased from 583 MCM to 219 MCM, 76 MCM and 17 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.13 Ponnanai Ar Sub-basin

In the Ponnanai Ar sub-basin [Refer Table 4.10.13(a) to Table 4.10.13(h)], it is found that all the months are surplus in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability except the months of April and May in 100% water year dependable flow. The maximum water surplus 85 MCM is in the month of November in 50% water year dependable flow and maximum water deficit of 2 MCM is in the month of April in 100% water year dependable flow.

The amount of annual surplus water has decreased from 244 MCM to 217 MCM, 157 MCM and 61 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.14 Upper Coleroon Sub-basin

In the Upper Coleroon sub-basin [Refer Table 4.10.14(a) to Table 4.10.14(h)], it is found that the months of October, November and December are surplus and the month of June, is deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability in all the four water year dependable flows. The maximum water surplus 192 MCM is in the month of November in 50% water year dependable flow and maximum water deficit of 37 MCM is in the month of June in 100% water year dependable flow with the ground water availability considerations. In the month of August the sub-basin becomes water deficit in 90% and 100% water year dependable flows from water surplus in 50% and 75% water year dependable flows.

The amount of annual surplus and annual deficit water has decreased from 508 MCM, 358 MCM, 243 MCM to –65 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.15 Lower Coleroon Sub-basin

In the Lower Coleroon sub-basin [Refer Table 4.10.15(a) to Table 4.10.15(h)], it is found that in any month no deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability for all four water year dependable flows. The maximum water surplus 102 MCM is in the month of September in 50% water year dependable flow.

The amount of annual surplus water has decreased from 485 MCM to 340 MCM, 285 MCM and 183 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.6.16 Cauvery Delta Sub-basin

In the Cauvery Delta sub-basin [Refer Table 4.10.16(a) to Table 4.10.16(h)], it is found that in any month no deficit in the water availability in comparison to the water needs in the sub-basin, with the consideration of ground water availability for all four water year dependable flows except in the month of May in 90% and 100% water year dependable flows. The maximum water surplus 192 MCM is in the month of September in 50% water year dependable flow.

The amount of annual surplus water has decreased from 2121 MCM to 1413 MCM, 952 MCM and 554 MCM in the sub-basin with the ground water availability for 50%, 75% 90% and 100% water year dependable flows, respectively.

4.7 WATER BALANCE OF CAUVERY BASIN AS A WHOLE

The detailed water balance studies carried out monthly on annual basis for all the 16 sub-basins in the Cauvery river basin for 75%, 50%, 90%, and 100% water year dependable flows, with and without considerations of ground water are presented in the Tables 4.10.1(a) to Table 4.10.4(h). The abstracts of the sub-basinwise annual water balance studies for Cauvery basin for 75%, 50%, 90% and 100% water year dependable flows without and with considerations of ground water, are presented in Table 4.11.1 to Table 4.11.4. The abstract of annual water balance for Cauvery basin as a whole for 75%, 50%, 90% and 100% water year dependable flows without and with ground water considerations is presented in table 4.11.5. The sub-basin wise annual water balance for 75%, 50%, 90% and 100% water year dependable flows without and with ground water are presented in Table 4.12.1 to Table 4.12.4. The sub-basinwise monthly deficits/surpluses for 75%, 50%, 90%, and 100% water year dependable flows, with and without considerations of ground water are presented in the Table 4.13.1 to Table 4.13.4. The sub-basinwise monthly deficits or surpluses in descending order with percent of deficit or surplus for 75%, 50%, 90%, and 100% water year dependable flows, with and without considerations of ground water are presented in the Table 4.14.1 to Table 4.14.16. The graphical presentations of the monthly water deficits-surpluses for all the 16 sub-basins in the Cauvery river-basin, without and with ground water considerations are presented in the Figures 4.4.1 to 4.4.16.

Table 4.10.1(a): Upper Cauvery Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Monthj	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	36.60	117.70	87.02	241.32	19.15	26.38	0.00	1.62	288.48	79.12	367.60	0.00	14.94	15.32	21.11	51.36	161.67	213.03	-154.57
Jul	85.40	274.64	203.05	563.09	19.79	27.26	0.00	22.69	632.84	1110.68	1743.52	0.00	34.85	15.83	21.81	72.49	2269.40	2341.89	598.37
Aug	86.20	277.22	204.95	568.37	19.79	27.26	0.00	18.17	633.59	889.46	1523.05	0.00	35.18	15.83	21.81	72.82	1817.38	1890.20	367.15
Sep	84.40	271.43	200.67	556.50	19.15	26.38	0.00	4.81	606.84	235.42	842.27	0.00	34.44	15.32	21.11	70.87	481.03	551.90	-290.37
Oct	92.20	296.51	219.21	607.93	19.79	27.26	0.00	3.76	658.74	184.22	842.96	0.00	37.62	15.83	21.81	75.27	376.41	451.68	-391.29
Nov	6.20	19.94	14.74	40.88	19.15	26.38	0.00	0.60	87.01	29.17	116.18	0.00	2.53	15.32	21.11	38.96	59.61	98.57	-17.62
Dec	13.50	43.42	32.10	89.01	19.79	27.26	0.00	0.72	136.78	35.00	171.78	0.00	5.51	15.83	21.81	43.15	71.51	114.66	-57.12
Jan	15.90	51.13	37.80	104.84	19.79	27.26	0.00	0.29	152.18	14.20	166.38	0.00	6.49	15.83	21.81	44.13	29.02	73.15	-93.23
Feb	20.00	64.32	47.55	131.87	17.87	24.62	0.00	0.30	174.67	14.60	189.27	0.00	8.16	14.30	19.70	42.16	29.83	71.99	-117.28
Mar	19.30	62.07	45.89	127.26	19.79	27.26	0.00	0.22	174.53	10.84	185.36	0.00	7.88	15.83	21.81	45.52	22.14	67.66	-117.71
Apr	3.30	10.61	7.85	21.76	19.15	26.38	0.00	0.21	67.51	10.49	78.00	0.00	1.35	15.32	21.11	37.77	21.43	59.20	-18.79
May	0.00	0.00	0.00	0.00	19.79	27.26	0.00	0.55	47.60	26.80	74.40	0.00	0.00	15.83	21.81	37.64	54.75	92.39	18.00
Total	463.00	1489.0	1100.82	3052.8	233.0	321.0	0.00	53.94	3660.76	2640.0	6300.76	0.0	188.9	186.4	256.8	632.1	5394.18	6026.31	-274.45

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.1(b): Upper Cauvery Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	36.60	117.70	87.02	241.32	26.38	26.38	0.00	1.62	295.71	79.12	374.83	0.00	14.94	21.11	21.11	57.15	161.67	45.73	264.55	-110.28
Jul	85.40	274.64	203.05	563.09	27.26	27.26	0.00	22.69	640.31	1110.68	1750.99	0.00	34.85	21.81	21.81	78.47	2269.40	106.70	2454.57	703.58
Aug	86.20	277.22	204.95	568.37	27.26	27.26	0.00	18.17	641.07	889.46	1530.52	0.00	35.18	21.81	21.81	78.80	1817.38	107.70	2003.88	473.36
Sep	84.40	271.43	200.67	556.50	26.38	26.38	0.00	4.81	614.07	235.42	849.50	0.00	34.44	21.11	21.11	76.65	481.03	105.45	663.14	-186.36
Oct	92.20	296.51	219.21	607.93	27.26	27.26	0.00	3.76	666.22	184.22	850.44	0.00	37.62	21.81	21.81	81.24	376.41	115.20	572.85	-277.58
Nov	6.20	19.94	14.74	40.88	26.38	26.38	0.00	0.60	94.24	29.17	123.42	0.00	2.53	21.11	21.11	44.74	59.61	7.75	112.10	-11.32
Dec	13.50	43.42	32.10	89.01	27.26	27.26	0.00	0.72	144.25	35.00	179.25	0.00	5.51	21.81	21.81	49.13	71.51	16.87	137.51	-41.75
Jan	15.90	51.13	37.80	104.84	27.26	27.26	0.00	0.29	159.65	14.20	173.86	0.00	6.49	21.81	21.81	50.11	29.02	19.87	99.00	-74.86
Feb	20.00	64.32	47.55	131.87	24.62	24.62	0.00	0.30	181.42	14.60	196.02	0.00	8.16	19.70	19.70	47.56	29.83	24.99	102.38	-93.64
Mar	19.30	62.07	45.89	127.26	27.26	27.26	0.00	0.22	182.00	10.84	192.84	0.00	7.88	21.81	21.81	51.50	22.14	24.11	97.75	-95.09
Apr	3.30	10.61	7.85	21.76	26.38	26.38	0.00	0.21	74.74	10.49	85.23	0.00	1.35	21.11	21.11	43.56	21.43	4.12	69.11	-16.11
May	0.00	0.00	0.00	0.00	27.26	27.26	0.00	0.55	55.07	26.80	81.87	0.00	0.00	21.81	21.81	43.62	54.75	0.00	98.37	16.50
Total	463.0	1489.0	1100.82	3052.8	321.0	321.0	0.00	53.94	3748.76	2640.0	6388.76	0.00	188.9	256.80	256.80	702.53	5394.18	578.50	6675.21	286.45

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19) Column no. 21 = Column no.(20-12).

Table 4.10.1(c): Upper Cauvery Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	36.60	117.70	87.02	241.32	19.15	26.38	0.00	6.08	292.94	297.52	590.45	0.00	14.94	15.32	21.11	51.36	607.90	659.26	68.81
Jul	85.40	274.64	203.05	563.09	19.79	27.26	0.00	22.05	632.19	1079.02	1711.21	0.00	34.85	15.83	21.81	72.49	2204.70	2277.19	565.98
Aug	86.20	277.22	204.95	568.37	19.79	27.26	0.00	4.79	620.21	234.63	854.84	0.00	35.18	15.83	21.81	72.82	479.40	552.22	-302.62
Sep	84.40	271.43	200.67	556.50	19.15	26.38	0.00	3.84	605.87	188.08	793.96	0.00	34.44	15.32	21.11	70.87	384.30	455.17	-338.79
Oct	92.20	296.51	219.21	607.93	19.79	27.26	0.00	9.55	664.53	467.44	1131.97	0.00	37.62	15.83	21.81	75.27	955.10	1030.37	-101.61
Nov	6.20	19.94	14.74	40.88	19.15	26.38	0.00	2.97	89.39	145.41	234.79	0.00	2.53	15.32	21.11	38.96	297.10	336.06	101.27
Dec	13.50	43.42	32.10	89.01	19.79	27.26	0.00	0.24	136.31	11.75	148.05	0.00	5.51	15.83	21.81	43.15	24.00	67.15	-80.90
Jan	15.90	51.13	37.80	104.84	19.79	27.26	0.00	0.00	151.89	0.00	151.89	0.00	6.49	15.83	21.81	44.13	0.00	44.13	-107.76
Feb	20.00	64.32	47.55	131.87	17.87	24.62	0.00	0.30	174.67	14.83	189.50	0.00	8.16	14.30	19.70	42.16	30.30	72.46	-117.04
Mar	19.30	62.07	45.89	127.26	19.79	27.26	0.00	1.31	175.62	64.06	239.68	0.00	7.88	15.83	21.81	45.52	130.90	176.42	-63.26
Apr	3.30	10.61	7.85	21.76	19.15	26.38	0.00	5.69	72.98	278.28	351.26	0.00	1.35	15.32	21.11	37.77	568.60	606.37	255.11
May	0.00	0.00	0.00	0.00	19.79	27.26	0.00	6.36	53.42	311.42	364.83	0.00	0.00	15.83	21.81	37.64	636.30	673.94	309.11
Total	463.00	1489.0	1100.82	3052.82	233.0	321.0	0.00	63.19	3670.01	3092.4	6762.4	0.0	188.9	186.4	256.8	632.1	6318.60	6950.73	188.30

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.1(d): Upper Cauvery Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	36.60	117.70	87.02	241.32	26.38	26.38	0.00	6.08	300.17	297.52	597.69	0.00	14.94	21.11	21.11	57.15	607.90	45.73	710.78	113.09
Jul	85.40	274.64	203.05	563.09	27.26	27.26	0.00	22.05	639.66	1079.0	1718.68	0.00	34.85	21.81	21.81	78.47	2204.70	106.70	2389.9	671.19
Aug	86.20	277.22	204.95	568.37	27.26	27.26	0.00	4.79	627.69	234.63	862.31	0.00	35.18	21.81	21.81	78.80	479.40	107.70	665.90	-196.41
Sep	84.40	271.43	200.67	556.50	26.38	26.38	0.00	3.84	613.11	188.08	801.19	0.00	34.44	21.11	21.11	76.65	384.30	105.45	566.41	-234.78
Oct	92.20	296.51	219.21	607.93	27.26	27.26	0.00	9.55	672.00	467.44	1139.45	0.00	37.62	21.81	21.81	81.24	955.10	115.20	1151.54	12.10
Nov	6.20	19.94	14.74	40.88	26.38	26.38	0.00	2.97	96.62	145.41	242.02	0.00	2.53	21.11	21.11	44.74	297.10	7.75	349.59	107.57
Dec	13.50	43.42	32.10	89.01	27.26	27.26	0.00	0.24	143.78	11.75	155.53	0.00	5.51	21.81	21.81	49.13	24.00	16.87	90.00	-65.53
Jan	15.90	51.13	37.80	104.84	27.26	27.26	0.00	0.00	159.36	0.00	159.36	0.00	6.49	21.81	21.81	50.11	0.00	19.87	69.98	-89.39
Feb	20.00	64.32	47.55	131.87	24.62	24.62	0.00	0.30	181.42	14.83	196.25	0.00	8.16	19.70	19.70	47.56	30.30	24.99	102.85	-93.40
Mar	19.30	62.07	45.89	127.26	27.26	27.26	0.00	1.31	183.09	64.06	247.16	0.00	7.88	21.81	21.81	51.50	130.90	24.11	206.51	-40.64
Apr	3.30	10.61	7.85	21.76	26.38	26.38	0.00	5.69	80.21	278.28	358.49	0.00	1.35	21.11	21.11	43.56	568.60	4.12	616.28	257.79
May	0.00	0.00	0.00	0.00	27.26	27.26	0.00	6.36	60.89	311.42	372.30	0.00	0.00	21.81	21.81	43.62	636.30	0.00	679.92	307.62
Total	463.0	1489.0	1100.82	3052.82	321.0	321.0	0.00	62.30	3757.12	2640.0	6850.4	0.00	188.9	256.80	256.80	702.53	6230.30	578.50	7511.33	660.90

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.1(e): Upper Cauvery Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	36.60	117.70	87.02	241.32	19.15	26.38	0.00	3.50	290.36	171.47	461.83	0.00	14.94	15.32	21.11	51.36	350.35	401.71	-60.12
Jul	85.40	274.64	203.05	563.09	19.79	27.26	0.00	9.94	620.08	486.50	1106.58	0.00	34.85	15.83	21.81	72.49	994.04	1066.53	-40.05
Aug	86.20	277.22	204.95	568.37	19.79	27.26	0.00	4.01	619.43	196.19	815.61	0.00	35.18	15.83	21.81	72.82	400.86	473.68	-341.94
Sep	84.40	271.43	200.67	556.50	19.15	26.38	0.00	5.52	607.55	269.96	877.51	0.00	34.44	15.32	21.11	70.87	551.60	622.47	-255.04
Oct	92.20	296.51	219.21	607.93	19.79	27.26	0.00	8.16	663.14	399.21	1062.34	0.00	37.62	15.83	21.81	75.27	815.68	890.95	-171.40
Nov	6.20	19.94	14.74	40.88	19.15	26.38	0.00	4.26	90.68	208.67	299.35	0.00	2.53	15.32	21.11	38.96	426.36	465.32	165.97
Dec	13.50	43.42	32.10	89.01	19.79	27.26	0.00	0.95	137.02	46.70	183.71	0.00	5.51	15.83	21.81	43.15	95.41	138.56	-45.15
Jan	15.90	51.13	37.80	104.84	19.79	27.26	0.00	0.26	152.15	12.95	165.10	0.00	6.49	15.83	21.81	44.13	26.45	70.58	-94.52
Feb	20.00	64.32	47.55	131.87	17.87	24.62	0.00	0.20	174.57	9.82	184.39	0.00	8.16	14.30	19.70	42.16	20.07	62.23	-122.16
Mar	19.30	62.07	45.89	127.26	19.79	27.26	0.00	0.01	174.32	0.43	174.74	0.00	7.88	15.83	21.81	45.52	0.87	46.39	-128.36
Apr	3.30	10.61	7.85	21.76	19.15	26.38	0.00	5.18	72.47	253.32	325.79	0.00	1.35	15.32	21.11	37.77	517.59	555.36	229.58
May	0.00	0.00	0.00	0.00	19.79	27.26	0.00	6.41	53.46	313.58	367.04	0.00	0.00	15.83	21.81	37.64	640.72	678.36	311.32
Total	463.00	1489.0	1100.82	3052.8	233.0	321.0	0.00	48.40	3655.22	2368.8	6024.00	0.0	188.9	186.4	256.8	632.1	4840.00	5472.13	-551.86

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.1(f): Upper Cauvery Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	36.60	117.70	87.02	241.32	26.38	26.38	0.00	3.50	297.60	171.47	469.06	0.00	14.94	21.11	21.11	57.15	350.35	45.73	453.23	-15.83
Jul	85.40	274.64	203.05	563.09	27.26	27.26	0.00	9.94	627.56	486.50	1114.06	0.00	34.85	21.81	21.81	78.47	994.04	106.70	1179.21	65.16
Aug	86.20	277.22	204.95	568.37	27.26	27.26	0.00	4.01	626.90	196.19	823.09	0.00	35.18	21.81	21.81	78.80	400.86	107.70	587.36	-235.73
Sep	84.40	271.43	200.67	556.50	26.38	26.38	0.00	5.52	614.78	269.96	884.74	0.00	34.44	21.11	21.11	76.65	551.60	105.45	733.71	-151.03
Oct	92.20	296.51	219.21	607.93	27.26	27.26	0.00	8.16	670.61	399.21	1069.82	0.00	37.62	21.81	21.81	81.24	815.68	115.20	1012.12	-57.69
Nov	6.20	19.94	14.74	40.88	26.38	26.38	0.00	4.26	97.91	208.67	306.58	0.00	2.53	21.11	21.11	44.74	426.36	7.75	478.85	172.27
Dec	13.50	43.42	32.10	89.01	27.26	27.26	0.00	0.95	144.49	46.70	191.19	0.00	5.51	21.81	21.81	49.13	95.41	16.87	161.41	-29.78
Jan	15.90	51.13	37.80	104.84	27.26	27.26	0.00	0.26	159.63	12.95	172.57	0.00	6.49	21.81	21.81	50.11	26.45	19.87	96.43	-76.15
Feb	20.00	64.32	47.55	131.87	24.62	24.62	0.00	0.20	181.32	9.82	191.14	0.00	8.16	19.70	19.70	47.56	20.07	24.99	92.62	-98.52
Mar	19.30	62.07	45.89	127.26	27.26	27.26	0.00	0.01	181.79	0.43	182.22	0.00	7.88	21.81	21.81	51.50	0.87	24.11	76.48	-105.74
Apr	3.30	10.61	7.85	21.76	26.38	26.38	0.00	5.18	79.70	253.32	333.02	0.00	1.35	21.11	21.11	43.56	517.59	4.12	565.27	232.25
May	0.00	0.00	0.00	0.00	27.26	27.26	0.00	6.41	60.93	313.58	374.51	0.00	0.00	21.81	21.81	43.62	640.72	0.00	684.34	309.83
Total	463.0	1489.0	1100.82	3052.8	321.0	321.0	0.00	48.40	3743.22	2640.0	6112.00	0.00	188.9	256.80	256.80	702.53	4840.00	578.50	6121.03	-262.19

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.1(g): Upper Cauvery Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	36.60	117.70	87.02	241.32	19.15	26.38	0.00	3.04	289.90	148.62	438.52	0.00	14.94	15.32	21.11	51.36	303.67	355.03	-83.48
Jul	85.40	274.64	203.05	563.09	19.79	27.26	0.00	8.83	618.97	432.02	1050.99	0.00	34.85	15.83	21.81	72.49	882.73	955.22	-95.77
Aug	86.20	277.22	204.95	568.37	19.79	27.26	0.00	2.91	618.33	142.49	760.82	0.00	35.18	15.83	21.81	72.82	291.14	363.96	-396.86
Sep	84.40	271.43	200.67	556.50	19.15	26.38	0.00	5.09	607.12	248.97	856.08	0.00	34.44	15.32	21.11	70.87	508.70	579.57	-276.52
Oct	92.20	296.51	219.21	607.93	19.79	27.26	0.00	3.95	658.93	193.47	852.40	0.00	37.62	15.83	21.81	75.27	395.31	470.58	-381.83
Nov	6.20	19.94	14.74	40.88	19.15	26.38	0.00	1.61	88.02	78.78	166.80	0.00	2.53	15.32	21.11	38.96	160.96	199.92	33.12
Dec	13.50	43.42	32.10	89.01	19.79	27.26	0.00	0.00	136.07	0.00	136.07	0.00	5.51	15.83	21.81	43.15	0.00	43.15	-92.91
Jan	15.90	51.13	37.80	104.84	19.79	27.26	0.00	0.00	151.89	0.00	151.89	0.00	6.49	15.83	21.81	44.13	0.00	44.13	-107.76
Feb	20.00	64.32	47.55	131.87	17.87	24.62	0.00	0.97	175.34	47.48	222.82	0.00	8.16	14.30	19.70	42.16	97.02	139.18	-83.64
Mar	19.30	62.07	45.89	127.26	19.79	27.26	0.00	0.00	174.31	0.00	174.31	0.00	7.88	15.83	21.81	45.52	0.00	45.52	-128.79
Apr	3.30	10.61	7.85	21.76	19.15	26.38	0.00	1.86	69.16	91.25	160.41	0.00	1.35	15.32	21.11	37.77	186.45	224.22	63.81
May	0.00	0.00	0.00	0.00	19.79	27.26	0.00	3.26	50.31	159.50	209.81	0.00	0.00	15.83	21.81	37.64	325.89	363.53	153.72
Total	463.00	1489.0	1100.82	3052.8	233.0	321.0	0.00	31.50	3638.32	1542.6	5180.92	0.0	188.9	186.4	256.8	632.1	3150.00	3782.13	-1398.76

Note : Column no. 10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.1(h): Upper Cauvery Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	36.60	117.70	87.02	241.32	26.38	26.38	0.00	3.04	297.13	148.62	445.75	0.00	14.94	21.11	21.11	57.15	303.67	45.73	406.55	-39.20
Jul	85.40	274.64	203.05	563.09	27.26	27.26	0.00	8.83	626.44	432.02	1058.47	0.00	34.85	21.81	21.81	78.47	882.73	106.70	1067.90	9.44
Aug	86.20	277.22	204.95	568.37	27.26	27.26	0.00	2.91	625.80	142.49	768.29	0.00	35.18	21.81	21.81	78.80	291.14	107.70	477.64	-290.65
Sep	84.40	271.43	200.67	556.50	26.38	26.38	0.00	5.09	614.35	248.97	863.32	0.00	34.44	21.11	21.11	76.65	508.70	105.45	690.81	-172.51
Oct	92.20	296.51	219.21	607.93	27.26	27.26	0.00	3.95	666.41	193.47	859.88	0.00	37.62	21.81	21.81	81.24	395.31	115.20	591.75	-268.12
Nov	6.20	19.94	14.74	40.88	26.38	26.38	0.00	1.61	95.26	78.78	174.03	0.00	2.53	21.11	21.11	44.74	160.96	7.75	213.45	39.42
Dec	13.50	43.42	32.10	89.01	27.26	27.26	0.00	0.00	143.54	0.00	143.54	0.00	5.51	21.81	21.81	49.13	0.00	16.87	66.00	-77.54
Jan	15.90	51.13	37.80	104.84	27.26	27.26	0.00	0.00	159.36	0.00	159.36	0.00	6.49	21.81	21.81	50.11	0.00	19.87	69.98	-89.39
Feb	20.00	64.32	47.55	131.87	24.62	24.62	0.00	0.97	182.09	47.48	229.57	0.00	8.16	19.70	19.70	47.56	97.02	24.99	169.57	-60.00
Mar	19.30	62.07	45.89	127.26	27.26	27.26	0.00	0.00	181.78	0.00	181.78	0.00	7.88	21.81	21.81	51.50	0.00	24.11	75.61	-106.17
Apr	3.30	10.61	7.85	21.76	26.38	26.38	0.00	1.86	76.39	91.25	167.64	0.00	1.35	21.11	21.11	43.56	186.45	4.12	234.13	66.49
May	0.00	0.00	0.00	0.00	27.26	27.26	0.00	3.26	57.78	159.50	217.28	0.00	0.00	21.81	21.81	43.62	325.89	0.00	369.51	152.23
Total	463.0	1489.0	1100.82	3052.8	321.0	321.0	0.00	31.50	3726.32	2640.0	5268.92	0.00	188.9	256.80	256.80	702.53	3150.00	578.50	4431.03	-1935.29

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.2(a): Kabini Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	21.20	13.65	17.87	52.72	18.49	23.01	0.75	3.67	98.64	180.77	279.41	7.35	5.06	14.79	18.41	38.26	366.65	412.27	132.86
Jul	184.50	118.75	155.46	458.71	19.11	23.78	0.75	9.51	511.86	469.06	980.92	63.99	44.02	15.29	19.02	78.34	951.39	1093.71	112.79
Aug	180.51	116.18	152.10	448.79	19.11	23.78	0.75	9.61	502.04	473.72	975.76	62.60	43.07	15.29	19.02	77.38	960.86	1100.85	125.08
Sep	144.05	92.71	121.38	358.15	18.49	23.01	0.75	4.59	404.99	226.19	631.18	49.96	34.37	14.79	18.41	67.58	458.78	576.32	-54.86
Oct	16.00	10.30	13.48	39.79	19.11	23.78	0.75	3.23	86.66	159.23	245.88	5.55	3.82	15.29	19.02	38.13	322.96	366.64	120.76
Nov	47.63	30.66	40.14	118.43	18.49	23.01	0.75	2.09	162.78	103.22	266.00	16.52	11.37	14.79	18.41	44.57	209.36	270.45	4.46
Dec	94.18	60.62	79.36	234.16	19.11	23.78	0.75	1.06	278.86	52.24	331.10	32.67	22.48	15.29	19.02	56.79	105.95	195.40	-135.69
Jan	136.42	87.80	114.96	339.19	19.11	23.78	0.75	0.31	383.14	15.44	398.58	47.32	32.56	15.29	19.02	66.87	31.31	145.50	-253.08
Feb	124.09	79.87	104.56	308.52	17.26	21.48	0.75	0.29	348.30	14.22	362.52	43.04	29.61	13.81	17.18	60.60	28.85	132.49	-230.02
Mar	64.50	41.52	54.35	160.37	19.11	23.78	0.75	0.38	204.39	18.67	223.06	22.37	15.39	15.29	19.02	49.70	37.86	109.94	-113.12
Apr	15.16	9.76	12.78	37.70	18.49	23.01	0.75	0.65	80.61	31.95	112.55	5.26	3.62	14.79	18.41	36.82	64.8	106.88	-5.67
May	6.85	4.41	5.77	17.02	19.11	23.78	0.75	1.05	61.71	51.88	113.59	2.37	1.63	15.29	19.02	35.95	105.23	143.55	29.96
Total	1035.11	666.21	871.96	2573.28	225.0	280.0	9.0	36.41	3123.69	1795.1	4918.78	359.0	247.0	180.0	224.0	651.0	3641.0	4651.0	-267.78

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.2(b): Kabini Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	21.20	13.60	17.81	52.61	23.01	23.01	0.75	3.67	103.06	180.77	283.82	7.35	5.06	18.41	18.41	41.88	366.65	7.90	423.79	139.96
Jul	184.50	118.36	154.92	457.78	23.78	23.78	0.75	9.51	515.61	469.06	984.66	63.99	44.02	19.02	19.02	82.07	951.39	68.74	1166.19	181.53
Aug	180.51	115.80	151.57	447.88	23.78	23.78	0.75	9.61	505.80	473.72	979.53	62.60	43.07	19.02	19.02	81.12	960.86	67.25	1171.84	192.31
Sep	144.05	92.42	120.96	357.42	23.01	23.01	0.75	4.59	408.79	226.19	634.98	49.96	34.37	18.41	18.41	71.19	458.78	53.67	633.60	-1.37
Oct	16.00	10.27	13.44	39.71	23.78	23.78	0.75	3.23	91.25	159.23	250.48	5.55	3.82	19.02	19.02	41.87	322.96	5.96	376.34	125.87
Nov	47.63	30.56	40.00	118.19	23.01	23.01	0.75	2.09	167.06	103.22	270.28	16.52	11.37	18.41	18.41	48.19	209.36	17.75	291.82	21.54
Dec	94.18	60.42	79.08	233.69	23.78	23.78	0.75	1.06	283.06	52.24	335.29	32.67	22.48	19.02	19.02	60.52	105.95	35.09	234.23	-101.06
Jan	136.42	87.52	114.55	338.50	23.78	23.78	0.75	0.31	387.13	15.44	402.56	47.32	32.56	19.02	19.02	70.61	31.31	50.83	200.06	-202.50
Feb	124.09	79.61	104.20	307.89	21.48	21.48	0.75	0.29	351.89	14.22	366.12	43.04	29.61	17.18	17.18	63.98	28.85	46.23	182.10	-184.01
Mar	64.50	41.38	54.16	160.05	23.78	23.78	0.75	0.38	208.74	18.67	227.41	22.37	15.39	19.02	19.02	53.44	37.86	24.03	137.70	-89.70
Apr	15.16	9.73	12.73	37.63	23.01	23.01	0.75	0.65	85.05	31.95	117.00	5.26	3.62	18.41	18.41	40.44	64.8	5.65	116.15	-0.85
May	6.85	4.39	5.75	16.98	23.78	23.78	0.75	1.05	66.35	51.88	118.23	2.37	1.63	19.02	19.02	39.68	105.23	2.55	149.84	31.61
Total	1035.11	666.21	871.96	2573.28	280.0	280.0	9.0	36.41	3178.7	1795.1	4973.8	359.0	247.0	224.0	224.00	695.0	3641.0	386.4	5081.4	107.62

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.2(c): Kabini Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	21.20	13.65	17.87	52.72	18.49	23.01	0.75	3.68	98.66	181.53	280.19	7.35	5.06	14.79	18.41	38.26	368.2	413.82	133.63
Jul	184.50	118.75	155.46	458.71	19.11	23.78	0.75	2.31	504.66	113.99	618.65	63.99	44.02	15.29	19.02	78.34	231.2	373.52	-245.13
Aug	180.51	116.18	152.10	448.79	19.11	23.78	0.75	10.14	502.57	500.02	1002.59	62.60	43.07	15.29	19.02	77.38	1014	1154.19	151.59
Sep	144.05	92.71	121.38	358.15	18.49	23.01	0.75	11.11	411.51	547.75	959.26	49.96	34.37	14.79	18.41	67.58	1111	1228.54	269.28
Oct	16.00	10.30	13.48	39.79	19.11	23.78	0.75	4.90	88.33	241.58	329.91	5.55	3.82	15.29	19.02	38.13	490	533.68	203.77
Nov	47.63	30.66	40.14	118.43	18.49	23.01	0.75	1.23	161.91	60.54	222.45	16.52	11.37	14.79	18.41	44.57	122.8	183.89	-38.56
Dec	94.18	60.62	79.36	234.16	19.11	23.78	0.75	0.24	278.04	11.93	289.97	32.67	22.48	15.29	19.02	56.79	24.2	113.65	-176.32
Jan	136.42	87.80	114.96	339.19	19.11	23.78	0.75	0.00	382.83	0.00	382.83	47.32	32.56	15.29	19.02	66.87	0	114.19	-268.64
Feb	124.09	79.87	104.56	308.52	17.36	21.48	0.75	0.00	348.01	0.00	348.01	43.04	29.61	13.81	17.18	60.60	0	103.64	-244.36
Mar	64.50	41.52	54.35	160.37	19.11	23.78	0.75	0.00	204.01	0.00	204.01	22.37	15.39	15.29	19.02	49.70	0	72.08	-131.94
Apr	15.16	9.76	12.78	37.70	18.49	23.01	0.75	0.75	80.71	37.17	117.89	5.26	3.62	14.79	18.41	36.82	75.4	117.48	-0.41
May	6.85	4.41	5.77	17.02	19.11	23.78	0.75	9.39	70.05	462.90	532.95	2.37	1.63	15.29	19.02	35.95	938.9	977.22	444.27
Total	1035.11	666.21	871.96	2573.28	225.0	280.0	9.0	43.76	3131	1795.1	4926.13	359.0	247.0	180.0	224.0	651.0	4376.0	5386.0	459.87

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.2(d): Kabini Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	21.20	13.60	17.81	52.61	23.01	23.01	0.75	3.68	103.07	181.53	284.60	7.35	5.06	18.41	18.41	41.88	368.2	7.90	425.34	140.73
Jul	184.50	118.36	154.92	457.78	23.78	23.78	0.75	2.31	508.41	113.99	622.39	63.99	44.02	19.02	19.02	82.07	231.2	68.74	446.00	-176.39
Aug	180.51	115.80	151.57	447.88	23.78	23.78	0.75	10.14	506.34	500.02	1006.36	62.60	43.07	19.02	19.02	81.12	1014	67.25	1225.2	218.82
Sep	144.05	92.42	120.96	357.42	23.01	23.01	0.75	11.11	415.31	547.75	963.06	49.96	34.37	18.41	18.41	71.19	1111	53.67	1285.8	322.76
Oct	16.00	10.27	13.44	39.71	23.78	23.78	0.75	4.90	92.92	241.58	334.50	5.55	3.82	19.02	19.02	41.87	490	5.96	543.38	208.88
Nov	47.63	30.56	40.00	118.19	23.01	23.01	0.75	1.23	166.19	60.54	226.74	16.52	11.37	18.41	18.41	48.19	122.8	17.75	205.26	-21.48
Dec	94.18	60.42	79.08	233.69	23.78	23.78	0.75	0.24	282.24	11.93	294.17	32.67	22.48	19.02	19.02	60.52	24.2	35.09	152.48	-141.69
Jan	136.42	87.52	114.55	338.50	23.78	23.78	0.75	0.00	386.81	0.00	386.81	47.32	32.56	19.02	19.02	70.61	0	50.83	168.75	-218.06
Feb	124.09	79.61	104.20	307.89	21.48	21.48	0.75	0.00	351.60	0.00	351.60	43.04	29.61	17.18	17.18	63.98	0	46.23	153.25	-198.35
Mar	64.50	41.38	54.16	160.05	23.78	23.78	0.75	0.00	208.36	0.00	208.36	22.37	15.39	19.02	19.02	53.44	0	24.03	99.84	-108.52
Apr	15.16	9.73	12.73	37.63	23.01	23.01	0.75	0.75	85.16	37.17	122.33	5.26	3.62	18.41	18.41	40.44	75.4	5.65	126.75	4.42
May	6.85	4.39	5.75	16.98	23.78	23.78	0.75	9.39	74.68	462.90	537.58	2.37	1.63	19.02	19.02	39.68	938.9	2.55	983.51	445.92
Total	1035.11	666.2	871.96	2573.28	280.0	280.0	9.0	43.76	3186.0	1795.1	4981.13	359.0	247.0	224.0	224.0	695.0	4376.0	386.4	5816.4	835.27

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.2(e): Kabini Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses			Total	Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial				
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	21.20	13.65	17.87	52.72	18.49	23.01	0.75	3.50	98 47	172.40	270.87	7.35	5.06	14.79	18.41	38.26	349 7	395.30	124 43
Jul	184.50	118.75	155.46	458.71	19.11	23.78	0.75	4.92	507.27	242.61	749.88	63.99	44.02	15.29	19.02	78.34	492.1	634.41	-115.47
Aug	180.51	116.18	152.10	448.79	19.11	23.78	0.75	5.41	497.84	266.92	764.76	62.60	43.07	15.29	19.02	77.38	541.4	681.39	-83.38
Sep	144.05	92.71	121.38	358.15	18.49	23.01	0.75	2.44	402.84	120.30	523.14	49.96	34.37	14.79	18.41	67.58	244	361.54	-161.60
Oct	16.00	10.30	13.48	39.79	19.11	23.78	0.75	5.98	89.41	294.85	384.26	5.55	3.82	15.29	19.02	38.13	598.1	641.73	257.47
Nov	47.63	30.66	40.14	118.43	18.49	23.01	0.75	1.94	162.62	95.68	258.30	16.52	11.37	14.79	18.41	44.57	194.1	255.16	-3.14
Dec	94.18	60.62	79.36	234.16	19.11	23.78	0.75	0.45	278.25	21.99	300.24	32.67	22.48	15.29	19.02	56.79	44.61	134.06	-166.18
Jan	136.42	87.80	114.96	339.19	19.11	23.78	0.75	0.13	382.96	6.36	389.32	47.32	32.56	15.29	19.02	66.87	12.91	127.10	-262.22
Feb	124.09	79.87	104.56	308.52	17.26	21.48	0.75	0.11	348.11	5.30	353.42	43.04	29.61	13.81	17.18	60.60	10.76	114.40	-239.02
Mar	64.50	41.52	54.35	160.37	19.11	23.78	0.75	0.94	204.96	46.57	251.53	22 37	15.39	15.29	19.02	49.70	94.46	166.54	-84.99
Apr	15.16	9.76	12.78	37.70	18.49	23.01	0.75	1.43	81.39	70.74	152.13	5.26	3.62	14.79	18.41	36.82	143.5	185.56	33.43
May	6.85	4.41	5.77	17.02	19.11	23.78	0.75	3.14	63.80	155.05	218.85	2.37	1.63	15.29	19.02	35.95	314.5	352.81	133.96
Total	1035.11	666.21	871.96	2573 27	225.0	280.0	9.0	30.40	3117.67	1795.1	4912.76	359.0	247.0	180.0	224.0	651.0	3040 0	4050.0	-862.76

Note : Column no. 10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.2(f): Kabini Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses			Total	Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial					
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	21.20	13.60	17.81	52.61	23.01	23.01	0.75	3.50	102.89	172.40	275.29	7.35	5.06	18.41	18.41	41.88	349.7	7.90	406.82	131.53
Jul	184.50	118.36	154.92	457.78	23.78	23.78	0.75	4.92	511.01	242.61	753.63	63.99	44.02	19.02	19.02	82.07	492 1	68.74	706.89	-46.74
Aug	180.51	115.80	151.57	447.88	23.78	23.78	0.75	5.41	501.61	266.92	768.53	62.60	43.07	19.02	19.02	81.12	541.4	67.25	752.38	-16.15
Sep	144.05	92.42	120.96	357.42	23.01	23.01	0.75	2.44	406.64	120.30	526.94	49.96	34.37	18.41	18.41	71.19	244	53.67	418.82	-108.12
Oct	16.00	10.27	13.44	39.71	23.78	23.78	0.75	5.98	94.00	294.85	388.85	5.55	3.82	19.02	19.02	41.87	598.1	5.96	651.43	262.58
Nov	47.63	30.56	40.00	118.19	23.01	23.01	0.75	1.94	166.91	95.68	262.59	16.52	11.37	18.41	18.41	48.19	194.1	17.75	276.53	13.94
Dec	94.18	60.42	79.08	233.69	23.78	23.78	0 75	0.45	282.45	21.99	304.44	32.67	22.48	19.02	19.02	60.52	44.61	35.09	172.89	-131.55
Jan	136.42	87.52	114.55	338.50	23.78	23.78	0.75	0.13	386.94	6.36	393.31	47.32	32.56	19.02	19.02	70.61	12.91	50.83	181.66	-211.64
Feb	124.09	79.61	104.20	307.89	21.48	21.48	0.75	0.11	351.71	5.30	357.02	43.04	29.61	17.18	17.18	63.98	10.76	46.23	164.01	-193.00
Mar	64.50	41.38	54.16	160 05	23.78	23.78	0.75	0.94	209.31	46.57	255.88	22.37	15.39	19.02	19.02	53.44	94.46	24.03	194.30	-61.57
Apr	15.16	9.73	12.73	37.63	23.01	23.01	0.75	1.43	85.84	70.74	156.58	5.26	3.62	18.41	18.41	40.44	143.5	5.65	194.83	38.25
May	6.85	4.39	5.75	16.98	23.78	23.78	0.75	3.14	68.44	155.05	223.49	2.37	1.63	19.02	19.02	39.68	314 5	2.55	359.10	135.61
Total	1035.11	666.2	872.0	2573.28	280.0	280.0	9.0	30.40	3172.68	1795	4967.77	359.0	247.0	224.0	224.0	695.0	3040.0	386.4	4480.4	-487.37

Note : Column no. 10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.2(g): Kabini Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	21.20	13.65	17.87	52.72	18.49	23.01	0.75	1.20	96.18	59.16	155.34	7.35	5.06	14.79	18.41	38.26	120	165.62	10.28
Jul	184.50	118.75	155.46	458.71	19.11	23.78	0.75	3.77	506.12	185.76	691.88	63.99	44.02	15.29	19.02	78.34	376.78	519.10	-172.78
Aug	180.51	116.18	152.10	448.79	19.11	23.78	0.75	3.67	496.09	180.76	676.86	62.60	43.07	15.29	19.02	77.38	366.64	506.63	-170.23
Sep	144.05	92.71	121.38	358.15	18.49	23.01	0.75	2.18	402.58	107.23	509.81	49.96	34.37	14.79	18.41	67.58	217.5	335.04	-174.77
Oct	16.00	10.30	13.48	39.79	19.11	23.78	0.75	1.91	85.34	94.32	179.66	5.55	3.82	15.29	19.02	38.13	191.31	234.99	55.33
Nov	47.63	30.66	40.14	118.43	18.49	23.01	0.75	2.82	163.51	139.24	302.75	16.52	11.37	14.79	18.41	44.57	282.43	343.52	40.77
Dec	94.18	60.62	79.36	234.16	19.11	23.78	0.75	0.32	278.12	15.83	293.95	32.67	22.48	15.29	19.02	56.79	32.1	121.55	-172.39
Jan	136.42	87.80	114.96	339.19	19.11	23.78	0.75	0.15	382.98	7.43	390.41	47.32	32.56	15.29	19.02	66.87	15.08	129.27	-261.15
Feb	124.09	79.87	104.56	308.52	17.26	21.48	0.75	0.07	348.08	3.48	351.55	43.04	29.61	13.81	17.18	60.60	7.05	110.69	-240.86
Mar	64.50	41.52	54.35	160.37	19.11	23.78	0.75	0.40	204.42	19.89	224.31	22.37	15.39	15.29	19.02	49.70	40.35	112.43	-111.89
Apr	15.16	9.76	12.78	37.70	18.49	23.01	0.75	0.90	80.85	44.14	124.99	5.26	3.62	14.79	18.41	36.82	89.53	131.61	6.62
May	6.85	4.41	5.77	17.02	19.11	23.78	0.75	2.43	63.09	120.03	183.12	2.37	1.63	15.29	19.02	35.95	243.45	281.77	98.65
Total	1035.11	666.21	871.96	2573.28	225.0	280.0	9.0	19.82	3107.1	1795.1	4902.2	359.0	247.0	180.0	224.0	651.0	1982.0	2992.0	-1910.2

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.2(h): Kabini Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	21.20	13.60	17.81	52.61	23.01	23.01	0.75	1.20	100.59	59.16	159.75	7.35	5.06	18.41	18.41	41.88	120	7.90	177.14	17.38
Jul	184.50	118.36	154.92	457.78	23.78	23.78	0.75	3.77	509.86	185.76	695.62	63.99	44.02	19.02	19.02	82.07	376.78	68.74	591.58	-104.04
Aug	180.51	115.80	151.57	447.88	23.78	23.78	0.75	3.67	499.86	180.76	680.62	62.60	43.07	19.02	19.02	81.12	366.64	67.25	577.62	-103.01
Sep	144.05	92.42	120.96	357.42	23.01	23.01	0.75	2.18	406.38	107.23	513.61	49.96	34.37	18.41	18.41	71.19	217.5	53.67	392.32	-121.29
Oct	16.00	10.27	13.44	39.71	23.78	23.78	0.75	1.91	89.93	94.32	184.25	5.55	3.82	19.02	19.02	41.87	191.31	5.96	244.69	60.44
Nov	47.63	30.56	40.00	118.19	23.01	23.01	0.75	2.82	167.79	139.24	307.03	16.52	11.37	18.41	18.41	48.19	282.43	17.75	364.89	57.86
Dec	94.18	60.42	79.08	233.69	23.78	23.78	0.75	0.32	282.32	15.83	298.15	32.67	22.48	19.02	19.02	60.52	32.1	35.09	160.38	-137.76
Jan	136.42	87.52	114.55	338.50	23.78	23.78	0.75	0.15	386.96	7.43	394.40	47.32	32.56	19.02	19.02	70.61	15.08	50.83	183.83	-210.57
Feb	124.09	79.61	104.20	307.89	21.48	21.48	0.75	0.07	351.67	3.48	355.15	43.04	29.61	17.18	17.18	63.98	7.05	46.23	160.30	-194.85
Mar	64.50	41.38	54.16	160.05	23.78	23.78	0.75	0.40	208.77	19.89	228.66	22.37	15.39	19.02	19.02	53.44	40.35	24.03	140.19	-88.46
Apr	15.16	9.73	12.73	37.63	23.01	23.01	0.75	0.90	85.30	44.14	129.44	5.26	3.62	18.41	18.41	40.44	89.53	5.65	140.88	11.44
May	6.85	4.39	5.75	16.98	23.78	23.78	0.75	2.43	67.73	120.03	187.76	2.37	1.63	19.02	19.02	39.68	243.45	2.55	288.06	100.30
Total	1035.11	666.21	871.96	2573.28	280.0	280.0	9.0	19.82	3162.1	1795.1	4957.2	359.0	247.0	224.0	224.0	695.0	1982.0	386.4	3422.4	-1534.8

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.3(a): Shimsha Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	4.21	29.29	16.90	50.42	21.29	28.60	0.00	0.15	100.47	0.37	100.84	39.85	5.36	17.03	22.88	45.27	15.47	100.59	-0.25
Jul	27.84	193.74	111.80	333.56	22.00	29.56	0.00	0.10	385.21	0.23	385.44	263.61	35.47	17.60	23.64	76.71	9.65	349.97	-35.47
Aug	31.23	217.29	125.39	374.10	22.00	29.56	0.00	0.12	425.78	0.30	426.07	295.65	39.78	17.60	23.64	81.02	12.25	388.92	-37.15
Sep	23.75	165.23	95.35	284.48	21.29	28.60	0.00	0.89	335.26	2.16	337.42	224.82	30.25	17.03	22.88	70.16	89.18	384.16	46.74
Oct	3.50	24.33	14.04	41.88	22.00	29.56	0.00	3.20	96.64	7.76	104.40	33.10	4.45	17.60	23.64	45.70	320.33	399.12	294.72
Nov	19.55	136.05	78.51	234.23	21.29	28.60	0.00	1.27	285.39	3.08	288.48	185.11	24.90	17.03	22.88	64.82	127.2	377.13	88.65
Dec	36.00	250.49	144.54	431.25	22.00	29.56	0.00	0.16	482.97	0.39	483.36	340.82	45.85	17.60	23.64	87.10	16.1	444.02	-39.34
Jan	47.68	331.75	191.43	571.15	22.00	29.56	0.00	0.01	622.71	0.01	622.72	451.38	60.73	17.60	23.64	101.97	0.5	553.86	-68.87
Feb	37.61	261.71	151.02	450.57	19.87	26.70	0.00	0.00	497.14	0.00	497.14	356.09	47.91	15.89	21.36	85.16	0.12	441.37	-55.77
Mar	20.30	141.25	81.51	243.19	22.00	29.56	0.00	0.00	294.75	0.01	294.75	192.19	25.86	17.60	23.64	67.10	0.25	259.54	-35.21
Apr	7.87	54.74	31.59	94.24	21.29	28.60	0.00	0.04	144.17	0.09	144.26	74.48	10.02	17.03	22.88	49.93	3.65	128.06	-16.19
May	3.54	24.62	14.21	42.39	22.00	29.56	0.00	0.24	94.18	0.59	94.78	33.50	4.51	17.60	23.64	45.75	24.39	103.64	8.86
Total	263.00	1830	1056	3150.7	259.0	348.0	0.00	6.19	3763.9	14.9	3778.8	2490.0	335.0	207.2	278.4	820.6	619.0	3929.6	150.81

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no 20 = Column no.(19-12).

Table 4.10.3(b): Shimsha Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	4.21	29.30	16.90	50.41	28.60	28.60	0.00	0.15	107.77	0.37	108.14	39.85	5.36	22.88	22.88	51.13	15.47	8.10	114.54	6.40
Jul	27.84	193.83	111.77	333.44	29.56	29.56	0.00	0.10	392.65	0.23	392.88	263.61	35.47	23.64	23.64	82.76	9.65	53.57	409.59	16.71
Aug	31.23	217.38	125.35	373.97	29.56	29.56	0.00	0.12	433.20	0.30	433.50	295.65	39.78	23.64	23.64	87.07	12.25	60.08	455.05	21.55
Sep	23.75	165.30	95.32	284.37	28.60	28.60	0.00	0.89	342.47	2.16	344.63	224.82	30.25	22.88	22.88	76.01	89.18	45.69	435.70	91.07
Oct	3.50	24.34	14.03	41.87	29.56	29.56	0.00	3.20	104.18	7.76	111.94	33.10	4.45	23.64	23.64	51.74	320.33	6.73	411.90	299.95
Nov	19.55	136.11	78.49	234.15	28.60	28.60	0.00	1.27	292.62	3.08	295.71	185.11	24.90	22.88	22.88	70.67	127.2	37.62	420.60	124.89
Dec	36.00	250.59	144.50	431.10	29.56	29.56	0.00	0.16	490.37	0.39	490.76	340.82	45.85	23.64	23.64	93.14	16.1	69.26	519.32	28.56
Jan	47.68	331.89	191.38	570.95	29.56	29.56	0.00	0.01	630.06	0.01	630.08	451.38	60.73	23.64	23.64	108.02	0.5	91.73	651.63	21.55
Feb	37.61	261.82	150.98	450.41	26.70	26.70	0.00	0.00	503.80	0.00	503.80	356.09	47.91	21.36	21.36	90.62	0.12	72.36	519.19	15.39
Mar	20.30	141.31	81.49	243.10	29.56	29.56	0.00	0.00	302.22	0.01	302.22	192.19	25.86	23.64	23.64	73.15	0.25	39.06	304.65	2.42
Apr	7.87	54.76	31.58	94.21	28.60	28.60	0.00	0.04	151.45	0.09	151.54	74.48	10.02	22.88	22.88	55.78	3.65	15.13	149.05	-2.49
May	3.54	24.63	14.20	42.37	29.56	29.56	0.00	0.24	101.73	0.59	102.32	33.50	4.51	23.64	23.64	51.80	24.39	6.81	116.49	14.17
Total	263.00	1831	1056	3149.55	348.0	348.0	0.00	6.19	3851.74	14.91	3866.64	2490.0	335.0	278.4	278.4	891.8	619.0	506.0	4506.8	640.15

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.3(c): Shimsha Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	4.21	29.29	16.90	50.42	21.29	28.60	0.15	0.00	100.47	0.46	100.93	39.85	5.36	17.03	22.88	45.27	19.07	104.19	3.26
Jul	27.84	193.74	111.80	333.56	22.00	29.56	0.10	0.00	385.21	0.29	385.50	263.61	35.47	17.60	23.64	76.71	11.89	352.22	-33.28
Aug	31.23	217.29	125.39	374.10	22.00	29.56	0.12	0.00	425.78	0.37	426.14	295.65	39.78	17.60	23.64	81.02	15.10	391.77	-34.37
Sep	23.75	165.23	95.35	284.48	21.29	28.60	0.89	0.00	335.26	2.66	337.92	224.82	30.25	17.03	22.88	70.16	109.93	404.91	66.99
Oct	3.50	24.33	14.04	41.88	22.00	29.56	3.20	0.00	96.64	9.57	106.21	33.10	4.45	17.60	23.64	45.70	394.85	473.64	367.44
Nov	19.55	136.05	78.51	234.23	21.29	28.60	1.27	0.00	285.39	3.80	289.19	185.11	24.90	17.03	22.88	64.82	156.79	406.72	117.53
Dec	36.00	250.49	144.54	431.25	22.00	29.56	0.16	0.00	482.97	0.48	483.45	340.82	45.85	17.60	23.64	87.10	19.85	447.76	-35.69
Jan	47.68	331.75	191.43	571.15	22.00	29.56	0.01	0.00	622.71	0.01	622.73	451.38	60.73	17.60	23.64	101.97	0.62	553.97	-68.76
Feb	37.61	261.71	151.02	450.57	19.87	26.70	0.00	0.00	497.14	0.00	497.14	356.09	47.91	15.89	21.36	85.16	0.15	441.39	-55.75
Mar	20.30	141.25	81.51	243.19	22.00	29.56	0.00	0.00	294.75	0.01	294.75	192.19	25.86	17.60	23.64	67.10	0.31	259.60	-35.15
Apr	7.87	54.74	31.59	94.24	21.29	28.60	0.04	0.00	144.17	0.11	144.28	74.48	10.02	17.03	22.88	49.93	4.50	128.91	-15.37
May	3.54	24.62	14.21	42.39	22.00	29.56	0.24	0.00	94.18	0.73	94.91	33.50	4.51	17.60	23.64	45.75	30.06	109.31	14.40
Total	263.00	1830.0	1056.0	3150.7	259.0	348.0	6.19	0.00	3763.9	14.9	3778.8	2490.0	335.0	207.2	278.4	820.6	763.00	4073.6	294.81

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.3(d): Shimsha Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	4.21	29.30	16.90	50.41	28.60	28.60	0.19	0.00	107.80	0.46	108.26	39.85	5.36	22.88	22.88	51.13	19.07	8.10	118.14	9.88
Jul	27.84	193.83	111.77	333.44	29.56	29.56	0.12	0.00	392.67	0.29	392.96	263.61	35.47	23.64	23.64	82.76	11.89	53.57	411.83	18.88
Aug	31.23	217.38	125.35	373.97	29.56	29.56	0.15	0.00	433.23	0.37	433.60	295.65	39.78	23.64	23.64	87.07	15.10	60.08	457.90	24.31
Sep	23.75	165.30	95.32	284.37	28.60	28.60	1.10	0.00	342.68	2.66	345.34	224.82	30.25	22.88	22.88	76.01	109.93	45.69	456.45	111.11
Oct	3.50	24.34	14.03	41.87	29.56	29.56	3.95	0.00	104.93	9.57	114.49	33.10	4.45	23.64	23.64	51.74	394.85	6.73	486.42	371.92
Nov	19.55	136.11	78.49	234.15	28.60	28.60	1.57	0.00	292.92	3.80	296.72	185.11	24.90	22.88	22.88	70.67	156.79	37.62	450.19	153.47
Dec	36.00	250.59	144.50	431.10	29.56	29.56	0.20	0.00	490.41	0.48	490.89	340.82	45.85	23.64	23.64	93.14	19.85	69.26	523.07	32.18
Jan	47.68	331.89	191.38	570.95	29.56	29.56	0.01	0.00	630.07	0.01	630.08	451.38	60.73	23.64	23.64	108.02	0.62	91.73	651.75	21.67
Feb	37.61	261.82	150.98	450.41	26.70	26.70	0.00	0.00	503.80	0.00	503.81	356.09	47.91	21.36	21.36	90.62	0.15	72.36	519.22	15.41
Mar	20.30	141.31	81.49	243.10	29.56	29.56	0.00	0.00	302.22	0.01	302.22	192.19	25.86	23.64	23.64	73.15	0.31	39.06	304.71	2.48
Apr	7.87	54.76	31.58	94.21	28.60	28.60	0.04	0.00	151.46	0.11	151.57	74.48	10.02	22.88	22.88	55.78	4.50	15.13	149.90	-1.67
May	3.54	24.63	14.20	42.37	29.56	29.56	0.30	0.00	101.78	0.73	102.51	33.50	4.51	23.64	23.64	51.80	30.06	6.81	122.17	19.65
Total	263.00	1830.8	1055.7	3149.5	348.0	348.0	7.63	0.00	3853.18	14.91	3868.10	2490.0	335.0	278.4	278.4	891.8	763.00	506.0	4650.8	782.71

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.3(e): Shimsha Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	4.21	29.29	16.90	50.42	21.29	28.60	0.15	0.00	100.47	0.31	100.78	39.85	5.36	17.03	22.88	45.27	12.64	97.76	-3.01
Jul	27.84	193.74	111.80	333.56	22.00	29.56	0.10	0.00	385.21	0.19	385.40	263.61	35.47	17.60	23.64	76.71	7.89	348.21	-37.19
Aug	31.23	217.29	125.39	374.10	22.00	29.56	0.12	0.00	425.78	0.24	426.02	295.65	39.78	17.60	23.64	81.02	10.01	386.68	-39.34
Sep	23.75	165.23	95.35	284.48	21.29	28.60	0.89	0.00	335.26	1.77	337.02	224.82	30.25	17.03	22.88	70.16	72.89	367.87	30.85
Oct	3.50	24.33	14.04	41.88	22.00	29.56	3.20	0.00	96.64	6.34	102.98	33.10	4.45	17.60	23.64	45.70	261.81	340.60	237.62
Nov	19.55	136.05	78.51	234.23	21.29	28.60	1.27	0.00	285.39	2.52	287.91	185.11	24.90	17.03	22.88	64.82	103.96	353.89	65.98
Dec	36.00	250.49	144.54	431.25	22.00	29.56	0.16	0.00	482.97	0.32	483.29	340.82	45.85	17.60	23.64	87.10	13.16	441.08	-42.21
Jan	47.68	331.75	191.43	571.15	22.00	29.56	0.01	0.00	622.71	0.01	622.72	451.38	60.73	17.60	23.64	101.97	0.41	553.77	-68.96
Feb	37.61	261.71	151.02	450.57	19.87	26.70	0.00	0.00	497.14	0.00	497.14	356.09	47.91	15.89	21.36	85.16	0.1	441.35	-55.79
Mar	20.30	141.25	81.51	243.19	22.00	29.56	0.00	0.00	294.75	0.00	294.75	192.19	25.86	17.60	23.64	67.10	0.2	259.49	-35.26
Apr	7.87	54.74	31.59	94.24	21.29	28.60	0.04	0.00	144.17	0.07	144.24	74.48	10.02	17.03	22.88	49.93	2.98	127.39	-16.85
May	3.54	24.62	14.21	42.39	22.00	29.56	0.24	0.00	94.18	0.48	94.67	33.50	4.51	17.60	23.64	45.75	19.93	99.18	4.51
Total	263.00	1830.0	1056.0	3150.7	259.0	348.0	6.19	0.00	3763.9	14.9	3778.8	2490.0	335.0	207.2	278.4	820.6	506.0	3816.6	37.79

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18) Column no.20 = Column no.(19-12).

Table 4.10.3(f): Shimsha Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	4.21	29.30	16.90	50.41	28.60	28.60	0.13	0.00	107.74	0.31	108.04	39.85	5.36	22.88	22.88	51.13	12.64	9.70	113.31	5.27
Jul	27.84	193.83	111.77	333.44	29.56	29.56	0.08	0.00	392.63	0.19	392.82	263.61	35.47	23.64	23.64	82.76	7.89	64.16	418.42	25.59
Aug	31.23	217.38	125.35	373.97	29.56	29.56	0.10	0.00	433.18	0.24	433.42	295.65	39.78	23.64	23.64	87.07	10.01	71.95	464.68	31.26
Sep	23.75	165.30	95.32	284.37	28.60	28.60	0.73	0.00	342.31	1.77	344.07	224.82	30.25	22.88	22.88	76.01	72.89	54.72	428.44	84.37
Oct	3.50	24.34	14.03	41.87	29.56	29.56	2.62	0.00	103.60	6.34	109.94	33.10	4.45	23.64	23.64	51.74	261.81	8.06	354.71	244.77
Nov	19.55	136.11	78.49	234.15	28.60	28.60	1.04	0.00	292.39	2.52	294.91	185.11	24.90	22.88	22.88	70.67	103.96	45.05	404.79	109.88
Dec	36.00	250.59	144.50	431.10	29.56	29.56	0.13	0.00	490.34	0.32	490.66	340.82	45.85	23.64	23.64	93.14	13.16	82.95	530.07	39.41
Jan	47.68	331.89	191.38	570.95	29.56	29.56	0.00	0.00	630.06	0.01	630.07	451.38	60.73	23.64	23.64	108.02	0.41	109.86	669.67	39.59
Feb	37.61	261.82	150.98	450.41	26.70	26.70	0.00	0.00	503.80	0.00	503.80	356.09	47.91	21.36	21.36	90.62	0.1	86.66	533.47	29.67
Mar	20.30	141.31	81.49	243.10	29.56	29.56	0.00	0.00	302.22	0.00	302.22	192.19	25.86	23.64	23.64	73.15	0.2	46.77	312.32	10.09
Apr	7.87	54.76	31.58	94.21	28.60	28.60	0.03	0.00	151.44	0.07	151.51	74.48	10.02	22.88	22.88	55.78	2.98	18.13	151.37	-0.14
May	3.54	24.63	14.20	42.37	29.56	29.56	0.20	0.00	101.68	0.48	102.17	33.50	4.51	23.64	23.64	51.80	19.93	8.15	113.38	11.21
Total	263.00	1830.8	1055.7	3149.5	348.0	348.0	5.06	0.00	3850.6	14.91	3865.5	2490.0	335.0	278.4	278.4	891.8	506.0	606.0	4493.8	628.26

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.3(g): Shimsha Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	4.21	29.29	16.90	50.42	21.29	28.60	0.15	0.00	100.47	0.19	100.66	39.85	5.36	17.03	22.88	45.27	7.92	93.04	-7.62
Jul	27.84	193.74	111.80	333.56	22.00	29.56	0.10	0.00	385.21	0.12	385.33	263.61	35.47	17.60	23.64	76.71	4.94	345.26	-40.07
Aug	31.23	217.29	125.39	374.10	22.00	29.56	0.12	0.00	425.78	0.15	425.93	295.65	39.78	17.60	23.64	81.02	6.27	382.94	-42.99
Sep	23.75	165.23	95.35	284.48	21.29	28.60	0.89	0.00	335.26	1.11	336.36	224.82	30.25	17.03	22.88	70.16	45.66	340.64	4.28
Oct	3.50	24.33	14.04	41.88	22.00	29.56	3.20	0.00	96.64	3.97	100.61	33.10	4.45	17.60	23.64	45.70	164.02	242.81	142.20
Nov	19.55	136.05	78.51	234.23	21.29	28.60	1.27	0.00	285.39	1.58	286.97	185.11	24.90	17.03	22.88	64.82	65.13	315.06	28.09
Dec	36.00	250.49	144.54	431.25	22.00	29.56	0.16	0.00	482.97	0.20	483.17	340.82	45.85	17.60	23.64	87.10	8.24	436.16	-47.01
Jan	47.68	331.75	191.43	571.15	22.00	29.56	0.01	0.00	622.71	0.01	622.72	451.38	60.73	17.60	23.64	101.97	0.26	553.62	-69.10
Feb	37.61	261.71	151.02	450.57	19.87	26.70	0.00	0.00	497.14	0.00	497.14	356.09	47.91	15.89	21.36	85.16	0.06	441.31	-55.83
Mar	20.30	141.25	81.51	243.19	22.00	29.56	0.00	0.00	294.75	0.00	294.75	192.19	25.86	17.60	23.64	67.10	0.13	259.42	-35.33
Apr	7.87	54.74	31.59	94.24	21.29	28.60	0.04	0.00	144.17	0.05	144.21	74.48	10.02	17.03	22.88	49.93	1.87	126.28	-17.93
May	3.54	24.62	14.21	42.39	22.00	29.56	0.24	0.00	94.18	0.30	94.49	33.50	4.51	17.60	23.64	45.75	12.49	91.74	-2.75
Total	263.00	1830.0	1056.0	3150.7	259.0	348.0	6.19	0.00	3763.9	14.9	3778.8	2490.0	335.0	207.2	278.4	820.6	317.0	3627.6	-151.2

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.3(h): Shimsha Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	4.21	29.30	16.90	50.41	28.60	28.60	0.08	0.00	107.69	0.19	107.88	39.85	5.36	22.88	22.88	51.13	7.92	8.10	106.99	-0.89
Jul	27.84	193.83	111.77	333.44	29.56	29.56	0.05	0.00	392.60	0.12	392.72	263.61	35.47	23.64	23.64	82.76	4.94	53.57	404.88	12.16
Aug	31.23	217.38	125.35	373.97	29.56	29.56	0.06	0.00	433.14	0.15	433.29	295.65	39.78	23.64	23.64	87.07	6.27	60.08	449.07	15.78
Sep	23.75	165.30	95.32	284.37	28.60	28.60	0.46	0.00	342.03	1.11	343.14	224.82	30.25	22.88	22.88	76.01	45.66	45.69	392.18	49.04
Oct	3.50	24.34	14.03	41.87	29.56	29.56	1.64	0.00	102.62	3.97	106.59	33.10	4.45	23.64	23.64	51.74	164.02	6.73	255.59	148.99
Nov	19.55	136.11	78.49	234.15	28.60	28.60	0.65	0.00	292.00	1.58	293.58	185.11	24.90	22.88	22.88	70.67	65.13	37.62	358.53	64.95
Dec	36.00	250.59	144.50	431.10	29.56	29.56	0.08	0.00	490.29	0.20	490.49	340.82	45.85	23.64	23.64	93.14	8.24	69.26	511.46	20.97
Jan	47.68	331.89	191.38	570.95	29.56	29.56	0.00	0.00	630.06	0.01	630.07	451.38	60.73	23.64	23.64	108.02	0.26	91.73	651.39	21.32
Feb	37.61	261.82	150.98	450.41	26.70	26.70	0.00	0.00	503.80	0.00	503.80	356.09	47.91	21.36	21.36	90.62	0.06	72.36	519.13	15.33
Mar	20.30	141.31	81.49	243.10	29.56	29.56	0.00	0.00	302.22	0.00	302.22	192.19	25.86	23.64	23.64	73.15	0.13	39.06	304.53	2.31
Apr	7.87	54.76	31.58	94.21	28.60	28.60	0.02	0.00	151.43	0.05	151.48	74.48	10.02	22.88	22.88	55.78	1.87	15.13	147.27	-4.21
May	3.54	24.63	14.20	42.37	29.56	29.56	0.12	0.00	101.61	0.30	101.91	33.50	4.51	23.64	23.64	51.80	12.49	6.81	104.59	2.68
Total	263.00	1830.8	1055.7	3149.5	348.0	348.0	3.17	0.00	3848.7	14.91	3863.6	2490.0	335.0	278.4	278.4	891.8	317.0	506.0	4204.8	341.17

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.4(a): Arkavathi Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	5.21	4.80	3.23	13.16	39.37	45.95	0.00	0.10	98.65	28.52	127.16	10.85	0.56	31.50	36.76	68.81	10.1	89.76	-37.40
Jul	12.66	11.67	7.84	31.97	40.68	47.48	0.00	0.07	120.30	21.15	141.45	26.35	1.35	32.55	37.98	71.88	7.49	105.72	-35.73
Aug	17.02	15.68	10.54	42.98	40.68	47.48	0.00	0.14	131.31	38.96	170.27	35.42	1.82	32.55	37.98	72.35	13.8	121.57	-48.70
Sep	19.60	18.06	12.14	49.49	39.37	45.95	0.00	0.99	134.98	280.75	415.73	40.79	2.09	31.50	36.76	70.35	99.44	210.57	-205.15
Oct	14.16	13.05	8.77	35.76	40.68	47.48	0.00	0.90	124.09	254.75	378 83	29.47	1.51	32.55	37.98	72.04	90.23	191.74	-187.09
Nov	16.33	15.05	10.12	41.25	39.37	45.95	0.00	0.37	126.73	104.29	231.03	34.00	1.75	31.50	36.76	70.00	36.94	140 93	-90.09
Dec	31.00	28.57	19.21	78.31	40.68	47.48	0.00	0.10	166.64	28.20	194.84	64.54	3.31	32.55	37.98	73.84	9.99	148.37	-46.48
Jan	34.38	31.68	21.30	86.85	40.68	47.48	0.00	0.04	175.18	11.10	186.27	71.57	3.67	32.55	37 98	74.20	3.93	149.71	-36.57
Feb	22.15	20.41	13.72	55.94	36.75	42.88	0.00	0.03	135.73	7.20	142.93	46.10	2.37	29.40	34 31	66.07	2.55	114.72	-28 21
Mar	13.74	12.67	8.51	34.71	40.68	47.48	0.00	0.02	123.03	5.42	128.45	28.60	1.47	32.55	37.98	72.00	1.92	102.52	-25 94
Apr	6.53	6.02	4.04	16.49	39.37	45.95	0.00	0.03	101.97	7.93	109.90	13.59	0.70	31.50	36.76	68.95	2.81	85.35	-24 56
May	3.71	3.42	2.30	9.36	40.68	47.48	0.00	0.08	97.69	22 02	119.71	7.72	0.40	32.55	37.98	70.92	7.8	86 44	-33.27
Total	196.48	181.1	121.73	496.3	479.0	559.0	0.00	2.87	1536.30	810.29	2346.6	409.0	21.00	383.2	447.2	851.4	287.0	1547.4	-799.19

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.4(b): Arkavathi Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	5.21	4.80	3.23	13.16	45.95	45.95	0.00	0.10	105.16	28.52	133.67	10.85	0.56	36.76	36.76	74.07	10.1	2.75	97.76	-35.91
Jul	12.66	11.67	7.83	31.97	47.48	47.48	0.00	0.07	127.00	21.15	148.15	26.35	1.35	37.98	37.98	77.32	7.49	6.67	117.82	-30.33
Aug	17.02	15.68	10.53	42.98	47.48	47.48	0.00	0.14	138.07	38.96	177.03	35.42	1.82	37.98	37.98	77.78	13.8	8.96	135.96	-41.07
Sep	19.60	18.06	12.13	49.49	45.95	45.95	0.00	0.99	142.38	280.75	423.13	40.79	2.09	36.76	36.76	75.61	99.44	10.32	226.16	-196.97
Oct	14.16	13.05	8.76	35.76	47.48	47.48	0.00	0.90	131.62	254.75	386.36	29.47	1.51	37.98	37.98	77.48	90.23	7.46	204.63	-181.73
Nov	16.33	15.05	10.11	41.25	45.95	45.95	0.00	0.37	133.51	104.29	237.80	34.00	1.75	36.76	36.76	75.26	36.94	8.60	154.80	-83.01
Dec	31.00	28.58	19.19	78.31	47.48	47.48	0.00	0.10	173.37	28.20	201.57	64.54	3.31	37.98	37.98	79.28	9.99	16.33	170.14	-31.4
Jan	34.38	31.69	21.28	86.85	47.48	47.48	0.00	0.04	181.84	11.10	192.94	71.57	3.67	37.98	37.98	79.64	3.93	18.11	173.25	-19.7
Feb	22.15	20.41	13.71	55.94	42.88	42.88	0.00	0.03	141.73	7.20	148.93	46.10	2.37	34.31	34.31	70.98	2.55	11.67	131.29	-17.6
Mar	13.74	12.66	8.50	34.71	47.48	47.48	0.00	0.02	129.68	5.42	135.10	28.60	1.47	37.98	37.98	77.43	1.92	7.24	115.19	-19.91
Apr	6.53	6.02	4.04	16.49	45.95	45.95	0.00	0.03	108.40	7.93	116.34	13.59	0.70	36.76	36.76	74.21	2.81	3.44	94.04	-22.29
May	3.71	3.42	2.29	9.36	47.48	47.48	0.00	0.08	104.39	22.02	126.42	7.72	0.40	37.98	37.98	76.36	7.8	1.95	93.83	-32.59
Total	196.48	181.1	121.6	496.3	559.0	559.0	0.00	2.87	1617.2	810.29	2427.46	409.0	21.0	447.2	447.2	915.4	287.0	103.5	1714.9	-713

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+13+18+19) Column no. 21 = Column no.(20-12).

Table 4.10.4(c): Arkavathi Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available		
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)		(20)
Jun	5.21	4.80	3.23	13.16	39.37	45.95	0.10	0.17	98.65	38.65	137.30	10.85	0.56	31.50	36.76	68.81	13.69	93.35		-43.95
Jul	12.66	11.67	7.84	31.97	40.68	47.48	0.07	0.17	120.30	28.66	148.96	26.35	1.35	32.55	37.98	71.88	10.15	108.38		-40.58
Aug	17.02	15.68	10.54	42.98	40.68	47.48	0.14	0.17	131.31	52.81	184.11	35.42	1.82	32.55	37.98	72.35	18.70	126.47		-57.64
Sep	19.60	18.06	12.14	49.49	39.37	45.95	0.99	0.17	134.98	380.53	515.50	40.79	2.09	31.50	36.76	70.35	134.78	245.91		-269.59
Oct	14.16	13.05	8.77	35.76	40.68	47.48	0.90	0.17	124.09	345.28	469.37	29.47	1.51	32.55	37.98	72.04	122.30	223.81		-245.56
Nov	16.33	15.05	10.12	41.25	39.37	45.95	0.37	0.17	126.73	141.36	268.09	34.00	1.75	31.50	36.76	70.00	50.07	154.06		-114.03
Dec	31.00	28.57	19.21	78.31	40.68	47.48	0.10	0.17	166.64	38.23	204.87	64.54	3.31	32.55	37.98	73.84	13.54	151.92		-52.95
Jan	34.38	31.68	21.30	86.85	40.68	47.48	0.04	0.17	175.18	15.04	190.21	71.57	3.67	32.55	37.98	74.20	5.33	151.10		-39.11
Feb	22.15	20.41	13.72	55.94	36.75	42.88	0.03	0.17	135.73	9.76	145.49	46.10	2.37	29.40	34.31	66.07	3.46	115.62		-29.87
Mar	13.74	12.67	8.51	34.71	40.68	47.48	0.02	0.17	123.03	7.35	130.38	28.60	1.47	32.55	37.98	72.00	2.60	103.20		-27.18
Apr	6.53	6.02	4.04	16.49	39.37	45.95	0.03	0.17	101.97	10.75	112.72	13.59	0.70	31.50	36.76	68.95	3.81	86.34		-26.38
May	3.71	3.42	2.30	9.36	40.68	47.48	0.08	0.17	97.69	29.85	127.54	7.72	0.40	32.55	37.98	70.92	10.57	89.21		-38.33
Total	196.48	181.07	121.73	496.3	479.0	559.0	2.87	2.00	1536.30	810.29	2346.6	409.0	21.00	383.20	447.20	851.40	389.00	1649.4		-697.19

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no (13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.4(d): Arkavathi Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	5.21	4.80	3.23	13.16	45.95	45.95	0.10	0.17	98.65	38.65	120.14	10.85	0.56	31.50	36.76	68.81	13.69	2.75	96.09	-24.05
Jul	12.66	11.67	7.83	31.97	47.48	47.48	0.07	0.17	120.30	28.66	172.50	26.35	1.35	32.55	37.98	71.88	10.15	6.67	115.05	-57.45
Aug	17.02	15.68	10.53	42.98	47.48	47.48	0.14	0.17	131.31	52.81	201.48	35.42	1.82	32.55	37.98	72.35	18.70	8.96	135.43	-66.05
Sep	19.60	18.06	12.13	49.49	45.95	45.95	0.99	0.17	134.98	380.53	215.78	40.79	2.09	31.50	36.76	70.35	134.78	10.32	256.24	40.45
Oct	14.16	13.05	8.76	35.76	47.48	47.48	0.90	0.17	124.09	345.28	182.47	29.47	1.51	32.55	37.98	72.04	122.30	7.46	231.27	48.79
Nov	16.33	15.05	10.11	41.25	45.95	45.95	0.37	0.17	126.73	141.36	194.08	34.00	1.75	31.50	36.76	70.00	50.07	8.60	162.66	-31.42
Dec	31.00	28.58	19.19	78.31	47.48	47.48	0.10	0.17	166.64	38.23	294.50	64.54	3.31	32.55	37.98	73.84	13.54	16.33	168.25	-126.25
Jan	34.38	31.69	21.28	86.85	47.48	47.48	0.04	0.17	175.18	15.04	316.97	71.57	3.67	32.55	37.98	74.20	5.33	18.11	169.21	-147.76
Feb	22.15	20.41	13.71	55.94	42.88	42.88	0.03	0.17	135.73	9.76	227.06	46.10	2.37	29.40	34.31	66.07	3.46	11.67	127.29	-99.77
Mar	13.74	12.66	8.50	34.71	47.48	47.48	0.02	0.17	123.03	7.35	179.70	28.60	1.47	32.55	37.98	72.00	2.60	7.24	110.44	-69.26
Apr	6.53	6.02	4.04	16.49	45.95	45.95	0.03	0.17	101.97	10.75	128.88	13.59	0.70	31.50	36.76	68.95	3.81	3.44	89.78	-39.10
May	3.71	3.42	2.29	9.36	47.48	47.48	0.08	0.17	97.69	29.85	112.98	7.72	0.40	32.55	37.98	70.92	10.57	1.95	91.16	-21.81
Total	196.48	121.60	121.6	496.3	559.0	559.0	2.87	2.00	1619.17	810.29	2429	409.0	21.0	383.2	447.2	851.4	389.00	103.5	1752.9	-676.56

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.4(e): Arkavathi Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	5.21	4.80	3.23	13.16	39.37	45.95	0.00	0.07	98.65	20.16	118.80	10.85	0.56	31.50	36.76	68.81	7.14	86.80	-32.01
Jul	12.66	11.67	7.84	31.97	40.68	47.48	0.00	0.05	120.30	14.96	135.26	26.35	1.35	32.55	37.98	71.88	5.3	103.53	-31.73
Aug	17.02	15.68	10.54	42.98	40.68	47.48	0.00	0.10	131.31	27.56	158.86	35.42	1.82	32.55	37.98	72.35	9.76	117.53	-41.34
Sep	19.60	18.06	12.14	49.49	39.37	45.95	0.00	0.70	134.98	198.59	333.57	40.79	2.09	31.50	36.76	70.35	70.34	181.47	-152.09
Oct	14.16	13.05	8.77	35.76	40.68	47.48	0.00	0.64	124.09	180.18	304.27	29.47	1.51	32.55	37.98	72.04	63.82	165.33	-138.94
Nov	16.33	15.05	10.12	41.25	39.37	45.95	0.00	0.26	126.73	73.77	200.51	34.00	1.75	31.50	36.76	70.00	26.13	130.12	-70.38
Dec	31.00	28.57	19.21	78.31	40.68	47.48	0.00	0.07	166.64	19.96	186.60	64.54	3.31	32.55	37.98	73.84	7.07	145.45	-41.15
Jan	34.38	31.68	21.30	86.85	40.68	47.48	0.00	0.03	175.18	7.85	183.02	71.57	3.67	32.55	37.98	74.20	2.78	148.56	-34.47
Feb	22.15	20.41	13.72	55.94	36.75	42.88	0.00	0.02	135.73	5.08	140.81	46.10	2.37	29.40	34.31	66.07	1.8	113.97	-26.85
Mar	13.74	12.67	8.51	34.71	40.68	47.48	0.00	0.01	123.03	3.84	126.87	28.60	1.47	32.55	37.98	72.00	1.36	101.96	-24.91
Apr	6.53	6.02	4.04	16.49	39.37	45.95	0.00	0.02	101.97	5.62	107.59	13.59	0.70	31.50	36.76	68.95	1.99	84.53	-23.06
May	3.71	3.42	2.30	9.36	40.68	47.48	0.00	0.06	97.69	15.58	113.27	7.72	0.40	32.55	37.98	70.92	5.52	84.16	-29.11
Total	196.48	181.07	121.73	496.3	479.0	559.0	0.00	2.03	1536.30	810.29	2346.6	409.0	21.00	383.20	447.20	851.40	203.0	1463.4	-883.19

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.4(f): Arkavathi Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	5.21	4.80	3.23	13.16	45.95	45.95	0.00	0.07	105.13	28.52	133.64	10.85	0.56	36.76	36.76	74.07	7.14	2.75	94.80	-38.84
Jul	12.66	11.67	7.83	31.97	47.48	47.48	0.00	0.05	126.93	21.15	148.07	26.35	1.35	37.98	37.98	77.32	5.3	6.67	115.63	-32.44
Aug	17.02	15.68	10.53	42.98	47.48	47.48	0.00	0.10	138.03	38.96	176.99	35.42	1.82	37.98	37.98	77.78	9.76	8.96	131.92	-45.07
Sep	19.60	18.06	12.13	49.49	45.95	45.95	0.00	0.70	142.09	280.75	422.84	40.79	2.09	36.76	36.76	75.61	70.34	10.32	197.06	-225.78
Oct	14.16	13.05	8.76	35.76	47.48	47.48	0.00	0.64	131.35	254.75	386.10	29.47	1.51	37.98	37.98	77.48	63.82	7.46	178.22	-207.88
Nov	16.33	15.05	10.11	41.25	45.95	45.95	0.00	0.26	133.40	104.29	237.70	34.00	1.75	36.76	36.76	75.26	26.13	8.60	143.99	-93.71
Dec	31.00	28.58	19.19	78.31	47.48	47.48	0.00	0.07	173.34	28.20	201.54	64.54	3.31	37.98	37.98	79.28	7.07	16.33	167.22	-34.33
Jan	34.38	31.69	21.28	86.85	47.48	47.48	0.00	0.03	181.83	11.10	192.93	71.57	3.67	37.98	37.98	79.64	2.78	18.11	172.10	-20.82
Feb	22.15	20.41	13.71	55.94	42.88	42.88	0.00	0.02	141.72	7.20	148.92	46.10	2.37	34.31	34.31	70.98	1.8	11.67	130.54	-18.38
Mar	13.74	12.66	8.50	34.71	47.48	47.48	0.00	0.01	129.67	5.42	135.09	28.60	1.47	37.98	37.98	77.43	1.36	7.24	114.63	-20.46
Apr	6.53	6.02	4.04	16.49	45.95	45.95	0.00	0.02	108.40	7.93	116.33	13.59	0.70	36.76	36.76	74.21	1.99	3.44	93.22	-23.11
May	3.71	3.42	2.29	9.36	47.48	47.48	0.00	0.06	104.37	22.02	126.39	7.72	0.40	37.98	37.98	76.36	5.52	1.95	91.55	-34.85
Total	196.48	181.1	121.6	496.3	559.0	559.0	0.00	2.03	1616.33	810.29	2426.6	409.0	21.0	447.20	447.2	915.4	203.0	103.5	1630.9	-795.72

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19) Column no. 21 = Column no.(20-12).

Table 4.10.4(g): Arkavathi Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available		
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)		(20)
Jun	5.21	4.80	3.23	13.16	39.37	45.95	0.10	0.17	98.65	12.22	110.87	10.85	0.56	31.50	36.76	68.81	4.33	83.99		-26.88
Jul	12.66	11.67	7.84	31.97	40.68	47.48	0.07	0.17	120.30	9.06	129.36	26.35	1.35	32.55	37.98	71.88	3.21	101.44		-27.92
Aug	17.02	15.68	10.54	42.98	40.68	47.48	0.14	0.17	131.31	16.69	147.99	35.42	1.82	32.55	37.98	72.35	5.91	113.68		-34.32
Sep	19.60	18.06	12.14	49.49	39.37	45.95	0.99	0.17	134.98	120.33	255.30	40.79	2.09	31.50	36.76	70.35	42.62	153.75		-101.55
Oct	14.16	13.05	8.77	35.76	40.68	47.48	0.90	0.17	124.09	109.18	233.26	29.47	1.51	32.55	37.98	72.04	38.67	140.18		-93.08
Nov	16.33	15.05	10.12	41.25	39.37	45.95	0.37	0.17	126.73	44.69	171.43	34.00	1.75	31.50	36.76	70.00	15.83	119.82		-51.60
Dec	31.00	28.57	19.21	78.31	40.68	47.48	0.10	0.17	166.64	12.08	178.72	64.54	3.31	32.55	37.98	73.84	4.28	142.66		-36.06
Jan	34.38	31.68	21.30	86.85	40.68	47.48	0.04	0.17	175.18	4.74	179.92	71.57	3.67	32.55	37.98	74.20	1.68	147.46		-32.46
Feb	22.15	20.41	13.72	55.94	36.75	42.88	0.03	0.17	135.73	3.08	138.81	46.10	2.37	29.40	34.31	66.07	1.09	113.26		-25.55
Mar	13.74	12.67	8.51	34.71	40.68	47.48	0.02	0.17	123.03	2.32	125.35	28.60	1.47	32.55	37.98	72.00	0.82	101.42		-23.93
Apr	6.53	6.02	4.04	16.49	39.37	45.95	0.03	0.17	101.97	3.39	105.36	13.59	0.70	31.50	36.76	68.95	1.2	83.74		-21.62
May	3.71	3.42	2.30	9.36	40.68	47.48	0.08	0.17	97.69	9.43	107.12	7.72	0.40	32.55	37.98	70.92	3.34	81.98		-25.14
Total	196.48	181.07	121.73	496.3	479.0	559.0	2.87	2.00	1536.30	347.21	1883.5	409.0	21.00	383.20	447.20	851.4	123.0	1383.4		-500.11

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.4(h): Arkavathi Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	5.21	4.80	3.23	13.16	45.95	45.95	0.10	0.17	105.32	12.22	117.55	10.85	0.56	36.76	36.76	74.07	4.33	2.75	91.99	-25.55
Jul	12.66	11.67	7.83	31.97	47.48	47.48	0.07	0.17	127.17	9.06	136.23	26.35	1.35	37.98	37.98	77.32	3.21	6.67	113.54	-22.69
Aug	17.02	15.68	10.53	42.98	47.48	47.48	0.14	0.17	138.24	16.69	154.92	35.42	1.82	37.98	37.98	77.78	5.91	8.96	128.07	-26.85
Sep	19.60	18.06	12.13	49.49	45.95	45.95	0.99	0.17	142.54	120.33	262.87	40.79	2.09	36.76	36.76	75.61	42.62	10.32	169.34	-93.54
Oct	14.16	13.05	8.76	35.76	47.48	47.48	0.90	0.17	131.78	109.18	240.96	29.47	1.51	37.98	37.98	77.48	38.67	7.46	153.07	-87.89
Nov	16.33	15.05	10.11	41.25	45.95	45.95	0.37	0.17	133.68	44.69	178.37	34.00	1.75	36.76	36.76	75.26	15.83	8.60	133.69	-44.69
Dec	31.00	28.58	19.19	78.31	47.48	47.48	0.10	0.17	173.53	12.08	185.62	64.54	3.31	37.98	37.98	79.28	4.28	16.33	164.43	-21.19
Jan	34.38	31.69	21.28	86.85	47.48	47.48	0.04	0.17	182.01	4.74	186.75	71.57	3.67	37.98	37.98	79.64	1.68	18.11	171.00	-15.75
Feb	22.15	20.41	13.71	55.94	42.88	42.88	0.03	0.17	141.89	3.08	144.97	46.10	2.37	34.31	34.31	70.98	1.09	11.67	129.83	-15.14
Mar	13.74	12.66	8.50	34.71	47.48	47.48	0.02	0.17	129.85	2.32	132.16	28.60	1.47	37.98	37.98	77.43	0.82	7.24	114.09	-18.07
Apr	6.53	6.02	4.04	16.49	45.95	45.95	0.03	0.17	108.57	3.39	111.96	13.59	0.70	36.76	36.76	74.21	1.2	3.44	92.43	-19.53
May	3.71	3.42	2.29	9.36	47.48	47.48	0.08	0.17	104.56	9.43	113.99	7.72	0.40	37.98	37.98	76.36	3.34	1.95	89.37	-24.62
Total	196.48	181.1	121.6	496.3	559.0	559.0	2.87	2.00	1619.17	347.21	1966.4	409.0	21.0	447.20	447.2	915.4	123.0	103.5	1550.9	-415.48

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.5(a): Middle Cauvery Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.05	7.91	7.95	17.91	6.82	8.96	0.00	0.01	33.70	0.61	34.31	15.88	1.93	5.46	7.17	14.56	0.96	31.39	-2.92
Jul	38.61	148.89	149.69	337.20	7.05	9.26	0.00	0.18	353.68	11.31	364.99	298.99	36.35	5.64	7.41	49.40	17.69	366.07	1.08
Aug	35.52	136.98	137.71	310.21	7.05	9.26	0.00	0.46	326.98	29.51	356.49	275.06	33.44	5.64	7.41	46.49	46.15	367.69	11.21
Sep	28.52	109.98	110.57	249.08	6.82	8.96	0.00	0.82	265.68	52.29	317.97	220.85	26.85	5.46	7.17	39.48	81.78	342.11	24.14
Oct	2.56	9.89	9.94	22.39	7.05	9.26	0.00	0.73	39.43	46.48	85.91	19.85	2.41	5.64	7.41	15.46	72.69	108.00	22.10
Nov	8.65	33.34	33.51	75.49	6.82	8.96	0.00	0.72	91.99	45.87	137.86	66.94	8.14	5.46	7.17	20.76	71.73	159.43	21.58
Dec	17.84	68.80	69.17	155.81	7.05	9.26	0.00	0.22	172.34	13.98	186.31	138.15	16.80	5.64	7.41	29.84	21.86	189.86	3.54
Jan	25.48	98.26	98.79	222.54	7.05	9.26	0.00	0.08	238.93	5.20	244.13	197.32	23.99	5.64	7.41	37.04	8.14	242.50	-1.63
Feb	23.09	89.03	89.50	201.62	6.37	8.36	0.00	0.05	216.40	3.01	219.41	178.77	21.74	5.09	6.69	33.52	4.71	217.00	-2.41
Mar	16.04	61.85	62.19	140.08	7.05	9.26	0.00	0.02	156.41	1.32	157.73	124.21	15.10	5.64	7.41	28.15	2.06	154.42	-3.31
Apr	5.59	21.54	21.66	48.79	6.82	8.96	0.00	0.01	64.58	0.60	65.18	43.26	5.26	5.46	7.17	17.88	0.94	62.08	-3.10
May	1.03	3.96	3.98	8.97	7.05	9.26	0.00	0.01	25.29	0.82	26.11	7.95	1.0	5.64	7.41	14.01	1.28	23.25	-2.86
Total	205.00	790.48	794.71	1790.2	83.0	109.0	0.00	3.30	1985.5	211.0	2196.5	1587.3	193.0	66.4	87.2	346.6	330	2263.9	67.42

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.5(b): Middle Cauvery Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.05	7.91	7.94	17.89	8.96	8.96	0.00	0.01	35.82	0.61	36.44	15.88	1.93	7.17	7.17	16.26	0.96	2.06	35.16	-1.28
Jul	38.61	148.89	149.48	336.99	9.26	9.26	0.00	0.18	355.68	11.31	366.99	298.99	36.35	7.41	7.41	51.17	17.69	38.73	406.57	39.58
Aug	35.52	136.98	137.52	310.01	9.26	9.26	0.00	0.46	328.99	29.51	358.50	275.06	33.44	7.41	7.41	48.26	46.15	35.63	405.09	46.59
Sep	28.52	109.98	110.42	248.92	8.96	8.96	0.00	0.82	267.66	52.29	319.95	220.85	26.85	7.17	7.17	41.19	81.78	28.61	372.43	52.48
Oct	2.56	9.89	9.93	22.38	9.26	9.26	0.00	0.73	41.62	46.48	88.10	19.85	2.41	7.41	7.41	17.23	72.69	2.57	112.34	24.24
Nov	8.65	33.34	33.47	75.45	8.96	8.96	0.00	0.72	94.08	45.87	139.95	66.94	8.14	7.17	7.17	22.47	71.73	8.67	169.81	29.87
Dec	17.84	68.80	69.07	155.71	9.26	9.26	0.00	0.22	174.45	13.98	188.42	138.15	16.80	7.41	7.41	31.61	21.86	17.89	209.52	21.09
Jan	25.48	98.26	98.65	222.40	9.26	9.26	0.00	0.08	240.99	5.20	246.20	197.32	23.99	7.41	7.41	38.80	8.14	25.56	269.82	23.62
Feb	23.09	89.03	89.38	201.49	8.36	8.36	0.00	0.05	218.26	3.01	221.27	178.77	21.74	6.69	6.69	35.12	4.71	23.16	241.75	20.48
Mar	16.04	61.85	62.10	139.99	9.26	9.26	0.00	0.02	158.53	1.32	159.85	124.21	15.10	7.41	7.41	29.91	2.06	16.09	172.27	12.42
Apr	5.59	21.54	21.63	48.75	8.96	8.96	0.00	0.01	66.68	0.60	67.28	43.26	5.26	7.17	7.17	19.59	0.94	5.60	69.39	2.11
May	1.03	3.96	3.98	8.97	9.26	9.26	0.00	0.01	27.49	0.82	28.31	7.95	0.97	7.41	7.41	15.78	1.28	1.03	26.04	-2.27
Total	205.00	790.48	793.59	1789.1	109.0	109.0	0.00	3.3	2010.4	211.0	2221.4	1587.3	193.0	87.2	87.2	367.4	330	205.60	2490.3	268.94

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.5(c): Middle Cauvery Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.05	7.91	7.95	17.91	6.82	8.96	0.00	0.01	33.70	0.73	34.43	15.88	1.93	5.46	7.17	14.56	1.14	31.57	-2.85
Jul	38.61	148.89	149.69	337.20	7.05	9.26	0.00	0.18	353.68	13.44	367.12	298.99	36.35	5.64	7.41	49.40	21.01	369.40	2.28
Aug	35.52	136.98	137.71	310.21	7.05	9.26	0.00	0.46	326.98	35.05	362.03	275.06	33.44	5.64	7.41	46.49	54.82	376.37	14.33
Sep	28.52	109.98	110.57	249.08	6.82	8.96	0.00	0.82	265.68	62.12	327.79	220.85	26.85	5.46	7.17	39.48	97.15	357.48	29.68
Oct	2.56	9.89	9.94	22.39	7.05	9.26	0.00	0.73	39.43	55.21	94.64	19.85	2.41	5.64	7.41	15.46	86.35	121.66	27.02
Nov	8.65	33.34	33.51	75.49	6.82	8.96	0.00	0.72	91.99	54.48	146.48	66.94	8.14	5.46	7.17	20.76	85.21	172.91	26.44
Dec	17.84	68.80	69.17	155.81	7.05	9.26	0.00	0.22	172.34	16.60	188.94	138.15	16.80	5.64	7.41	29.84	25.97	193.97	5.02
Jan	25.48	98.26	98.79	222.54	7.05	9.26	0.00	0.08	238.93	6.18	245.11	197.32	23.99	5.64	7.41	37.04	9.67	244.02	-1.08
Feb	23.09	89.03	89.50	201.62	6.37	8.36	0.00	0.05	216.40	3.58	219.97	178.77	21.74	5.09	6.69	33.52	5.60	217.89	-2.09
Mar	16.04	61.85	62.19	140.08	7.05	9.26	0.00	0.02	156.41	1.56	157.97	124.21	15.10	5.64	7.41	28.15	2.45	154.80	-3.17
Apr	5.59	21.54	21.66	48.79	6.82	8.96	0.00	0.01	64.58	0.71	65.29	43.26	5.26	5.46	7.17	17.88	1.12	62.26	-3.03
May	1.03	3.96	3.98	8.97	7.05	9.26	0.00	0.01	25.29	0.97	26.26	7.95	1.0	5.64	7.41	14.01	1.52	23.49	-2.78
Total	205.00	790.48	794.71	1790.2	83.0	109.0	0.00	3.30	1985.5	211.0	2196.5	1587.3	193.0	66.4	87.2	346.6	392.00	2325.9	129.43

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11). Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.5(d): Middle Cauvery Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.05	7.91	7.94	17.89	8.96	8.96	0.00	0.01	35.82	0.73	36.55	15.88	1.93	7.17	7.17	16.26	1.14	2.06	35.34	-1.21
Jul	38.61	148.89	149.48	336.99	9.26	9.26	0.00	0.18	355.68	13.44	369.11	298.99	36.35	7.41	7.41	51.17	21.01	38.73	409.89	40.78
Aug	35.52	136.98	137.52	310.01	9.26	9.26	0.00	0.46	328.99	35.05	364.05	275.06	33.44	7.41	7.41	48.26	54.82	35.63	413.76	49.72
Sep	28.52	109.98	110.42	248.92	8.96	8.96	0.00	0.82	267.66	62.12	329.78	220.85	26.85	7.17	7.17	41.19	97.15	28.61	387.79	58.02
Oct	2.56	9.89	9.93	22.38	9.26	9.26	0.00	0.73	41.62	55.21	96.83	19.85	2.41	7.41	7.41	17.23	86.35	2.57	126.00	29.17
Nov	8.65	33.34	33.47	75.45	8.96	8.96	0.00	0.72	94.08	54.48	148.57	66.94	8.14	7.17	7.17	22.47	85.21	8.67	183.29	34.73
Dec	17.84	68.80	69.07	155.71	9.26	9.26	0.00	0.22	174.45	16.60	191.05	138.15	16.80	7.41	7.41	31.61	25.97	17.89	213.63	22.58
Jan	25.48	98.26	98.65	222.40	9.26	9.26	0.00	0.08	240.99	6.18	247.18	197.32	23.99	7.41	7.41	38.80	9.67	25.56	271.35	24.17
Feb	23.09	89.03	89.38	201.49	8.36	8.36	0.00	0.05	218.26	3.58	221.84	178.77	21.74	6.69	6.69	35.12	5.60	23.16	242.64	20.80
Mar	16.04	61.85	62.10	139.99	9.26	9.26	0.00	0.02	158.53	1.56	160.09	124.21	15.10	7.41	7.41	29.91	2.45	16.09	172.66	12.56
Apr	5.59	21.54	21.63	48.75	8.96	8.96	0.00	0.01	66.68	0.71	67.40	43.26	5.26	7.17	7.17	19.59	1.12	5.60	69.57	2.17
May	1.03	3.96	3.98	8.97	9.26	9.26	0.00	0.01	27.49	0.97	28.47	7.95	0.97	7.41	7.41	15.78	1.52	1.03	26.28	-2.18
Total	205.00	790.48	793.59	1789.1	109.0	109.0	0.00	3.3	2010.4	211.0	2221.4	1587.3	193.0	87.2	87.2	367.4	392.00	205.60	2552.3	330.95

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11). Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.5(e): Middle Cauvery Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.05	7.91	7.95	17.91	6.82	8.96	0.00	0.01	33.69	0.51	34.21	15.88	1.93	5.46	7.17	14.56	0.8	31.23	-2.97
Jul	38.61	148.89	149.69	337.20	7.05	9.26	0.00	0.15	353.65	9.42	363.08	298.99	36.35	5.64	7.41	49.40	14.74	363.12	0.05
Aug	35.52	136.98	137.71	310.21	7.05	9.26	0.00	0.38	326.90	24.59	351.49	275.06	33.44	5.64	7.41	46.49	38.46	360.00	8.51
Sep	28.52	109.98	110.57	249.08	6.82	8.96	0.00	0.68	265.54	43.58	309.12	220.85	26.85	5.46	7.17	39.48	68.15	328.48	19.36
Oct	2.56	9.89	9.94	22.39	7.05	9.26	0.00	0.61	39.30	38.74	78.04	19.85	2.41	5.64	7.41	15.46	60.58	95.89	17.85
Nov	8.65	33.34	33.51	75.49	6.82	8.96	0.00	0.60	91.87	38.22	130.10	66.94	8.14	5.46	7.17	20.76	59.78	147.48	17.39
Dec	17.84	68.80	69.17	155.81	7.05	9.26	0.00	0.18	172.30	11.65	183.95	138.15	16.80	5.64	7.41	29.84	18.22	186.22	2.27
Jan	25.48	98.26	98.79	222.54	7.05	9.26	0.00	0.07	238.91	4.34	243.25	197.32	23.99	5.64	7.41	37.04	6.78	241.14	-2.11
Feb	23.09	89.03	89.50	201.62	6.37	8.36	0.00	0.04	216.39	2.51	218.90	178.77	21.74	5.09	6.69	33.52	3.93	216.22	-2.68
Mar	16.04	61.85	62.19	140.08	7.05	9.26	0.00	0.02	156.41	1.10	157.51	124.21	15.10	5.64	7.41	28.15	1.72	154.08	-3.43
Apr	5.59	21.54	21.66	48.79	6.82	8.96	0.00	0.01	64.57	0.50	65.07	43.26	5.26	5.46	7.17	17.88	0.78	61.92	-3.15
May	1.03	3.96	3.98	8.97	7.05	9.26	0.00	0.01	25.29	0.68	25.97	7.95	1.01	5.64	7.41	14.01	1.07	23.04	-2.94
Total	205.00	790.48	794.71	1790.2	83.0	109.0	0.00	2.75	1984.9	211.0	2195.9	1587.3	193.0	66.4	87.2	346.6	275	2208.9	12.98

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.5(f): Middle Cauvery Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.05	7.91	7.94	17.89	8.96	8.96	0.00	0.01	35.82	0.51	36.33	15.88	1.93	7.17	7.17	16.26	0.8	2.06	35.00	-1.33
Jul	38.61	148.89	149.48	336.99	9.26	9.26	0.00	0.15	355.65	9.42	365.07	298.99	36.35	7.41	7.41	51.17	14.74	38.73	403.62	38.54
Aug	35.52	136.98	137.52	310.01	9.26	9.26	0.00	0.38	328.91	24.59	353.51	275.06	33.44	7.41	7.41	48.26	38.46	35.63	397.40	43.89
Sep	28.52	109.98	110.42	248.92	8.96	8.96	0.00	0.68	267.52	43.58	311.10	220.85	26.85	7.17	7.17	41.19	68.15	28.61	358.80	47.70
Oct	2.56	9.89	9.93	22.38	9.26	9.26	0.00	0.61	41.50	38.74	80.23	19.85	2.41	7.41	7.41	17.23	60.58	2.57	100.23	20.00
Nov	8.65	33.34	33.47	75.45	8.96	8.96	0.00	0.60	93.96	38.22	132.19	66.94	8.14	7.17	7.17	22.47	59.78	8.67	157.86	25.68
Dec	17.84	68.80	69.07	155.71	9.26	9.26	0.00	0.18	174.41	11.65	186.06	138.15	16.80	7.41	7.41	31.61	18.22	17.89	205.88	19.82
Jan	25.48	98.26	98.65	222.40	9.26	9.26	0.00	0.07	240.98	4.34	245.32	197.32	23.99	7.41	7.41	38.80	6.78	25.56	268.46	23.14
Feb	23.09	89.03	89.38	201.49	8.36	8.36	0.00	0.04	218.26	2.51	220.77	178.77	21.74	6.69	6.69	35.12	3.93	23.16	240.97	20.20
Mar	16.04	61.85	62.10	139.99	9.26	9.26	0.00	0.02	158.53	1.10	159.63	124.21	15.10	7.41	7.41	29.91	1.72	16.09	171.93	12.30
Apr	5.59	21.54	21.63	48.75	8.96	8.96	0.00	0.01	66.68	0.50	67.18	43.26	5.26	7.17	7.17	19.59	0.78	5.60	69.23	2.05
May	1.03	3.96	3.98	8.97	9.26	9.26	0.00	0.01	27.49	0.68	28.18	7.95	0.97	7.41	7.41	15.78	1.07	1.03	25.83	-2.34
Total	205.00	790.48	793.59	1789.1	109.0	109.0	0.00	2.75	2009.8	211.0	2220.8	1587.3	193.0	87.2	87.2	367.4	275	205.60	2435.3	214.50

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.5(g): Middle Cauvery Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.05	7.91	7.95	17.91	6.82	8.96	0.00	0.01	33.70	0.35	34.05	15.88	1.93	5.46	7.17	14.56	0.55	30.98	-3.07
Jul	38.61	148.89	149.69	337.20	7.05	9.26	0.00	0.18	353.68	6.48	360.16	298.99	36.35	5.64	7.41	49.40	10.13	358.51	-1.64
Aug	35.52	136.98	137.71	310.21	7.05	9.26	0.00	0.46	326.98	16.90	343.88	275.06	33.44	5.64	7.41	46.49	26.43	347.97	4.10
Sep	28.52	109.98	110.57	249.08	6.82	8.96	0.00	0.82	265.68	29.95	295.63	220.85	26.85	5.46	7.17	39.48	46.84	307.17	11.54
Oct	2.56	9.89	9.94	22.39	7.05	9.26	0.00	0.73	39.43	26.62	66.04	19.85	2.41	5.64	7.41	15.46	41.63	76.94	10.90
Nov	8.65	33.34	33.51	75.49	6.82	8.96	0.00	0.72	91.99	26.27	118.26	66.94	8.14	5.46	7.17	20.76	41.08	128.78	10.52
Dec	17.84	68.80	69.17	155.81	7.05	9.26	0.00	0.22	172.34	8.01	180.34	138.15	16.80	5.64	7.41	29.84	12.52	180.52	0.18
Jan	25.48	98.26	98.79	222.54	7.05	9.26	0.00	0.08	238.93	2.98	241.90	197.32	23.99	5.64	7.41	37.04	4.66	239.02	-2.89
Feb	23.09	89.03	89.50	201.62	6.37	8.36	0.00	0.05	216.40	1.73	218.12	178.77	21.74	5.09	6.69	33.52	2.7	214.99	-3.13
Mar	16.04	61.85	62.19	140.08	7.05	9.26	0.00	0.02	156.41	0.75	157.16	124.21	15.10	5.64	7.41	28.15	1.18	153.54	-3.63
Apr	5.59	21.54	21.66	48.79	6.82	8.96	0.00	0.01	64.58	0.35	64.92	43.26	5.26	5.46	7.17	17.88	0.54	61.68	-3.24
May	1.03	3.96	3.98	8.97	7.05	9.26	0.00	0.01	25.29	0.47	25.76	7.95	1.0	5.64	7.41	14.03	0.73	22.70	-3.06
Total	205.00	790.48	794.71	1790.2	83.0	109.0	0.00	3.30	1985.5	211.0	2196.5	1587.3	193.0	66.4	87.2	346.6	189	2122.9	-73.57

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.5(h): Middle Cauvery Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.05	7.91	7.94	17.89	8.96	8.96	0.00	0.01	35.82	0.35	36.17	15.88	1.93	7.17	7.17	16.26	0.55	2.06	34.75	-1.43
Jul	38.61	148.89	149.48	336.99	9.26	9.26	0.00	0.18	355.68	6.48	362.16	298.99	36.35	7.41	7.41	51.17	10.13	38.73	399.01	36.85
Aug	35.52	136.98	137.52	310.01	9.26	9.26	0.00	0.46	328.99	16.90	345.89	275.06	33.44	7.41	7.41	48.26	26.43	35.63	385.37	39.48
Sep	28.52	109.98	110.42	248.92	8.96	8.96	0.00	0.82	267.66	29.95	297.61	220.85	26.85	7.17	7.17	41.19	46.84	28.61	337.49	39.88
Oct	2.56	9.89	9.93	22.38	9.26	9.26	0.00	0.73	41.62	26.62	68.24	19.85	2.41	7.41	7.41	17.23	41.63	2.57	81.28	13.04
Nov	8.65	33.34	33.47	75.45	8.96	8.96	0.00	0.72	94.08	26.27	120.35	66.94	8.14	7.17	7.17	22.47	41.08	8.67	139.16	18.81
Dec	17.84	68.80	69.07	155.71	9.26	9.26	0.00	0.22	174.45	8.01	182.45	138.15	16.80	7.41	7.41	31.61	12.52	17.89	200.18	17.73
Jan	25.48	98.26	98.65	222.40	9.26	9.26	0.00	0.08	240.99	2.98	243.97	197.32	23.99	7.41	7.41	38.80	4.66	25.56	266.34	22.37
Feb	23.09	89.03	89.38	201.49	8.36	8.36	0.00	0.05	218.26	1.73	219.99	178.77	21.74	6.69	6.69	35.12	2.7	23.16	239.74	19.75
Mar	16.04	61.85	62.10	139.99	9.26	9.26	0.00	0.02	158.53	0.75	159.28	124.21	15.10	7.41	7.41	29.91	1.18	16.09	171.39	12.11
Apr	5.59	21.54	21.63	48.75	8.96	8.96	0.00	0.01	66.68	0.35	67.03	43.26	5.26	7.17	7.17	19.59	0.54	5.60	68.99	1.97
May	1.03	3.96	3.98	8.97	9.26	9.26	0.00	0.01	27.49	0.47	27.96	7.95	0.97	7.41	7.41	15.78	0.73	1.03	25.49	-2.47
Total	205.00	790.48	793.59	1789.1	109.0	109.0	0.00	3.3	2010.4	211.0	2221.4	1587.3	193.0	87.2	87.2	367.4	189	205.60	2349.3	127.95

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.6(a): Suvarnavathi Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	3.04	1.37	2.05	6.45	2.88	5.18	0.00	0.02	14.52	0.00	14.52	4.95	0.50	2.30	4.14	6.95	1.55	13.45	-1.08
Jul	56.98	25.61	38.37	120.96	2.97	5.35	0.00	0.03	129.31	0.00	129.31	93.11	9.46	2.38	4.28	16.12	3.08	112.31	-17.01
Aug	52.37	23.54	35.26	111.16	2.97	5.35	0.00	0.02	119.50	0.00	119.50	85.56	8.69	2.38	4.28	15.35	1.67	102.58	-16.92
Sep	42.65	19.17	28.72	90.54	2.88	5.18	0.00	0.10	98.69	0.00	98.69	69.68	7.08	2.30	4.14	13.53	9.58	92.79	-5.90
Oct	3.79	1.70	2.55	8.05	2.97	5.35	0.00	0.10	16.47	0.00	16.47	6.20	0.63	2.38	4.28	7.29	9.5	22.98	6.52
Nov	12.63	5.68	8.50	26.81	2.88	5.18	0.00	0.10	34.96	0.00	34.96	20.64	2.10	2.30	4.14	8.54	9.62	38.80	3.83
Dec	27.02	12.14	18.19	57.36	2.97	5.35	0.00	0.01	65.69	0.00	65.69	44.14	4.49	2.38	4.28	11.14	0.52	55.80	-9.89
Jan	39.98	17.97	26.92	84.87	2.97	5.35	0.00	0.00	93.19	0.00	93.19	65.32	6.64	2.38	4.28	13.30	0.06	78.68	-14.51
Feb	35.75	16.07	24.08	75.90	2.68	4.83	0.00	0.00	83.42	0.00	83.42	58.42	5.94	2.15	3.87	11.95	0.2	70.57	-12.85
Mar	20.53	9.23	13.83	43.59	2.97	5.35	0.00	0.00	51.91	0.00	51.91	33.55	3.41	2.38	4.28	10.07	0.11	43.72	-8.19
Apr	5.41	2.43	3.64	11.49	2.88	5.18	0.00	0.00	19.55	0.00	19.55	8.84	0.90	2.30	4.14	7.34	0.48	16.67	-2.88
May	1.53	0.69	1.03	3.25	2.97	5.35	0.00	0.02	11.59	0.00	11.59	2.50	0.25	2.38	4.28	6.91	1.63	11.04	-0.55
Total	301.69	135.60	203.15	640.43	35.00	63.00	0.00	0.38	738.81	0.00	738.81	492.00	50.00	28.00	50.40	128.4	38	658.4	-80.41

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.6(b): Suvarnavathi Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	3.04	1.37	2.05	6.45	5.18	5.18	0.00	0.02	16.83	0.00	16.83	4.95	0.50	4.14	4.14	8.79	1.55	0.64	15.93	-0.89
Jul	56.98	25.61	38.37	120.96	5.35	5.35	0.00	0.03	131.69	0.00	131.69	93.11	9.46	4.28	4.28	18.02	3.08	12.07	126.28	-5.41
Aug	52.37	23.54	35.26	111.16	5.35	5.35	0.00	0.02	121.88	0.00	121.88	85.56	8.69	4.28	4.28	17.26	1.67	11.09	115.57	-6.31
Sep	42.65	19.17	28.72	90.54	5.18	5.18	0.00	0.10	100.99	0.00	100.99	69.68	7.08	4.14	4.14	15.37	9.58	9.03	103.66	2.67
Oct	3.79	1.70	2.55	8.05	5.35	5.35	0.00	0.10	18.85	0.00	18.85	6.20	0.63	4.28	4.28	9.19	9.50	0.80	25.69	6.84
Nov	12.63	5.68	8.50	26.81	5.18	5.18	0.00	0.10	37.26	0.00	37.26	20.64	2.10	4.14	4.14	10.38	9.62	2.68	43.31	6.05
Dec	27.02	12.14	18.19	57.36	5.35	5.35	0.00	0.01	68.07	0.00	68.07	44.14	4.49	4.28	4.28	13.05	0.52	5.72	63.43	-4.64
Jan	39.98	17.97	26.92	84.87	5.35	5.35	0.00	0.00	95.57	0.00	95.57	65.32	6.64	4.28	4.28	15.20	0.06	8.47	89.05	-6.52
Feb	35.75	16.07	24.08	75.90	4.83	4.83	0.00	0.00	85.57	0.00	85.57	58.42	5.94	3.87	3.87	13.67	0.20	7.57	79.86	-5.71
Mar	20.53	9.23	13.83	43.59	5.35	5.35	0.00	0.00	54.29	0.00	54.29	33.55	3.41	4.28	4.28	11.97	0.11	4.35	49.98	-4.31
Apr	5.41	2.43	3.64	11.49	5.18	5.18	0.00	0.00	21.85	0.00	21.85	8.84	0.90	4.14	4.14	9.18	0.48	1.15	19.65	-2.20
May	1.53	0.69	1.03	3.25	5.35	5.35	0.00	0.02	13.97	0.00	13.97	2.50	0.25	4.28	4.28	8.82	1.63	0.32	13.27	-0.70
Total	301.69	135.60	203.15	640.43	63.0	63.0	0.00	0.38	766.81	0.00	766.81	492.0	50.0	50.40	50.4	150.80	38.00	63.90	744.70	-22.11

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.6(c): Suvarnavathi Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	3.04	1.37	2.05	6.45	2.88	5.18	0.00	0.02	14.52	0.00	14.52	4.95	0.50	2.30	4.14	6.95	3.88	15.77	1.25
Jul	56.98	25.61	38.37	120.96	2.97	5.35	0.00	0.03	129.31	0.00	129.31	93.11	9.46	2.38	4.28	16.12	7.70	116.93	-12.39
Aug	52.37	23.54	35.26	111.16	2.97	5.35	0.00	0.02	119.50	0.00	119.50	85.56	8.69	2.38	4.28	15.35	4.18	105.09	-14.42
Sep	42.65	19.17	28.72	90.54	2.88	5.18	0.00	0.10	98.69	0.00	98.69	69.68	7.08	2.30	4.14	13.53	23.95	107.16	8.47
Oct	3.79	1.70	2.55	8.05	2.97	5.35	0.00	0.10	16.47	0.00	16.47	6.20	0.63	2.38	4.28	7.29	23.75	37.23	20.77
Nov	12.63	5.68	8.50	26.81	2.88	5.18	0.00	0.10	34.96	0.00	34.96	20.64	2.10	2.30	4.14	8.54	24.05	53.23	18.26
Dec	27.02	12.14	18.19	57.36	2.97	5.35	0.00	0.01	65.69	0.00	65.69	44.14	4.49	2.38	4.28	11.14	1.30	56.58	-9.11
Jan	39.98	17.97	26.92	84.87	2.97	5.35	0.00	0.00	93.19	0.00	93.19	65.32	6.64	2.38	4.28	13.30	0.15	78.77	-14.42
Feb	35.75	16.07	24.08	75.90	2.68	4.83	0.00	0.00	83.42	0.00	83.42	58.42	5.94	2.15	3.87	11.95	0.50	70.87	-12.55
Mar	20.53	9.23	13.83	43.59	2.97	5.35	0.00	0.00	51.91	0.00	51.91	33.55	3.41	2.38	4.28	10.07	0.28	43.89	-8.02
Apr	5.41	2.43	3.64	11.49	2.88	5.18	0.00	0.00	19.55	0.00	19.55	8.84	0.90	2.30	4.14	7.34	1.20	17.39	-2.16
May	1.53	0.69	1.03	3.25	2.97	5.35	0.00	0.02	11.59	0.00	11.59	2.50	0.25	2.38	4.28	6.91	4.08	13.49	1.90
Total	301.69	135.60	203.15	640.43	35.00	63.00	0.00	0.38	738.81	0.00	738.81	492.00	50.0	28.00	50.40	128.4	95.00	715.40	-23.41

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.6(d): Suvarnavathi Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	3.04	1.37	2.05	6.45	5.18	5.18	0.00	0.02	16.83	0.00	16.83	4.95	0.50	2.30	4.14	6.95	3.88	0.64	16.42	-0.41
Jul	56.98	25.61	38.37	120.96	5.35	5.35	0.00	0.03	131.69	0.00	131.69	93.11	9.46	2.38	4.28	16.12	7.70	12.07	129.00	-2.69
Aug	52.37	23.54	35.26	111.16	5.35	5.35	0.00	0.02	121.88	0.00	121.88	85.56	8.69	2.38	4.28	15.35	4.18	11.09	116.18	-5.70
Sep	42.65	19.17	28.72	90.54	5.18	5.18	0.00	0.10	100.99	0.00	100.99	69.68	7.08	2.30	4.14	13.53	23.95	9.03	116.19	15.20
Oct	3.79	1.70	2.55	8.05	5.35	5.35	0.00	0.10	18.85	0.00	18.85	6.20	0.63	2.38	4.28	7.29	23.75	0.80	38.04	19.19
Nov	12.63	5.68	8.50	26.81	5.18	5.18	0.00	0.10	37.26	0.00	37.26	20.64	2.10	2.30	4.14	8.54	24.05	2.68	55.90	18.64
Dec	27.02	12.14	18.19	57.36	5.35	5.35	0.00	0.01	68.07	0.00	68.07	44.14	4.49	2.38	4.28	11.14	1.30	5.72	62.30	-5.76
Jan	39.98	17.97	26.92	84.87	5.35	5.35	0.00	0.00	95.57	0.00	95.57	65.32	6.64	2.38	4.28	13.30	0.15	8.47	87.24	-8.33
Feb	35.75	16.07	24.08	75.90	4.83	4.83	0.00	0.00	85.57	0.00	85.57	58.42	5.94	2.15	3.87	11.95	0.50	7.57	78.44	-7.12
Mar	20.53	9.23	13.83	43.59	5.35	5.35	0.00	0.00	54.29	0.00	54.29	33.55	3.41	2.38	4.28	10.07	0.28	4.35	48.24	-6.05
Apr	5.41	2.43	3.64	11.49	5.18	5.18	0.00	0.00	21.85	0.00	21.85	8.84	0.90	2.30	4.14	7.34	1.20	1.15	18.53	-3.32
May	1.53	0.69	1.03	3.25	5.35	5.35	0.00	0.02	13.97	0.00	13.97	2.50	0.25	2.38	4.28	6.91	4.08	0.32	13.81	-0.15
Total	301.69	135.60	203.15	640.43	63.0	63.0	0.00	0.38	766.81	0.00	766.81	492.0	50.0	28.0	50.4	128.39	95.00	63.90	779.29	12.48

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.6(e): Suvarnavathi Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	3.04	1.37	2.05	6.45	2.88	5.18	0.00	0.02	14.52	0.00	14.52	4.95	0.50	2.30	4.14	6.95	0.41	12.31	-2.22
Jul	56.98	25.61	38.37	120.96	2.97	5.35	0.00	0.03	129.31	0.00	129.31	93.11	9.46	2.38	4.28	16.12	0.81	110.04	-19.28
Aug	52.37	23.54	35.26	111.16	2.97	5.35	0.00	0.02	119.50	0.00	119.50	85.56	8.69	2.38	4.28	15.35	0.44	101.35	-18.15
Sep	42.65	19.17	28.72	90.54	2.88	5.18	0.00	0.10	98.69	0.00	98.69	69.68	7.08	2.30	4.14	13.53	2.52	85.73	-12.96
Oct	3.79	1.70	2.55	8.05	2.97	5.35	0.00	0.10	16.47	0.00	16.47	6.20	0.63	2.38	4.28	7.29	2.5	15.98	-0.48
Nov	12.63	5.68	8.50	26.81	2.88	5.18	0.00	0.10	34.96	0.00	34.96	20.64	2.10	2.30	4.14	8.54	2.53	31.71	-3.26
Dec	27.02	12.14	18.19	57.36	2.97	5.35	0.00	0.01	65.69	0.00	65.69	44.14	4.49	2.38	4.28	11.14	0.14	55.42	-10.27
Jan	39.98	17.97	26.92	84.87	2.97	5.35	0.00	0.00	93.19	0.00	93.19	65.32	6.64	2.38	4.28	13.30	0.02	78.64	-14.55
Feb	35.75	16.07	24.08	75.90	2.68	4.83	0.00	0.00	83.42	0.00	83.42	58.42	5.94	2.15	3.87	11.95	0.05	70.42	-13.00
Mar	20.53	9.23	13.83	43.59	2.97	5.35	0.00	0.00	51.91	0.00	51.91	33.55	3.41	2.38	4.28	10.07	0.03	43.64	-8.27
Apr	5.41	2.43	3.64	11.49	2.88	5.18	0.00	0.00	19.55	0.00	19.55	8.84	0.90	2.30	4.14	7.34	0.13	16.32	-3.23
May	1.53	0.69	1.03	3.25	2.97	5.35	0.00	0.02	11.59	0.00	11.59	2.50	0.25	2.38	4.28	6.91	0.43	9.84	-1.75
Total	301.69	135.60	203.15	640.43	35.00	63.00	0.00	0.38	738.81	0.00	738.81	492.00	50.00	28.00	50.40	128.4	10	630.4	-108.4

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.6(f): Suvarnavathi Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	3.04	1.37	2.05	6.45	5.18	5.18	0.00	0.00	16.81	0.00	16.81	4.95	0.50	4.14	4.14	8.79	0.41	0.64	14.79	-2.02
Jul	56.98	25.61	38.37	120.96	5.35	5.35	0.00	0.03	131.69	0.00	131.69	93.11	9.46	4.28	4.28	18.02	0.81	12.07	124.01	-7.68
Aug	52.37	23.54	35.26	111.16	5.35	5.35	0.00	0.02	121.88	0.00	121.88	85.56	8.69	4.28	4.28	17.26	0.44	11.09	114.34	-7.54
Sep	42.65	19.17	28.72	90.54	5.18	5.18	0.00	0.10	100.99	0.00	100.99	69.68	7.08	4.14	4.14	15.37	2.52	9.03	96.60	-4.39
Oct	3.79	1.70	2.55	8.05	5.35	5.35	0.00	0.10	18.85	0.00	18.85	6.20	0.63	4.28	4.28	9.19	2.5	0.80	18.69	-0.16
Nov	12.63	5.68	8.50	26.81	5.18	5.18	0.00	0.10	37.26	0.00	37.26	20.64	2.10	4.14	4.14	10.38	2.53	2.68	36.22	-1.04
Dec	27.02	12.14	18.19	57.36	5.35	5.35	0.00	0.01	68.07	0.00	68.07	44.14	4.49	4.28	4.28	13.05	0.14	5.72	63.05	-5.02
Jan	39.98	17.97	26.92	84.87	5.35	5.35	0.00	0.00	95.57	0.00	95.57	65.32	6.64	4.28	4.28	15.20	0.02	8.47	89.01	-6.56
Feb	35.75	16.07	24.08	75.90	4.83	4.83	0.00	0.00	85.57	0.00	85.57	58.42	5.94	3.87	3.87	13.67	0.05	7.57	79.71	-5.86
Mar	20.53	9.23	13.83	43.59	5.35	5.35	0.00	0.00	54.29	0.00	54.29	33.55	3.41	4.28	4.28	11.97	0.03	4.35	49.90	-4.39
Apr	5.41	2.43	3.64	11.49	5.18	5.18	0.00	0.00	21.85	0.00	21.85	8.84	0.90	4.14	4.14	9.18	0.13	1.15	19.30	-2.55
May	1.53	0.69	1.03	3.25	5.35	5.35	0.00	0.02	13.97	0.00	13.97	2.50	0.25	4.28	4.28	8.82	0.43	0.32	12.07	-1.90
Total	301.69	135.60	203.15	640.43	63.0	63.0	0.00	0.38	766.81	0.00	766.81	492.0	50.0	50.40	50.4	150.80	10	63.90	716.70	-50.11

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.6(g): Suvarnavathi Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	3.04	1.37	2.05	6.45	2.88	5.18	0.00	0.02	14.52	0.00	14.52	4.95	0.50	2.30	4.14	6.95	0.00	11.90	-2.63
Jul	56.98	25.61	38.37	120.96	2.97	5.35	0.00	0.03	129.31	0.00	129.31	93.11	9.46	2.38	4.28	16.12	0.00	109.23	-20.09
Aug	52.37	23.54	35.26	111.16	2.97	5.35	0.00	0.02	119.50	0.00	119.50	85.56	8.69	2.38	4.28	15.35	0.00	100.91	-18.59
Sep	42.65	19.17	28.72	90.54	2.88	5.18	0.00	0.10	98.69	0.00	98.69	69.68	7.08	2.30	4.14	13.53	0.00	83.21	-15.48
Oct	3.79	1.70	2.55	8.05	2.97	5.35	0.00	0.10	16.47	0.00	16.47	6.20	0.63	2.38	4.28	7.29	0.00	13.48	-2.98
Nov	12.63	5.68	8.50	26.81	2.88	5.18	0.00	0.10	34.96	0.00	34.96	20.64	2.10	2.30	4.14	8.54	0.00	29.18	-5.79
Dec	27.02	12.14	18.19	57.36	2.97	5.35	0.00	0.01	65.69	0.00	65.69	44.14	4.49	2.38	4.28	11.14	0.00	55.28	-10.41
Jan	39.98	17.97	26.92	84.87	2.97	5.35	0.00	0.00	93.19	0.00	93.19	65.32	6.64	2.38	4.28	13.30	0.00	78.62	-14.57
Feb	35.75	16.07	24.08	75.90	2.68	4.83	0.00	0.00	83.42	0.00	83.42	58.42	5.94	2.15	3.87	11.95	0.00	70.37	-13.05
Mar	20.53	9.23	13.83	43.59	2.97	5.35	0.00	0.00	51.91	0.00	51.91	33.55	3.41	2.38	4.28	10.07	0.00	43.61	-8.30
Apr	5.41	2.43	3.64	11.49	2.88	5.18	0.00	0.00	19.55	0.00	19.55	8.84	0.90	2.30	4.14	7.34	0.00	16.19	-3.36
May	1.53	0.69	1.03	3.25	2.97	5.35	0.00	0.02	11.59	0.00	11.59	2.50	0.25	2.38	4.28	6.91	0.00	9.41	-2.18
Total	301.69	135.60	203.15	640.43	35.00	63.00	0.00	0.38	738.81	0.00	738.81	492.00	50.00	28.00	50.40	128.40	0.00	620.40	-118.41

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.6(h): Suvarnavathi Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	3.04	1.37	2.05	6.45	5.18	5.18	0.00	0.02	16.83	0.00	16.83	4.95	0.50	4.14	4.14	8.79	0.00	0.64	14.38	-2.44
Jul	56.98	25.61	38.37	120.96	5.35	5.35	0.00	0.03	131.69	0.00	131.69	93.11	9.46	4.28	4.28	18.02	0.00	12.07	123.20	-8.49
Aug	52.37	23.54	35.26	111.16	5.35	5.35	0.00	0.02	121.88	0.00	121.88	85.56	8.69	4.28	4.28	17.26	0.00	11.09	113.90	-7.98
Sep	42.65	19.17	28.72	90.54	5.18	5.18	0.00	0.10	100.99	0.00	100.99	69.68	7.08	4.14	4.14	15.37	0.00	9.03	94.08	-6.91
Oct	3.79	1.70	2.55	8.05	5.35	5.35	0.00	0.10	18.85	0.00	18.85	6.20	0.63	4.28	4.28	9.19	0.00	0.80	16.19	-2.66
Nov	12.63	5.68	8.50	26.81	5.18	5.18	0.00	0.10	37.26	0.00	37.26	20.64	2.10	4.14	4.14	10.38	0.00	2.68	33.69	-3.57
Dec	27.02	12.14	18.19	57.36	5.35	5.35	0.00	0.01	68.07	0.00	68.07	44.14	4.49	4.28	4.28	13.05	0.00	5.72	62.91	-5.16
Jan	39.98	17.97	26.92	84.87	5.35	5.35	0.00	0.00	95.57	0.00	95.57	65.32	6.64	4.28	4.28	15.20	0.00	8.47	88.99	-6.58
Feb	35.75	16.07	24.08	75.90	4.83	4.83	0.00	0.00	85.57	0.00	85.57	58.42	5.94	3.87	3.87	13.67	0.00	7.57	79.66	-5.91
Mar	20.53	9.23	13.83	43.59	5.35	5.35	0.00	0.00	54.29	0.00	54.29	33.55	3.41	4.28	4.28	11.97	0.00	4.35	49.87	-4.42
Apr	5.41	2.43	3.64	11.49	5.18	5.18	0.00	0.00	21.85	0.00	21.85	8.84	0.90	4.14	4.14	9.18	0.00	1.15	19.17	-2.68
May	1.53	0.69	1.03	3.25	5.35	5.35	0.00	0.02	13.97	0.00	13.97	2.50	0.25	4.28	4.28	8.82	0.00	0.32	11.64	-2.33
Total	301.69	135.60	203.15	640.43	63.00	63.00	0.00	0.38	766.81	0.00	766.81	492.00	50.00	50.40	50.40	150.80	0.00	63.90	706.70	-60.11

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.7(a): Palar Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.47	0.14	0.39	3.00	0.90	3.62	0.00	0.10	7.62	0.00	7.62	0.00	0.15	0.72	2.89	3.76	9.86	13.62	6.00
Jul	43.58	2.41	6.91	52.90	0.93	3.74	0.00	0.21	57.81	0.00	57.81	0.00	2.57	0.75	2.99	6.31	20.75	27.06	-30.75
Aug	40.06	2.22	6.35	48.63	0.93	3.74	0.00	0.26	53.58	0.00	53.58	0.00	2.37	0.75	2.99	6.10	26.03	32.13	-21.45
Sep	32.48	1.80	5.15	39.44	0.90	3.62	0.00	0.29	44.25	0.00	44.25	0.00	1.92	0.72	2.89	5.53	28.71	34.24	-10.00
Oct	3.94	0.22	0.63	4.78	0.93	3.74	0.00	0.07	9.53	0.00	9.53	0.00	0.23	0.75	2.99	3.97	7.40	11.37	1.84
Nov	11.29	0.62	1.79	13.70	0.90	3.62	0.00	0.00	18.24	0.00	18.24	0.00	0.67	0.72	2.89	4.28	0.25	4.53	-13.70
Dec	19.04	1.05	3.02	23.12	0.93	3.74	0.00	0.04	27.84	0.00	27.84	0.00	1.12	0.75	2.99	4.86	3.86	8.72	-19.12
Jan	23.09	1.28	3.66	28.03	0.93	3.74	0.00	0.03	32.74	0.00	32.74	0.00	1.36	0.75	2.99	5.10	2.88	7.98	-24.76
Feb	24.40	1.35	3.87	29.62	0.84	3.38	0.00	0.02	33.87	0.00	33.87	0.00	1.44	0.68	2.70	4.82	1.73	6.55	-27.33
Mar	14.55	0.81	2.31	17.66	0.93	3.74	0.00	0.02	22.34	0.00	22.34	0.00	0.86	0.75	2.99	4.60	1.56	6.16	-16.19
Apr	4.08	0.23	0.65	4.95	0.90	3.62	0.00	0.00	9.47	0.00	9.47	0.00	0.24	0.72	2.89	3.86	0.17	4.03	-5.45
May	1.23	0.07	0.20	1.50	0.93	3.74	0.00	0.02	6.19	0.00	6.19	0.00	0.07	0.75	2.99	3.81	1.79	5.60	-0.59
Total	220.37	12.20	34.96	267.53	11.00	44.00	0.00	1.05	323.48	0.00	323.48	0.00	13.0	8.80	35.20	57.0	104.99	161.99	-161.49

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.7(b): Palar Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.47	0.14	0.39	3.00	3.62	3.62	0.00	0.10	10.33	0.00	10.33	0.00	0.15	2.89	2.89	5.93	9.86	1.57	17.36	7.03
Jul	43.58	2.41	6.91	52.90	3.74	3.74	0.00	0.21	60.58	0.00	60.58	0.00	2.57	2.99	2.99	8.55	20.75	27.62	56.93	-3.66
Aug	40.06	2.22	6.35	48.63	3.74	3.74	0.00	0.26	56.36	0.00	56.36	0.00	2.37	2.99	2.99	8.34	26.03	25.39	59.77	3.40
Sep	32.48	1.80	5.15	39.44	3.62	3.62	0.00	0.29	46.96	0.00	46.96	0.00	1.92	2.89	2.89	7.70	28.71	20.59	57.01	10.05
Oct	3.94	0.22	0.63	4.78	3.74	3.74	0.00	0.07	12.33	0.00	12.33	0.00	0.23	2.99	2.99	6.21	7.40	2.50	16.11	3.78
Nov	11.29	0.62	1.79	13.70	3.62	3.62	0.00	0.00	20.94	0.00	20.94	0.00	0.67	2.89	2.89	6.45	0.25	7.16	13.86	-7.08
Dec	19.04	1.05	3.02	23.12	3.74	3.74	0.00	0.04	30.63	0.00	30.63	0.00	1.12	2.99	2.99	7.10	3.86	12.07	23.03	-7.59
Jan	23.09	1.28	3.66	28.03	3.74	3.74	0.00	0.03	35.53	0.00	35.53	0.00	1.36	2.99	2.99	7.34	2.88	14.63	24.86	-10.67
Feb	24.40	1.35	3.87	29.62	3.38	3.38	0.00	0.02	36.39	0.00	36.39	0.00	1.44	2.70	2.70	6.84	1.73	15.47	24.04	-12.35
Mar	14.55	0.81	2.31	17.66	3.74	3.74	0.00	0.02	25.15	0.00	25.15	0.00	0.86	2.99	2.99	6.84	1.56	9.22	17.62	-7.53
Apr	4.08	0.23	0.65	4.95	3.62	3.62	0.00	0.00	12.18	0.00	12.18	0.00	0.24	2.89	2.89	6.03	0.17	2.58	8.78	-3.40
May	1.23	0.07	0.20	1.50	3.74	3.74	0.00	0.02	8.99	0.00	8.99	0.00	0.07	2.99	2.99	6.05	1.79	0.78	8.62	-0.36
Total	220.37	12.20	34.96	267.53	44.00	44.00	0.00	1.05	356.58	0.00	356.58	0.00	13.0	35.20	35.20	83.4	104.99	139.70	328.09	-28.49

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.7(c): Palar Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.47	0.14	0.39	3.00	0.90	3.62	0.00	0.10	7.62	0.00	7.62	0.00	0.15	0.72	2.89	3.76	16.06	19.82	12.20
Jul	43.58	2.41	6.91	52.90	0.93	3.74	0.00	0.21	57.81	0.00	57.81	0.00	2.57	0.75	2.99	6.31	33.80	40.11	-17.70
Aug	40.06	2.22	6.35	48.63	0.93	3.74	0.00	0.26	53.58	0.00	53.58	0.00	2.37	0.75	2.99	6.10	42.40	48.50	-5.09
Sep	32.48	1.80	5.15	39.44	0.90	3.62	0.00	0.29	44.25	0.00	44.25	0.00	1.92	0.72	2.89	5.53	46.76	52.29	8.05
Oct	3.94	0.22	0.63	4.78	0.93	3.74	0.00	0.07	9.53	0.00	9.53	0.00	0.23	0.75	2.99	3.97	12.05	16.02	6.49
Nov	11.29	0.62	1.79	13.70	0.90	3.62	0.00	0.00	18.24	0.00	18.24	0.00	0.67	0.72	2.89	4.28	0.41	4.69	-13.55
Dec	19.04	1.05	3.02	23.12	0.93	3.74	0.00	0.04	27.84	0.00	27.84	0.00	1.12	0.75	2.99	4.86	6.29	11.15	-16.69
Jan	23.09	1.28	3.66	28.03	0.93	3.74	0.00	0.03	32.74	0.00	32.74	0.00	1.36	0.75	2.99	5.10	4.69	9.79	-22.95
Feb	24.40	1.35	3.87	29.62	0.84	3.38	0.00	0.02	33.87	0.00	33.87	0.00	1.44	0.68	2.70	4.82	2.82	7.63	-26.24
Mar	14.55	0.81	2.31	17.66	0.93	3.74	0.00	0.02	22.34	0.00	22.34	0.00	0.86	0.75	2.99	4.60	2.54	7.14	-15.20
Apr	4.08	0.23	0.65	4.95	0.90	3.62	0.00	0.00	9.47	0.00	9.47	0.00	0.24	0.72	2.89	3.86	0.28	4.13	-5.34
May	1.23	0.07	0.20	1.50	0.93	3.74	0.00	0.02	6.19	0.00	6.19	0.00	0.07	0.75	2.99	3.81	2.92	6.73	0.54
Total	220.37	12.20	34.96	267.53	11.00	44.00	0.00	1.05	323.48	0.00	323.48	0.00	13.0	8.80	35.20	57.0	171.00	228.00	-95.48

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.7(d): Palar Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.47	0.14	0.39	3.00	3.62	3.62	0.00	0.10	7.62	0.00	7.62	0.00	0.15	0.72	2.89	3.76	16.06	1.57	21.39	21.39
Jul	43.58	2.41	6.91	52.90	3.74	3.74	0.00	0.21	57.81	0.00	57.81	0.00	2.57	0.75	2.99	6.31	33.80	27.62	67.73	9.92
Aug	40.06	2.22	6.35	48.63	3.74	3.74	0.00	0.26	53.58	0.00	53.58	0.00	2.37	0.75	2.99	6.10	42.40	25.39	73.89	20.31
Sep	32.48	1.80	5.15	39.44	3.62	3.62	0.00	0.29	44.25	0.00	44.25	0.00	1.92	0.72	2.89	5.53	46.76	20.59	72.89	28.64
Oct	3.94	0.22	0.63	4.78	3.74	3.74	0.00	0.07	9.53	0.00	9.53	0.00	0.23	0.75	2.99	3.97	12.05	2.50	18.52	8.99
Nov	11.29	0.62	1.79	13.70	3.62	3.62	0.00	0.00	18.24	0.00	18.24	0.00	0.67	0.72	2.89	4.28	0.41	7.16	11.85	-6.39
Dec	19.04	1.05	3.02	23.12	3.74	3.74	0.00	0.04	27.84	0.00	27.84	0.00	1.12	0.75	2.99	4.86	6.29	12.07	23.22	-4.62
Jan	23.09	1.28	3.66	28.03	3.74	3.74	0.00	0.03	32.74	0.00	32.74	0.00	1.36	0.75	2.99	5.10	4.69	14.63	24.43	-8.32
Feb	24.40	1.35	3.87	29.62	3.38	3.38	0.00	0.02	33.87	0.00	33.87	0.00	1.44	0.68	2.70	4.82	2.82	15.47	23.10	-10.77
Mar	14.55	0.81	2.31	17.66	3.74	3.74	0.00	0.02	22.34	0.00	22.34	0.00	0.86	0.75	2.99	4.60	2.54	9.22	16.36	-5.98
Apr	4.08	0.23	0.65	4.95	3.62	3.62	0.00	0.00	9.47	0.00	9.47	0.00	0.24	0.72	2.89	3.86	0.28	2.58	6.72	-2.75
May	1.23	0.07	0.20	1.50	3.74	3.74	0.00	0.02	6.19	0.00	6.19	0.00	0.07	0.75	2.99	3.81	2.92	0.78	7.51	1.32
Total	220.37	12.20	34.96	267.53	44.00	44.00	0.00	1.05	323.48	0.00	323.48	0.00	13.0	8.8	35.20	57.0	171.00	139.70	367.70	44.22

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.7(e): Palar Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.47	0.14	0.39	3.00	0.90	3.62	0.00	0.10	7.62	0.00	7.62	0.00	0.15	0.72	2.89	3.76	6.76	10.52	2.90
Jul	43.58	2.41	6.91	52.90	0.93	3.74	0.00	0.21	57.81	0.00	57.81	0.00	2.57	0.75	2.99	6.31	14.23	20.54	-37.27
Aug	40.06	2.22	6.35	48.63	0.93	3.74	0.00	0.26	53.58	0.00	53.58	0.00	2.37	0.75	2.99	6.10	17.85	23.95	-29.63
Sep	32.48	1.80	5.15	39.44	0.90	3.62	0.00	0.29	44.25	0.00	44.25	0.00	1.92	0.72	2.89	5.53	19.69	25.22	-19.02
Oct	3.94	0.22	0.63	4.78	0.93	3.74	0.00	0.07	9.53	0.00	9.53	0.00	0.23	0.75	2.99	3.97	5.07	9.04	-0.49
Nov	11.29	0.62	1.79	13.70	0.90	3.62	0.00	0.00	18.24	0.00	18.24	0.00	0.67	0.72	2.89	4.28	0.17	4.45	-13.78
Dec	19.04	1.05	3.02	23.12	0.93	3.74	0.00	0.04	27.84	0.00	27.84	0.00	1.12	0.75	2.99	4.86	2.65	7.51	-20.33
Jan	23.09	1.28	3.66	28.03	0.93	3.74	0.00	0.03	32.74	0.00	32.74	0.00	1.36	0.75	2.99	5.10	1.97	7.07	-25.67
Feb	24.40	1.35	3.87	29.62	0.84	3.38	0.00	0.02	33.87	0.00	33.87	0.00	1.44	0.68	2.70	4.82	1.19	6.01	-27.87
Mar	14.55	0.81	2.31	17.66	0.93	3.74	0.00	0.02	22.34	0.00	22.34	0.00	0.86	0.75	2.99	4.60	1.07	5.67	-16.68
Apr	4.08	0.23	0.65	4.95	0.90	3.62	0.00	0.00	9.47	0.00	9.47	0.00	0.24	0.72	2.89	3.86	0.12	3.98	-5.50
May	1.23	0.07	0.20	1.50	0.93	3.74	0.00	0.02	6.19	0.00	6.19	0.00	0.07	0.75	2.99	3.81	1.23	5.04	-1.15
Total	220.37	12.20	34.96	267.53	11.00	44.00	0.00	1.05	323.48	0.00	323.48	0.00	13.0	8.80	35.20	57.0	71.99	128.99	-194.49

Note : Column no.10 = Column no (5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no 20 = Column no.(19-12).

Table 4.10.7(f): Palar Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.47	0.14	0.39	3.00	3.62	3.62	0.00	0.10	10.33	0.00	10.33	0.00	0.15	2.89	2.89	5.93	6.76	1.57	14.26	3.93
Jul	43.58	2.41	6.91	52.90	3.74	3.74	0.00	0.21	60.58	0.00	60.58	0.00	2.57	2.99	2.99	8.55	14.23	27.62	50.41	-10.18
Aug	40.06	2.22	6.35	48.63	3.74	3.74	0.00	0.26	56.36	0.00	56.36	0.00	2.37	2.99	2.99	8.34	17.85	25.39	51.59	-4.78
Sep	32.48	1.80	5.15	39.44	3.62	3.62	0.00	0.29	46.96	0.00	46.96	0.00	1.92	2.89	2.89	7.70	19.69	20.59	47.99	1.03
Oct	3.94	0.22	0.63	4.78	3.74	3.74	0.00	0.07	12.33	0.00	12.33	0.00	0.23	2.99	2.99	6.21	5.07	2.50	13.78	1.45
Nov	11.29	0.62	1.79	13.70	3.62	3.62	0.00	0.00	20.94	0.00	20.94	0.00	0.67	2.89	2.89	6.45	0.17	7.16	13.78	-7.16
Dec	19.04	1.05	3.02	23.12	3.74	3.74	0.00	0.04	30.63	0.00	30.63	0.00	1.12	2.99	2.99	7.10	2.65	12.07	21.82	-8.80
Jan	23.09	1.28	3.66	28.03	3.74	3.74	0.00	0.03	35.53	0.00	35.53	0.00	1.36	2.99	2.99	7.34	1.97	14.63	23.95	-11.58
Feb	24.40	1.35	3.87	29.62	3.38	3.38	0.00	0.02	36.39	0.00	36.39	0.00	1.44	2.70	2.70	6.84	1.19	15.47	23.50	-12.89
Mar	14.55	0.81	2.31	17.66	3.74	3.74	0.00	0.02	25.15	0.00	25.15	0.00	0.86	2.99	2.99	6.84	1.07	9.22	17.13	-8.02
Apr	4.08	0.23	0.65	4.95	3.62	3.62	0.00	0.00	12.18	0.00	12.18	0.00	0.24	2.89	2.89	6.03	0.12	2.58	8.73	-3.45
May	1.23	0.07	0.20	1.50	3.74	3.74	0.00	0.02	8.99	0.00	8.99	0.00	0.07	2.99	2.99	6.05	1.23	0.78	8.06	-0.92
Total	220.37	12.20	34.96	267.53	44.00	44.00	0.00	1.05	356.58	0.00	356.58	0.00	13.0	35.2	35.20	83.4	71.99	139.70	295.09	-61.49

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.7(g): Palar Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.47	0.14	0.39	3.00	0.90	3.62	0.00	0.10	7.62	0.00	7.62	0.00	0.15	0.72	2.89	3.76	1.69	5.45	-2.17
Jul	43.58	2.41	6.91	52.90	0.93	3.74	0.00	0.21	57.81	0.00	57.81	0.00	2.57	0.75	2.99	6.31	3.56	9.87	-47.94
Aug	40.06	2.22	6.35	48.63	0.93	3.74	0.00	0.26	53.58	0.00	53.58	0.00	2.37	0.75	2.99	6.10	4.46	10.56	-43.02
Sep	32.48	1.80	5.15	39.44	0.90	3.62	0.00	0.29	44.25	0.00	44.25	0.00	1.92	0.72	2.89	5.53	4.92	10.45	-33.79
Oct	3.94	0.22	0.63	4.78	0.93	3.74	0.00	0.07	9.53	0.00	9.53	0.00	0.23	0.75	2.99	3.97	1.27	5.24	-4.29
Nov	11.29	0.62	1.79	13.70	0.90	3.62	0.00	0.00	18.24	0.00	18.24	0.00	0.67	0.72	2.89	4.28	0.04	4.32	-13.91
Dec	19.04	1.05	3.02	23.12	0.93	3.74	0.00	0.04	27.84	0.00	27.84	0.00	1.12	0.75	2.99	4.86	0.66	5.52	-22.32
Jan	23.09	1.28	3.66	28.03	0.93	3.74	0.00	0.03	32.74	0.00	32.74	0.00	1.36	0.75	2.99	5.10	0.49	5.59	-27.15
Feb	24.40	1.35	3.87	29.62	0.84	3.38	0.00	0.02	33.87	0.00	33.87	0.00	1.44	0.68	2.70	4.82	0.30	5.12	-28.76
Mar	14.55	0.81	2.31	17.66	0.93	3.74	0.00	0.02	22.34	0.00	22.34	0.00	0.86	0.75	2.99	4.60	0.27	4.87	-17.48
Apr	4.08	0.23	0.65	4.95	0.90	3.62	0.00	0.00	9.47	0.00	9.47	0.00	0.24	0.72	2.89	3.86	0.03	3.89	-5.59
May	1.23	0.07	0.20	1.50	0.93	3.74	0.00	0.02	6.19	0.00	6.19	0.00	0.07	0.75	2.99	3.81	0.31	4.12	-2.07
Total	220.37	12.20	34.96	267.53	11.00	44.00	0.00	1.05	323.48	0.00	323.48	0.00	13.0	8.80	35.20	57.0	18.00	75.00	-248.48

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.7(h): Palar Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.47	0.14	0.39	3.00	3.62	3.62	0.00	0.10	10.33	0.00	10.33	0.00	0.15	2.89	2.89	5.93	1.69	1.57	9.19	-1.14
Jul	43.58	2.41	6.91	52.90	3.74	3.74	0.00	0.21	60.58	0.00	60.58	0.00	2.57	2.99	2.99	8.55	3.56	27.62	39.74	-20.85
Aug	40.06	2.22	6.35	48.63	3.74	3.74	0.00	0.26	56.36	0.00	56.36	0.00	2.37	2.99	2.99	8.34	4.46	25.39	38.20	-18.17
Sep	32.48	1.80	5.15	39.44	3.62	3.62	0.00	0.29	46.96	0.00	46.96	0.00	1.92	2.89	2.89	7.70	4.92	20.59	33.22	-13.74
Oct	3.94	0.22	0.63	4.78	3.74	3.74	0.00	0.07	12.33	0.00	12.33	0.00	0.23	2.99	2.99	6.21	1.27	2.50	9.98	-2.35
Nov	11.29	0.62	1.79	13.70	3.62	3.62	0.00	0.00	20.94	0.00	20.94	0.00	0.67	2.89	2.89	6.45	0.04	7.16	13.65	-7.29
Dec	19.04	1.05	3.02	23.12	3.74	3.74	0.00	0.04	30.63	0.00	30.63	0.00	1.12	2.99	2.99	7.10	0.66	12.07	19.83	-10.79
Jan	23.09	1.28	3.66	28.03	3.74	3.74	0.00	0.03	35.53	0.00	35.53	0.00	1.36	2.99	2.99	7.34	0.49	14.63	22.47	-13.06
Feb	24.40	1.35	3.87	29.62	3.38	3.38	0.00	0.02	36.39	0.00	36.39	0.00	1.44	2.70	2.70	6.84	0.30	15.47	22.61	-13.78
Mar	14.55	0.81	2.31	17.66	3.74	3.74	0.00	0.02	25.15	0.00	25.15	0.00	0.86	2.99	2.99	6.84	0.27	9.22	16.33	-8.82
Apr	4.08	0.23	0.65	4.95	3.62	3.62	0.00	0.00	12.18	0.00	12.18	0.00	0.24	2.89	2.89	6.03	0.03	2.58	8.64	-3.54
May	1.23	0.07	0.20	1.50	3.74	3.74	0.00	0.02	8.99	0.00	8.99	0.00	0.07	2.99	2.99	6.05	0.31	0.78	7.14	-1.84
Total	220.37	12.20	34.96	267.53	44.00	44.00	0.00	1.05	356.58	0.00	356.58	0.00	13.0	35.2	35.20	83.4	18.00	139.70	241.10	-115.5

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.8(a): Chinnar Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	39.00	10.83	0.00	49.83	7.15	10.11	0.00	0.10	67.24	418.84	486.09	0.00	1.83	5.72	8.09	15.63	10.28	25.91	-460.17
Jul	20.76	5.76	0.00	26.52	7.39	10.45	0.00	0.03	44.41	130.79	175.20	0.00	0.97	5.91	8.36	15.24	3.21	18.45	-156.75
Aug	14.20	3.94	0.00	18.14	7.39	10.45	0.00	0.04	36.02	152.79	188.81	0.00	0.66	5.91	8.36	14.93	3.75	18.68	-170.13
Sep	49.94	13.86	0.00	63.80	7.15	10.11	0.00	0.79	81.88	3216.71	3298.59	0.00	2.34	5.72	8.09	16.14	78.95	95.09	-3203.49
Oct	40.88	11.35	0.00	52.23	7.39	10.45	0.00	1.07	71.16	4375.05	4446.21	0.00	1.91	5.91	8.36	16.18	107.38	123.56	-4322.64
Nov	48.41	13.44	0.00	61.85	7.15	10.11	0.00	0.72	79.86	2949.43	3029.29	0.00	2.27	5.72	8.09	16.07	72.39	88.46	-2940.83
Dec	57.01	15.82	0.00	72.84	7.39	10.45	0.00	0.15	90.85	596.89	687.75	0.00	2.67	5.91	8.36	16.94	14.65	31.59	-656.16
Jan	28.13	7.81	0.00	35.93	7.39	10.45	0.00	0.05	53.84	185.38	239.22	0.00	1.32	5.91	8.36	15.58	4.55	20.13	-219.08
Feb	58.33	16.19	0.00	74.52	6.67	9.44	0.00	0.03	90.72	124.27	214.99	0.00	2.73	5.34	7.55	15.62	3.05	18.67	-196.32
Mar	71.19	19.76	0.00	90.95	7.39	10.45	0.00	0.03	108.9	134.45	243.4	0.00	3.33	5.91	8.36	17.60	3.30	20.90	-222.45
Apr	54.80	15.21	0.00	70.01	7.15	10.11	0.00	0.02	87.36	99.82	187.18	0.00	2.56	5.72	8.09	16.37	2.45	18.82	-168.36
May	51.57	14.31	0.00	65.88	7.39	10.45	0.00	0.08	83.86	327.58	411.44	0.00	2.41	5.91	8.36	16.68	8.04	24.72	-386.71
Total	534.22	148.27	0.00	682.49	87.0	123.0	0.00	3.12	896.1	12712.00	13608.1	0.00	25.0	69.60	98.40	193.0	312.00	505.00	-13103.1

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.8(b): Chinnar Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	39.00	10.83	0.00	49.83	10.11	10.11	0.00	0.10	70.15	418.84	489.00	0.00	1.83	8.09	8.09	18.00	10.28	12.97	41.25	-447.75
Jul	20.76	5.76	0.00	26.52	10.45	10.45	0.00	0.03	47.45	130.79	178.23	0.00	0.97	8.36	8.36	17.69	3.21	6.90	27.80	-150.43
Aug	14.20	3.94	0.00	18.14	10.45	10.45	0.00	0.04	39.07	152.79	191.86	0.00	0.66	8.36	8.36	17.38	3.75	4.72	25.85	-166.01
Sep	49.94	13.86	0.00	63.80	10.11	10.11	0.00	0.79	84.81	3216.71	3301.52	0.00	2.34	8.09	8.09	18.51	78.95	16.60	114.06	-3187.45
Oct	40.88	11.35	0.00	52.23	10.45	10.45	0.00	1.07	74.19	4375.05	4449.24	0.00	1.91	8.36	8.36	18.63	107.38	13.59	139.60	-4309.64
Nov	48.41	13.44	0.00	61.85	10.11	10.11	0.00	0.72	82.79	2949.43	3032.22	0.00	2.27	8.09	8.09	18.44	72.39	16.09	106.93	-2925.30
Dec	57.01	15.82	0.00	72.84	10.45	10.45	0.00	0.15	93.88	596.89	690.77	0.00	2.67	8.36	8.36	19.38	14.65	18.95	52.99	-637.78
Jan	28.13	7.81	0.00	35.93	10.45	10.45	0.00	0.05	56.87	185.38	242.26	0.00	1.32	8.36	8.36	18.03	4.55	9.35	31.93	-210.32
Feb	58.33	16.19	0.00	74.52	9.44	9.44	0.00	0.03	93.42	124.27	217.69	0.00	2.73	7.55	7.55	17.83	3.05	19.39	40.27	-177.42
Mar	71.19	19.76	0.00	90.95	10.45	10.45	0.00	0.03	111.88	134.45	246.33	0.00	3.33	8.36	8.36	20.05	3.30	23.67	47.01	-199.32
Apr	54.80	15.21	0.00	70.01	10.11	10.11	0.00	0.02	90.25	99.82	190.08	0.00	2.56	8.09	8.09	18.74	2.45	18.22	39.41	-150.67
May	51.57	14.31	0.00	65.88	10.45	10.45	0.00	0.08	86.65	327.58	414.43	0.00	2.41	8.36	8.36	19.13	8.04	17.14	44.31	-370.12
Total	534.22	148.27	0.00	682.49	123.0	123.0	0.00	3.12	931.61	12712.00	13643.61	0.00	25.00	98.40	98.40	221.8	312.0	177.6	711.4	-12932.2

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.8(c): Chinnar Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation		Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total					Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)		(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	39.00	10.83	0.00	49.83	7.15	10.11	0.00	0.10	67.24	515.50	582.74		0.00	1.83	5.72	8.09	15.63	12.65	28.29	-554.46
Jul	20.76	5.76	0.00	26.52	7.39	10.45	0.00	0.03	44.41	160.97	205.38		0.00	0.97	5.91	8.36	15.24	3.95	19.19	-186.19
Aug	14.20	3.94	0.00	18.14	7.39	10.45	0.00	0.04	36.02	188.05	224.07		0.00	0.66	5.91	8.36	14.93	4.62	19.55	-204.52
Sep	49.94	13.86	0.00	63.80	7.15	10.11	0.00	0.79	81.88	3959.02	4040.90		0.00	2.34	5.72	8.09	16.14	97.17	113.31	-3927.6
Oct	40.88	11.35	0.00	52.23	7.39	10.45	0.00	1.07	71.16	5384.67	5455.83		0.00	1.91	5.91	8.36	16.18	132.16	148.34	-5307.5
Nov	48.41	13.44	0.00	61.85	7.15	10.11	0.00	0.72	79.86	3630.07	3709.93		0.00	2.27	5.72	8.09	16.07	89.10	105.17	-3604.8
Dec	57.01	15.82	0.00	72.84	7.39	10.45	0.00	0.15	90.85	734.64	825.49		0.00	2.67	5.91	8.36	16.94	18.03	34.97	-790.52
Jan	28.13	7.81	0.00	35.93	7.39	10.45	0.00	0.05	53.84	228.16	282.00		0.00	1.32	5.91	8.36	15.58	5.60	21.18	-260.82
Feb	58.33	16.19	0.00	74.52	6.67	9.44	0.00	0.03	90.72	152.95	243.66		0.00	2.73	5.34	7.55	15.62	3.75	19.37	-224.29
Mar	71.19	19.76	0.00	90.95	7.39	10.45	0.00	0.03	108.9	165.48	274.4		0.00	3.33	5.91	8.36	17.60	4.06	21.66	-252.72
Apr	54.80	15.21	0.00	70.01	7.15	10.11	0.00	0.02	87.36	122.86	210.22		0.00	2.56	5.72	8.09	16.37	3.02	19.39	-190.83
May	51.57	14.31	0.00	65.88	7.39	10.45	0.00	0.08	83.86	403.17	487.03		0.00	2.41	5.91	8.36	16.68	9.90	26.58	-460.45
Total	534.22	148.27	0.00	682.49	87.0	123.0	0.00	3.12	896.1	15645.5	16541.6		0.00	25.0	69.60	98.40	193.0	384.00	577.00	-15965

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.8(d): Chinnar Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	39.00	10.83	0.00	49.83	10.11	10.11	0.00	0.10	67.24	515.50	582.74	0.00	1.83	5.72	8.09	15.63	12.65	12.97	41.25	-541.49
Jul	20.76	5.76	0.00	26.52	10.45	10.45	0.00	0.03	44.41	160.97	205.38	0.00	0.97	5.91	8.36	15.24	3.95	6.90	26.09	-179.29
Aug	14.20	3.94	0.00	18.14	10.45	10.45	0.00	0.04	36.02	188.05	224.07	0.00	0.66	5.91	8.36	14.93	4.62	4.72	24.27	-199.80
Sep	49.94	13.86	0.00	63.80	10.11	10.11	0.00	0.79	81.88	3959.02	4040.90	0.00	2.34	5.72	8.09	16.14	97.17	16.60	129.92	-3910.99
Oct	40.88	11.35	0.00	52.23	10.45	10.45	0.00	1.07	71.16	5384.67	5455.83	0.00	1.91	5.91	8.36	16.18	132.16	13.59	161.93	-5293.90
Nov	48.41	13.44	0.00	61.85	10.11	10.11	0.00	0.72	79.86	3630.07	3709.93	0.00	2.27	5.72	8.09	16.07	89.10	16.09	121.26	-3588.67
Dec	57.01	15.82	0.00	72.84	10.45	10.45	0.00	0.15	90.85	734.64	825.49	0.00	2.67	5.91	8.36	16.94	18.03	18.95	53.92	-771.57
Jan	28.13	7.81	0.00	35.93	10.45	10.45	0.00	0.05	53.84	228.16	282.00	0.00	1.32	5.91	8.36	15.58	5.60	9.35	30.54	-251.46
Feb	58.33	16.19	0.00	74.52	9.44	9.44	0.00	0.03	90.72	152.95	243.66	0.00	2.73	5.34	7.55	15.62	3.75	19.39	38.76	-204.90
Mar	71.19	19.76	0.00	90.95	10.45	10.45	0.00	0.03	108.9	165.48	274.38	0.00	3.33	5.91	8.36	17.60	4.06	23.67	45.33	-229.05
Apr	54.80	15.21	0.00	70.01	10.11	10.11	0.00	0.02	87.36	122.86	210.22	0.00	2.56	5.72	8.09	16.37	3.02	18.22	37.61	-172.61
May	51.57	14.31	0.00	65.88	10.45	10.45	0.00	0.08	83.86	403.17	487.03	0.00	2.41	5.91	8.36	16.68	9.90	17.14	43.72	-443.31
Total	534.22	148.27	0.00	682.49	123.0	123.0	0.00	3.12	931.6	15645.5	16577.2	0.00	25.00	69.60	98.40	193.0	384.00	177.6	754.6	-15822.6

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.8(e): Chinnar Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	39.00	10.83	0.00	49.83	7.15	10.11	0.00	0.10	67.24	311.28	378.52	0.00	1.83	5.72	8.09	15.63	7.64	23.27	-355.25
Jul	20.76	5.76	0.00	26.52	7.39	10.45	0.00	0.03	44.41	97.38	141.79	0.00	0.97	5.91	8.36	15.24	2.39	17.63	-124.16
Aug	14.20	3.94	0.00	18.14	7.39	10.45	0.00	0.04	36.02	113.67	149.70	0.00	0.66	5.91	8.36	14.93	2.79	17.72	-131.97
Sep	49.94	13.86	0.00	63.80	7.15	10.11	0.00	0.79	81.88	2392.06	2473.94	0.00	2.34	5.72	8.09	16.14	58.71	74.85	-2399.08
Oct	40.88	11.35	0.00	52.23	7.39	10.45	0.00	1.07	71.16	3253.38	3324.53	0.00	1.91	5.91	8.36	16.18	79.85	96.03	-3228.50
Nov	48.41	13.44	0.00	61.85	7.15	10.11	0.00	0.72	79.86	2193.23	2273.09	0.00	2.27	5.72	8.09	16.07	53.83	69.90	-2203.19
Dec	57.01	15.82	0.00	72.84	7.39	10.45	0.00	0.15	90.85	443.70	534.55	0.00	2.67	5.91	8.36	16.94	10.89	27.83	-506.72
Jan	28.13	7.81	0.00	35.93	7.39	10.45	0.00	0.05	53.84	137.71	191.55	0.00	1.32	5.91	8.36	15.58	3.38	18.96	-172.58
Feb	58.33	16.19	0.00	74.52	6.67	9.44	0.00	0.03	90.72	92.49	183.21	0.00	2.73	5.34	7.55	15.62	2.27	17.89	-165.32
Mar	71.19	19.76	0.00	90.95	7.39	10.45	0.00	0.03	108.9	99.82	208.7	0.00	3.33	5.91	8.36	17.60	2.45	20.05	-188.67
Apr	54.80	15.21	0.00	70.01	7.15	10.11	0.00	0.02	87.36	74.15	161.51	0.00	2.56	5.72	8.09	16.37	1.82	18.19	-143.32
May	51.57	14.31	0.00	65.88	7.39	10.45	0.00	0.08	83.86	243.65	327.50	0.00	2.41	5.91	8.36	16.68	5.98	22.66	-304.84
Total	534.22	148.27	0.00	682.49	87.0	123.0	0.00	3.12	896.1	12712.00	13608.1	0.00	25.0	69.60	98.40	193.0	232.00	425.00	-13183.1

Note : Column no.10 = Column no.(5+6+7+8+9). Column No 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18) Column no.20 = Column no.(19-12)

Table 4.10.8(f): Chinnar Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	39.00	10.83	0.00	49.83	10.11	10.11	0.00	0.10	70.15	311.28	381.43	0.00	1.83	8.09	8.09	18.00	7.64	12.97	38.61	-342.83
Jul	20.76	5.76	0.00	26.52	10.45	10.45	0.00	0.03	47.45	97.38	144.82	0.00	0.97	8.36	8.36	17.69	2.39	6.90	26.98	-117.85
Aug	14.20	3.94	0.00	18.14	10.45	10.45	0.00	0.04	39.07	113.67	152.74	0.00	0.66	8.36	8.36	17.38	2.79	4.72	24.89	-127.85
Sep	49.94	13.86	0.00	63.80	10.11	10.11	0.00	0.79	84.81	2392.06	2476.87	0.00	2.34	8.09	8.09	18.51	58.71	16.60	93.82	-2383.04
Oct	40.88	11.35	0.00	52.23	10.45	10.45	0.00	1.07	74.19	3253.38	3327.57	0.00	1.91	8.36	8.36	18.63	79.85	13.59	112.07	-3215.50
Nov	48.41	13.44	0.00	61.85	10.11	10.11	0.00	0.72	82.79	2193.23	2276.02	0.00	2.27	8.09	8.09	18.44	53.83	16.09	88.37	-2187.66
Dec	57.01	15.82	0.00	72.84	10.45	10.45	0.00	0.15	93.88	443.70	537.57	0.00	2.67	8.36	8.36	19.38	10.89	18.95	49.23	-488.35
Jan	28.13	7.81	0.00	35.93	10.45	10.45	0.00	0.05	56.87	137.71	194.59	0.00	1.32	8.36	8.36	18.03	3.38	9.35	30.76	-163.82
Feb	58.33	16.19	0.00	74.52	9.44	9.44	0.00	0.03	93.42	92.49	185.91	0.00	2.73	7.55	7.55	17.83	2.27	19.39	39.49	-146.42
Mar	71.19	19.76	0.00	90.95	10.45	10.45	0.00	0.03	111.9	99.82	211.70	0.00	3.33	8.36	8.36	20.05	2.45	23.67	46.16	-165.54
Apr	54.80	15.21	0.00	70.01	10.11	10.11	0.00	0.02	90.25	74.15	164.41	0.00	2.56	8.09	8.09	18.74	1.82	18.22	38.78	-125.63
May	51.57	14.31	0.00	65.88	10.45	10.45	0.00	0.08	86.85	243.65	330.50	0.00	2.41	8.36	8.36	19.13	5.98	17.14	42.25	-288.25
Total	534.22	148.27	0.00	682.49	123.0	123.0	0.00	3.12	931.6	12712	13643.6	0.00	25.00	98.40	98.40	221.8	232.00	177.6	631.4	-13012.2

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19) Column no. 21 = Column no.(20-12).

Table 4.10.8(g): Chinnar Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	39.00	10.83	0.00	49.83	7.15	10.11	0.00	0.10	67.24	119.38	186.62	0.00	1.83	5.72	8.09	15.63	2.93	18.56	-168.06
Jul	20.76	5.76	0.00	26.52	7.39	10.45	0.00	0.03	44.41	37.48	81.90	0.00	0.97	5.91	8.36	15.24	0.92	16.16	-65.74
Aug	14.20	3.94	0.00	18.14	7.39	10.45	0.00	0.04	36.02	43.60	79.62	0.00	0.66	5.91	8.36	14.93	1.07	16.00	-63.62
Sep	49.94	13.86	0.00	63.80	7.15	10.11	0.00	0.79	81.88	917.55	999.43	0.00	2.34	5.72	8.09	16.14	22.52	38.66	-960.76
Oct	40.88	11.35	0.00	52.23	7.39	10.45	0.00	1.07	71.16	1248.0	1319.1	0.00	1.91	5.91	8.36	16.18	30.63	46.81	-1272.3
Nov	48.41	13.44	0.00	61.85	7.15	10.11	0.00	0.72	79.86	841.36	921.22	0.00	2.27	5.72	8.09	16.07	20.65	36.72	-884.49
Dec	57.01	15.82	0.00	72.84	7.39	10.45	0.00	0.15	90.85	170.31	261.16	0.00	2.67	5.91	8.36	16.94	4.18	21.12	-240.05
Jan	28.13	7.81	0.00	35.93	7.39	10.45	0.00	0.05	53.84	52.97	106.80	0.00	1.32	5.91	8.36	15.58	1.30	16.88	-89.92
Feb	58.33	16.19	0.00	74.52	6.67	9.44	0.00	0.03	90.72	35.45	126.16	0.00	2.73	5.34	7.55	15.62	0.87	16.49	-109.68
Mar	71.19	19.76	0.00	90.95	7.39	10.45	0.00	0.03	108.9	38.30	147.2	0.00	3.33	5.91	8.36	17.60	0.94	18.54	-128.66
Apr	54.80	15.21	0.00	70.01	7.15	10.11	0.00	0.02	87.36	28.52	115.88	0.00	2.56	5.72	8.09	16.37	0.70	17.07	-98.81
May	51.57	14.31	0.00	65.88	7.39	10.45	0.00	0.08	83.86	93.30	177.16	0.00	2.41	5.91	8.36	16.68	2.29	18.97	-158.19
Total	534.22	148.27	0.00	682.49	87.0	123.0	0.00	3.12	896.1	12712	13608.1	0.00	25.0	69.60	98.40	193.0	89.00	282.0	-13326

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.8(h): Chinnar Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	39.00	10.83	0.00	49.83	10.11	10.11	0.00	0.10	70.15	119.38	189.53	0.00	1.83	8.09	8.09	18.00	2.93	12.97	33.90	-155.63
Jul	20.76	5.76	0.00	26.52	10.45	10.45	0.00	0.03	47.45	37.48	84.93	0.00	0.97	8.36	8.36	17.69	0.92	6.90	25.51	-59.42
Aug	14.20	3.94	0.00	18.14	10.45	10.45	0.00	0.04	39.07	43.60	82.66	0.00	0.66	8.36	8.36	17.38	1.07	4.72	23.17	-59.49
Sep	49.94	13.86	0.00	63.80	10.11	10.11	0.00	0.79	84.81	917.55	1002.35	0.00	2.34	8.09	8.09	18.51	22.52	16.60	57.63	-944.72
Oct	40.88	11.35	0.00	52.23	10.45	10.45	0.00	1.07	74.19	1248.0	1322.2	0.00	1.91	8.36	8.36	18.63	30.63	13.59	62.85	-1259.3
Nov	48.41	13.44	0.00	61.85	10.11	10.11	0.00	0.72	82.79	841.36	924.15	0.00	2.27	8.09	8.09	18.44	20.65	16.09	55.19	-868.96
Dec	57.01	15.82	0.00	72.84	10.45	10.45	0.00	0.15	93.88	170.31	264.18	0.00	2.67	8.36	8.36	19.38	4.18	18.95	42.52	-221.67
Jan	28.13	7.81	0.00	35.93	10.45	10.45	0.00	0.05	56.87	52.97	109.84	0.00	1.32	8.36	8.36	18.03	1.30	9.35	28.68	-81.16
Feb	58.33	16.19	0.00	74.52	9.44	9.44	0.00	0.03	93.42	35.45	128.87	0.00	2.73	7.55	7.55	17.83	0.87	19.39	38.09	-90.78
Mar	71.19	19.76	0.00	90.95	10.45	10.45	0.00	0.03	111.9	38.30	150.18	0.00	3.33	8.36	8.36	20.05	0.94	23.67	44.65	-105.52
Apr	54.80	15.21	0.00	70.01	10.11	10.11	0.00	0.02	90.25	28.52	118.77	0.00	2.56	8.09	8.09	18.74	0.70	18.22	37.66	-81.12
May	51.57	14.31	0.00	65.88	10.45	10.45	0.00	0.08	86.85	93.30	180.15	0.00	2.41	8.36	8.36	19.13	2.29	17.14	38.56	-141.59
Total	534.22	148.27	0.00	682.49	123.0	123.0	0.00	3.12	931.6	12712	13643.6	0.00	25.00	98.40	98.40	221.8	89.00	177.6	488.4	-13155.2

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.9(a): Bhavani Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irriga-tion	Dome-stic	Indus-trial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	21.22	128.93	15.71	165.87	14.71	18.82	2.92	1.58	203.90	85.47	289.37	1.50	18.36	11.77	15.06	45.19	158.17	204.85	-84.52
Jul	28.58	173.63	21.16	223.37	15.20	19.45	2.92	4.40	265.33	237.52	502.84	2.02	24.72	12.16	15.56	52.45	439.54	494.00	-8.84
Aug	26.02	158.13	19.27	203.42	15.20	19.45	2.92	2.84	243.83	153.72	397.55	1.84	22.52	12.16	15.56	50.24	284.47	336.54	-61.01
Sep	11.57	70.30	8.57	90.44	14.71	18.82	2.92	1.53	128.42	82.68	211.10	0.82	10.01	11.77	15.06	36.84	153.00	190.65	-20.44
Oct	0.89	5.42	0.66	6.98	15.20	19.45	2.92	2.02	46.57	109.31	155.87	0.06	0.77	12.16	15.56	28.49	202.28	230.84	74.96
Nov	0.84	5.09	0.62	6.55	14.71	18.82	2.92	2.54	45.54	137.24	182.78	0.06	0.73	11.77	15.06	27.55	253.97	281.58	98.80
Dec	4.40	26.71	3.25	34.36	15.20	19.45	2.92	1.68	73.61	90.78	164.39	0.31	3.80	12.16	15.56	31.52	168.00	199.83	35.44
Jan	14.96	90.92	11.08	116.97	15.20	19.45	2.92	0.72	155.25	38.71	193.97	1.06	12.95	12.16	15.56	40.67	71.64	113.37	-80.60
Feb	22.00	133.69	16.29	171.98	13.73	17.57	2.92	0.48	206.67	25.69	232.36	1.55	19.04	10.99	14.05	44.08	47.54	93.17	-139.19
Mar	24.63	149.66	18.24	192.53	15.20	19.45	2.92	0.33	230.43	17.78	248.21	1.74	21.31	12.16	15.56	49.03	32.91	83.68	-164.53
Apr	8.96	54.45	6.64	70.05	14.71	18.82	2.92	0.37	106.87	19.95	126.82	0.63	7.75	11.77	15.06	34.58	36.91	72.12	-54.69
May	6.01	36.53	4.45	47.00	15.20	19.45	2.92	0.64	85.20	34.45	119.65	0.43	5.20	12.16	15.56	32.92	63.75	97.10	-22.55
Total	170.09	1033.5	125.9	1329.5	179.0	229.0	35.0	19.2	1791.7	1036.0	2827.7	12.0	147.2	143.2	183.2	473.6	1917.2	2402.74	-424.92

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.9(b): Bhavani Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irriga-tion	Dome-stic	Indus-trial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	21.22	128.93	15.71	165.87	18.82	18.82	2.92	1.58	208.01	85.47	293.48	1.50	18.34	15.06	15.06	48.46	158.17	23.42	231.54	-61.94
Jul	28.58	173.63	21.16	223.37	19.45	19.45	2.92	4.40	269.58	237.52	507.09	2.02	24.68	15.56	15.56	55.80	439.54	31.53	528.89	21.80
Aug	26.02	158.13	19.27	203.42	19.45	19.45	2.92	2.84	248.08	153.72	401.80	1.84	22.48	15.56	15.56	53.60	284.47	28.72	368.62	-33.18
Sep	11.57	70.30	8.57	90.44	18.82	18.82	2.92	1.53	132.53	82.68	215.21	0.82	9.99	15.06	15.06	40.11	153.00	12.77	206.69	-8.51
Oct	0.89	5.42	0.66	6.98	19.45	19.45	2.92	2.02	50.81	109.31	160.12	0.06	0.77	15.56	15.56	31.89	202.28	0.98	235.22	75.10
Nov	0.84	5.09	0.62	6.55	18.82	18.82	2.92	2.54	49.65	137.24	186.89	0.06	0.72	15.06	15.06	30.84	253.97	0.93	285.79	98.90
Dec	4.40	26.71	3.25	34.36	19.45	19.45	2.92	1.68	77.85	90.78	168.63	0.31	3.76	15.56	15.56	34.88	168.00	4.85	208.04	39.41
Jan	14.96	90.92	11.08	116.97	19.45	19.45	2.92	0.72	159.50	38.71	198.21	1.06	13.00	15.56	15.56	44.12	71.64	16.51	133.34	-64.87
Feb	22.00	133.69	16.29	171.98	17.57	17.57	2.92	0.48	210.51	25.69	236.20	1.55	19.01	14.05	14.05	47.11	47.54	24.28	120.48	-115.71
Mar	24.63	149.66	18.24	192.53	19.45	19.45	2.92	0.33	234.67	17.78	252.46	1.74	21.28	15.56	15.56	52.40	32.91	27.18	114.22	-138.23
Apr	8.96	54.45	6.64	70.05	18.82	18.82	2.92	0.37	110.98	19.95	130.93	0.63	7.74	15.06	15.06	37.86	36.91	9.89	85.29	-45.64
May	6.01	36.53	4.45	47.00	19.45	19.45	2.92	0.64	89.45	34.45	123.90	0.43	5.21	15.56	15.56	36.33	63.75	6.63	107.14	-16.76
Total	170.09	1033.5	125.95	1329.5	229.0	229.0	35.0	19.2	1841.7	1035.99	2877.7	12.0	147.0	183.2	183.20	513.4	1917.2	187.7	2630.3	-247.39

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no. 21 = Column no.(20-12).

Table 4.10.9(c): Bhavani Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	21.22	128.93	15.71	165.87	14.71	18.82	2.92	1.58	203.90	133.47	337.37	1.50	18.36	11.77	15.06	45.19	247.00	293.68	-43.69
Jul	28.58	173.63	21.16	223.37	15.20	19.45	2.92	4.40	265.33	115.64	380.97	2.02	24.72	12.16	15.56	52.45	214.00	268.46	-112.51
Aug	26.02	158.13	19.27	203.42	15.20	19.45	2.92	2.84	243.83	120.50	364.34	1.84	22.52	12.16	15.56	50.24	223.00	275.07	-89.26
Sep	11.57	70.30	8.57	90.44	14.71	18.82	2.92	1.53	128.42	136.17	264.60	0.82	10.01	11.77	15.06	36.84	252.00	289.65	25.06
Oct	0.89	5.42	0.66	6.98	15.20	19.45	2.92	2.02	46.57	209.12	255.69	0.06	0.77	12.16	15.56	28.49	387.00	415.56	159.87
Nov	0.84	5.09	0.62	6.55	14.71	18.82	2.92	2.54	45.54	111.86	157.40	0.06	0.73	11.77	15.06	27.55	207.00	234.61	77.21
Dec	4.40	26.71	3.25	34.36	15.20	19.45	2.92	1.68	73.61	89.70	163.31	0.31	3.80	12.16	15.56	31.52	166.00	197.83	34.52
Jan	14.96	90.92	11.08	116.97	15.20	19.45	2.92	0.72	155.25	54.58	209.83	1.06	12.95	12.16	15.56	40.67	101.00	142.73	-67.10
Feb	22.00	133.69	16.29	171.98	13.73	17.57	2.92	0.48	206.67	71.87	278.54	1.55	19.04	10.99	14.05	44.08	133.00	178.63	-99.91
Mar	24.63	149.66	18.24	192.53	15.20	19.45	2.92	0.33	230.43	119.42	349.85	1.74	21.31	12.16	15.56	49.03	221.00	271.77	-78.08
Apr	8.96	54.45	6.64	70.05	14.71	18.82	2.92	0.37	106.87	52.42	159.29	0.63	7.75	11.77	15.06	34.58	97.00	132.21	-27.08
May	6.01	36.53	4.45	47.00	15.20	19.45	2.92	0.64	85.20	108.61	193.82	0.43	5.20	12.16	15.56	32.92	201.00	234.35	-40.53
Total	170.09	1033.5	125.95	1329.5	179.0	229.0	35.0	19.2	1791.7	1036.0	2827.7	12.0	147.2	143.2	183.2	473.6	2444.00	2929.6	101.9

Note : Column no.10 = Column no.(5+6+7+8+9). Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.9(d): Bhavani Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	21.22	128.93	15.71	165.87	18.82	18.82	2.92	1.58	208.01	133.47	341.48	1.50	18.34	11.77	15.06	45.17	247.00	23.42	317.08	-24.40
Jul	28.58	173.63	21.16	223.37	19.45	19.45	2.92	4.40	269.58	115.64	385.22	2.02	24.68	12.16	15.56	52.41	214.00	31.53	299.96	-85.26
Aug	26.02	158.13	19.27	203.42	19.45	19.45	2.92	2.84	248.08	120.50	368.58	1.84	22.48	12.16	15.56	50.20	223.00	28.72	303.76	-64.83
Sep	11.57	70.30	8.57	90.44	18.82	18.82	2.92	1.53	132.53	136.17	268.70	0.82	9.99	11.77	15.06	36.82	252.00	12.77	302.41	33.70
Oct	0.89	5.42	0.66	6.98	19.45	19.45	2.92	2.02	50.81	209.12	259.94	0.06	0.77	12.16	15.56	28.49	387.00	0.98	416.54	156.60
Nov	0.84	5.09	0.62	6.55	18.82	18.82	2.92	2.54	49.65	111.86	161.51	0.06	0.72	11.77	15.06	27.55	207.00	0.93	235.54	74.02
Dec	4.40	26.71	3.25	34.36	19.45	19.45	2.92	1.68	77.85	89.70	167.55	0.31	3.76	12.16	15.56	31.49	166.00	4.85	202.64	35.09
Jan	14.96	90.92	11.08	116.97	19.45	19.45	2.92	0.72	159.50	54.58	214.08	1.06	13.00	12.16	15.56	40.73	101.00	16.51	159.30	-54.78
Feb	22.00	133.69	16.29	171.98	17.57	17.57	2.92	0.48	210.51	71.87	282.38	1.55	19.01	10.99	14.05	44.04	133.00	24.28	202.88	-79.50
Mar	24.63	149.66	18.24	192.53	19.45	19.45	2.92	0.33	234.67	119.42	354.10	1.74	21.28	12.16	15.56	49.00	221.00	27.18	298.92	-55.18
Apr	8.96	54.45	6.64	70.05	18.82	18.82	2.92	0.37	110.98	52.42	163.40	0.63	7.74	11.77	15.06	34.57	97.00	9.89	142.09	-21.31
May	6.01	36.53	4.45	47.00	19.45	19.45	2.92	0.64	89.45	108.61	198.06	0.43	5.21	12.16	15.56	32.93	201.00	6.63	240.99	42.93
Total	170.09	1033.5	125.95	1329.5	229.0	229.0	35.0	19.2	1841.7	1036.0	2877.7	12.0	147.0	143.2	183.20	473.4	2444.00	187.7	3117.1	239.43

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no. 21 = Column no.(20-12).

Table 4.10.9(e): Bhavani Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	21.22	128.93	15.71	165.87	14.71	18.82	2.92	1.58	203.90	53.70	257.60	1.50	18.36	11.77	15.06	45.19	99.38	146.06	-111.54
Jul	28.58	173.63	21.16	223.37	15.20	19.45	2.92	4.40	265.33	36.75	302.08	2.02	24.72	12.16	15.56	52.45	68.01	122.47	-179.61
Aug	26.02	158.13	19.27	203.42	15.20	19.45	2.92	2.84	243.83	117.81	361.64	1.84	22.52	12.16	15.56	50.24	218.01	270.08	-91.56
Sep	11.57	70.30	8.57	90.44	14.71	18.82	2.92	1.53	128.42	67.91	196.33	0.82	10.01	11.77	15.06	36.84	125.67	163.32	-33.01
Oct	0.89	5.42	0.66	6.98	15.20	19.45	2.92	2.02	46.57	74.01	120.58	0.06	0.77	12.16	15.56	28.49	136.97	165.53	44.94
Nov	0.84	5.09	0.62	6.55	14.71	18.82	2.92	2.54	45.54	72.78	118.32	0.06	0.73	11.77	15.06	27.55	134.68	162.29	43.97
Dec	4.40	26.71	3.25	34.36	15.20	19.45	2.92	1.68	73.61	102.18	175.78	0.31	3.80	12.16	15.56	31.52	189.09	220.92	45.14
Jan	14.96	90.92	11.08	116.97	15.20	19.45	2.92	0.72	155.25	122.25	277.50	1.06	12.95	12.16	15.56	40.67	226.23	267.96	-9.54
Feb	22.00	133.69	16.29	171.98	13.73	17.57	2.92	0.48	206.67	77.37	284.04	1.55	19.04	10.99	14.05	44.08	143.18	188.81	-95.23
Mar	24.63	149.66	18.24	192.53	15.20	19.45	2.92	0.33	230.43	8.55	238.98	1.74	21.31	12.16	15.56	49.03	15.83	66.60	-172.38
Apr	8.96	54.45	6.64	70.05	14.71	18.82	2.92	0.37	106.87	27.56	134.44	0.63	7.75	11.77	15.06	34.58	51.01	86.22	-48.21
May	6.01	36.53	4.45	47.00	15.20	19.45	2.92	0.64	85.20	56.70	141.90	0.43	5.20	12.16	15.56	32.92	104.92	138.27	-3.63
Total	170.09	1033.5	125.95	1329.5	179.0	229.0	35.0	19.17	1791.7	1036.0	2827.7	12.0	147.2	143.2	183.2	473.6	1513.0	1998.6	-829.1

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.9(f): Bhavani Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	21.22	128.93	15.71	165.87	18.82	18.82	2.92	1.58	208.01	53.70	261.71	1.50	18.34	15.06	15.06	48.46	99.38	23.42	172.75	-88.96
Jul	28.58	173.63	21.16	223.37	19.45	19.45	2.92	4.40	269.58	36.75	306.33	2.02	24.68	15.56	15.56	55.80	68.01	31.53	157.36	-148.96
Aug	26.02	158.13	19.27	203.42	19.45	19.45	2.92	2.84	248.08	117.81	365.89	1.84	22.48	15.56	15.56	53.60	218.01	28.72	302.16	-63.72
Sep	11.57	70.30	8.57	90.44	18.82	18.82	2.92	1.53	132.53	67.91	200.44	0.82	9.99	15.06	15.06	40.11	125.67	12.77	179.36	-21.08
Oct	0.89	5.42	0.66	6.98	19.45	19.45	2.92	2.02	50.81	74.01	124.83	0.06	0.77	15.56	15.56	31.89	136.97	0.98	169.91	45.08
Nov	0.84	5.09	0.62	6.55	18.82	18.82	2.92	2.54	49.65	72.78	122.43	0.06	0.72	15.06	15.06	30.84	134.68	0.93	166.50	44.07
Dec	4.40	26.71	3.25	34.36	19.45	19.45	2.92	1.68	77.85	102.18	180.03	0.31	3.76	15.56	15.56	34.88	189.09	4.85	229.13	49.10
Jan	14.96	90.92	11.08	116.97	19.45	19.45	2.92	0.72	159.50	122.25	281.75	1.06	13.00	15.56	15.56	44.12	226.23	16.51	287.93	6.18
Feb	22.00	133.69	16.29	171.98	17.57	17.57	2.92	0.48	210.51	77.37	287.88	1.55	19.01	14.05	14.05	47.11	143.18	24.28	216.12	-71.75
Mar	24.63	149.66	18.24	192.53	19.45	19.45	2.92	0.33	234.67	8.55	243.23	1.74	21.28	15.56	15.56	52.40	15.83	27.18	97.14	-146.08
Apr	8.96	54.45	6.64	70.05	18.82	18.82	2.92	0.37	110.98	27.56	138.55	0.63	7.74	15.06	15.06	37.86	51.01	9.89	99.39	-39.16
May	6.01	36.53	4.45	47.00	19.45	19.45	2.92	0.64	89.45	56.70	146.14	0.43	5.21	15.56	15.56	36.33	104.92	6.63	148.31	2.17
Total	170.09	1033.5	125.95	1329.5	229.0	229.0	35.0	19.2	1841.7	1036.0	2877.7	12.0	147.0	183.2	183.20	513.4	1513.0	187.7	2226.1	-651.57

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no. 21 = Column no.(20-12).

Table 4.10.9(g): Bhavani Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	21.22	128.93	15.71	165.87	14.71	18.82	2.92	1.58	203.90	42.94	246.84	1.50	18.36	11.77	15.06	45.19	79.47	126.15	-120.69
Jul	28.58	173.63	21.16	223.37	15.20	19.45	2.92	4.40	265.33	73.00	338.33	2.02	24.72	12.16	15.56	52.45	135.10	189.56	-148.77
Aug	26.02	158.13	19.27	203.42	15.20	19.45	2.92	2.84	243.83	24.00	267.84	1.84	22.52	12.16	15.56	50.24	44.42	96.49	-171.34
Sep	11.57	70.30	8.57	90.44	14.71	18.82	2.92	1.53	128.42	43.22	171.64	0.82	10.01	11.77	15.06	36.84	79.98	117.63	-54.01
Oct	0.89	5.42	0.66	6.98	15.20	19.45	2.92	2.02	46.57	85.00	131.57	0.06	0.77	12.16	15.56	28.49	157.30	185.86	54.29
Nov	0.84	5.09	0.62	6.55	14.71	18.82	2.92	2.54	45.54	28.26	73.80	0.06	0.73	11.77	15.06	27.55	52.29	79.90	6.10
Dec	4.40	26.71	3.25	34.36	15.20	19.45	2.92	1.68	73.61	142.82	216.43	0.31	3.80	12.16	15.56	31.52	264.30	296.13	79.71
Jan	14.96	90.92	11.08	116.97	15.20	19.45	2.92	0.72	155.25	25.27	180.53	1.06	12.95	12.16	15.56	40.67	46.77	88.50	-92.03
Feb	22.00	133.69	16.29	171.98	13.73	17.57	2.92	0.48	206.67	22.10	228.77	1.55	19.04	10.99	14.05	44.08	40.90	86.53	-142.24
Mar	24.63	149.66	18.24	192.53	15.20	19.45	2.92	0.33	230.43	14.53	244.95	1.74	21.31	12.16	15.56	49.03	26.88	77.65	-167.30
Apr	8.96	54.45	6.64	70.05	14.71	18.82	2.92	0.37	106.87	100.67	207.54	0.63	7.75	11.77	15.06	34.58	186.30	221.51	13.97
May	6.01	36.53	4.45	47.00	15.20	19.45	2.92	0.64	85.20	29.01	114.21	0.43	5.20	12.16	15.56	32.92	53.69	87.04	-27.18
Total	170.09	1033.5	125.95	1329.5	179.0	229.0	35.0	19.17	1791.7	1036.0	2827.7	12.0	147.2	143.2	183.2	473.6	1218.0	1703.6	-1124.1

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.9(h): Bhavani Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irrign-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	21.22	128.93	15.71	165.87	18.82	18.82	2.92	1.58	208.01	42.94	250.95	1.50	18.34	15.06	15.06	48.46	79.47	23.42	152.84	-98.11
Jul	28.58	173.63	21.16	223.37	19.45	19.45	2.92	4.40	269.58	73.00	342.58	2.02	24.68	15.56	15.56	55.80	135.10	31.53	224.45	-118.13
Aug	26.02	158.13	19.27	203.42	19.45	19.45	2.92	2.84	248.08	24.00	272.08	1.84	22.48	15.56	15.56	53.60	44.42	28.72	128.57	-143.51
Sep	11.57	70.30	8.57	90.44	18.82	18.82	2.92	1.53	132.53	43.22	175.75	0.82	9.99	15.06	15.06	40.11	79.98	12.77	133.67	-42.08
Oct	0.89	5.42	0.66	6.98	19.45	19.45	2.92	2.02	50.81	85.00	135.81	0.06	0.77	15.56	15.56	31.89	157.30	0.98	190.24	54.42
Nov	0.84	5.09	0.62	6.55	18.82	18.82	2.92	2.54	49.65	28.26	77.91	0.06	0.72	15.06	15.06	30.84	52.29	0.93	84.11	6.20
Dec	4.40	26.71	3.25	34.36	19.45	19.45	2.92	1.68	77.85	142.82	220.67	0.31	3.76	15.56	15.56	34.88	264.30	4.85	304.34	83.67
Jan	14.96	90.92	11.08	116.97	19.45	19.45	2.92	0.72	159.50	25.27	184.77	1.06	13.00	15.56	15.56	44.12	46.77	16.51	108.47	-76.31
Feb	22.00	133.69	16.29	171.98	17.57	17.57	2.92	0.48	210.51	22.10	232.61	1.55	19.01	14.05	14.05	47.11	40.90	24.28	113.84	-118.76
Mar	24.63	149.66	18.24	192.53	19.45	19.45	2.92	0.33	234.67	14.53	249.20	1.74	21.28	15.56	15.56	52.40	26.88	27.18	108.19	-141.01
Apr	8.96	54.45	6.64	70.05	18.82	18.82	2.92	0.37	110.98	100.67	211.65	0.63	7.74	15.06	15.06	37.86	186.30	9.89	234.68	23.02
May	6.01	36.53	4.45	47.00	19.45	19.45	2.92	0.64	89.45	29.01	118.46	0.43	5.21	15.56	15.56	36.33	53.69	6.63	97.08	-21.38
Total	170.09	1033.5	125.9	1329.5	229.0	229.0	35.0	19.2	1841.7	1036.0	2877.7	12.0	147.0	183.2	183.20	513.4	1218.0	187.7	1931.1	-946.57

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no. 21 = Column no.(20-12).

Table 4.10.10(a): Noyil Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	31.84	117.29	4.23	153.36	17.26	20.71	0.00	0.00	188.14	0.00	188.14	96.26	11.37	13.81	16.57	41.74	0.38	138.38	-49.75
Jul	18.05	66.49	2.40	86.94	17.84	21.40	0.00	0.01	124.04	0.00	124.04	54.35	6.44	14.27	17.12	37.83	1.15	93.34	-30.70
Aug	14.08	51.85	1.87	67.80	17.84	21.40	0.00	0.00	105.30	0.00	105.30	42.35	5.02	14.27	17.12	36.42	0.00	78.77	-26.54
Sep	7.13	26.26	0.95	34.34	17.26	20.71	0.00	0.06	71.42	0.00	71.42	21.40	2.55	13.81	16.57	32.92	5.90	60.23	-11.19
Oct	0.97	3.57	0.13	4.66	17.84	21.40	0.00	1.17	44.95	0.00	44.95	2.91	0.35	14.27	17.12	31.74	116.7	151.34	106.39
Nov	1.20	4.41	0.16	5.77	17.26	20.71	0.00	0.63	44.22	0.00	44.22	3.60	0.43	13.81	16.57	30.81	63.20	97.61	53.38
Dec	4.74	17.45	0.63	22.82	17.84	21.40	0.00	0.38	61.61	0.00	61.61	14.10	1.69	14.27	17.12	33.08	37.69	84.87	23.26
Jan	9.20	33.89	1.22	44.32	17.84	21.40	0.00	0.00	82.51	0.00	82.51	27.74	3.28	14.27	17.12	34.68	0.00	62.42	-20.10
Feb	11.86	43.68	1.58	57.11	16.11	19.33	0.00	0.00	91.24	0.00	91.24	35.77	4.23	12.89	15.47	32.59	0.00	68.36	-22.89
Mar	13.13	48.37	1.75	63.24	17.84	21.40	0.00	0.00	101.03	0.00	101.03	39.61	4.69	14.27	17.12	36.08	0.00	75.69	-25.34
Apr	9.99	36.79	1.33	48.11	17.26	20.71	0.00	0.00	84.98	0.00	84.98	30.13	3.57	13.81	16.57	33.94	0.00	64.08	-20.90
May	26.29	96.83	3.50	126.62	17.84	21.40	0.00	0.00	160.56	0.00	160.56	77.77	9.38	14.27	17.12	40.77	0.00	118.54	-42.01
Total	148.47	546.89	19.74	715.10	210.00	252.00	0.00	2.25	1160.00	0.00	1160.0	446.0	53.0	168.0	201.6	422.6	225.0	1093.6	-66.40

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.10(b): Noyil Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	31.84	117.29	4.23	153.36	20.71	20.71	0.00	0.00	194.79	0.00	194.79	96.26	11.37	16.57	16.57	44.51	0.38	11.62	152.77	-42.02
Jul	18.05	66.49	2.40	86.94	21.40	21.40	0.00	0.01	129.76	0.00	129.76	54.35	6.45	17.12	17.12	40.69	1.15	6.59	102.78	-26.97
Aug	14.08	51.85	1.87	67.80	21.40	21.40	0.00	0.00	110.60	0.00	110.60	42.35	5.03	17.12	17.12	39.27	0.00	5.14	86.76	-23.84
Sep	7.13	26.26	0.95	34.34	20.71	20.71	0.00	0.06	75.82	0.00	75.82	21.40	2.55	16.57	16.57	35.69	5.90	2.60	65.59	-10.23
Oct	0.97	3.57	0.13	4.66	21.40	21.40	0.00	1.17	48.64	0.00	48.64	2.91	0.35	17.12	17.12	34.59	116.7	0.35	154.54	105.91
Nov	1.20	4.41	0.16	5.77	20.71	20.71	0.00	0.63	47.83	0.00	47.83	3.60	0.43	16.57	16.57	33.57	63.20	0.44	100.81	52.98
Dec	4.74	17.45	0.63	22.82	21.40	21.40	0.00	0.38	66.00	0.00	66.00	14.10	1.69	17.12	17.12	35.94	37.69	1.73	89.46	23.46
Jan	9.20	33.89	1.22	44.32	21.40	21.40	0.00	0.00	87.12	0.00	87.12	27.74	3.29	17.12	17.12	37.53	0.00	3.36	68.63	-18.49
Feb	11.86	43.68	1.58	57.11	19.33	19.33	0.00	0.00	95.78	0.00	95.78	35.77	4.24	15.47	15.47	35.17	0.00	4.33	75.27	-20.51
Mar	13.13	48.37	1.75	63.24	21.40	21.40	0.00	0.00	106.05	0.00	106.05	39.61	4.69	17.12	17.12	38.93	0.00	4.79	83.34	-22.71
Apr	9.99	36.79	1.33	48.11	20.71	20.71	0.00	0.00	89.54	0.00	89.54	30.13	3.57	16.57	16.57	36.71	0.00	3.65	70.49	-19.05
May	26.29	96.83	3.50	126.62	21.40	21.40	0.00	0.00	169.42	0.00	169.42	77.77	9.39	17.12	17.12	43.63	0.00	9.60	131.00	-38.42
Total	148.47	546.89	19.74	715.10	252.00	252.00	0.00	2.25	1221.3	0.00	1221.3	446.0	53.03	201.60	201.6	456.2	225.0	54.20	1181.4	-39.92

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.10(c): Noyil Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	31.84	117.29	4.23	153.36	17.26	20.71	0.00	0.00	188.14	0.00	188.14	96.26	11.37	13.81	16.57	41.74	0.40	138.40	-49.74
Jul	18.05	66.49	2.40	86.94	17.84	21.40	0.00	0.01	124.04	0.00	124.04	54.35	6.44	14.27	17.12	37.83	1.20	93.38	-30.66
Aug	14.08	51.85	1.87	67.80	17.84	21.40	0.00	0.00	105.30	0.00	105.30	42.35	5.02	14.27	17.12	36.42	0.00	78.77	-26.54
Sep	7.13	26.26	0.95	34.34	17.26	20.71	0.00	0.06	71.42	0.00	71.42	21.40	2.55	13.81	16.57	32.92	6.14	60.46	-10.96
Oct	0.97	3.57	0.13	4.66	17.84	21.40	0.00	1.17	44.95	0.00	44.95	2.91	0.35	14.27	17.12	31.74	121.36	156.00	111.06
Nov	1.20	4.41	0.16	5.77	17.26	20.71	0.00	0.63	44.22	0.00	44.22	3.60	0.43	13.81	16.57	30.81	65.73	100.13	55.91
Dec	4.74	17.45	0.63	22.82	17.84	21.40	0.00	0.38	61.61	0.00	61.61	14.10	1.69	14.27	17.12	33.08	39.20	86.38	24.77
Jan	9.20	33.89	1.22	44.32	17.84	21.40	0.00	0.00	82.51	0.00	82.51	27.74	3.28	14.27	17.12	34.68	0.00	62.42	-20.10
Feb	11.86	43.68	1.58	57.11	16.11	19.33	0.00	0.00	91.24	0.00	91.24	35.77	4.23	12.89	15.47	32.59	0.00	68.36	-22.89
Mar	13.13	48.37	1.75	63.24	17.84	21.40	0.00	0.00	101.03	0.00	101.03	39.61	4.69	14.27	17.12	36.08	0.00	75.69	-25.34
Apr	9.99	36.79	1.33	48.11	17.26	20.71	0.00	0.00	84.98	0.00	84.98	30.13	3.57	13.81	16.57	33.94	0.00	64.08	-20.90
May	26.29	96.83	3.50	126.62	17.84	21.40	0.00	0.00	160.56	0.00	160.56	77.77	9.38	14.27	17.12	40.77	0.00	118.54	-42.01
Total	148.47	546.89	19.74	715.10	210.00	252.00	0.00	2.25	1160.00	0.00	1160.0	446.0	53.0	168.0	201.6	422.6	234.00	1102.6	-57.40

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.10(d): Noyil Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	*Gross* total utilisation	Import	Regeneration from uses				*Surface* water yields	*Ground* water yields	*Gross* water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	31.84	117.29	4.23	153.36	20.71	20.71	0.00	0.00	194.79	0.00	194.8	96.3	11.37	13.81	16.57	41.8	0.40	11.62	150.03	-44.77
Jul	18.05	66.49	2.40	86.94	21.40	21.40	0.00	0.01	129.76	0.00	129.8	54.4	6.45	14.27	17.12	37.8	1.20	6.59	99.98	-29.78
Aug	14.08	51.85	1.87	67.80	21.40	21.40	0.00	0.00	110.60	0.00	110.6	42.3	5.03	14.27	17.12	36.4	0.00	5.14	83.91	-26.70
Sep	7.13	26.26	0.95	34.34	20.71	20.71	0.00	0.06	75.82	0.00	75.8	21.4	2.55	13.81	16.57	32.9	6.14	2.60	63.07	-12.75
Oct	0.97	3.57	0.13	4.66	21.40	21.40	0.00	1.17	48.64	0.00	48.6	2.9	0.35	14.27	17.12	31.7	121.36	0.35	156.36	107.72
Nov	1.20	4.41	0.16	5.77	20.71	20.71	0.00	0.63	47.83	0.00	47.8	3.6	0.43	13.81	16.57	30.8	65.73	0.44	100.57	52.74
Dec	4.74	17.45	0.63	22.82	21.40	21.40	0.00	0.38	66.00	0.00	66.0	14.1	1.69	14.27	17.12	33.1	39.20	1.73	88.11	22.11
Jan	9.20	33.89	1.22	44.32	21.40	21.40	0.00	0.00	87.12	0.00	87.1	27.7	3.29	14.27	17.12	34.7	0.00	3.36	65.78	-21.35
Feb	11.86	43.68	1.58	57.11	19.33	19.33	0.00	0.00	95.78	0.00	95.8	35.8	4.24	12.89	15.47	32.6	0.00	4.33	72.69	-23.09
Mar	13.13	48.37	1.75	63.24	21.40	21.40	0.00	0.00	106.05	0.00	106.0	39.6	4.69	14.27	17.12	36.1	0.00	4.79	80.48	-25.57
Apr	9.99	36.79	1.33	48.11	20.71	20.71	0.00	0.00	89.54	0.00	89.5	30.1	3.57	13.81	16.57	33.9	0.00	3.65	67.72	-21.81
May	26.29	96.83	3.50	126.62	21.40	21.40	0.00	0.00	169.42	0.00	169.4	77.8	9.39	14.27	17.12	40.8	0.00	9.60	128.15	-41.28
Total	148.47	546.89	19.74	715.10	252.00	252.0	0.00	2.25	1221.3	0.00	1221	446	53	168	202	423	234.00	54.20	1156.8	-64.52

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.10(e): Noyil Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	31.84	117.29	4.23	153.36	17.26	20.71	0.00	0.00	188.14	0.00	188.14	96.26	11.37	13.81	16.57	41.74	0.36	138.36	-49.77
Jul	18.05	66.49	2.40	86.94	17.84	21.40	0.00	0.01	124.04	0.00	124.04	54.35	6.44	14.27	17.12	37.83	1.09	93.28	-30.76
Aug	14.08	51.85	1.87	67.80	17.84	21.40	0.00	0.00	105.30	0.00	105.30	42.35	5.02	14.27	17.12	36.42	0.00	78.77	-26.54
Sep	7.13	26.26	0.95	34.34	17.26	20.71	0.00	0.06	71.42	0.00	71.42	21.40	2.55	13.81	16.57	32.92	5.59	59.92	-11.50
Oct	0.97	3.57	0.13	4.66	17.84	21.40	0.00	1.17	44.95	0.00	44.95	2.91	0.35	14.27	17.12	31.74	110.5	145.11	100.16
Nov	1.20	4.41	0.16	5.77	17.26	20.71	0.00	0.63	44.22	0.00	44.22	3.60	0.43	13.81	16.57	30.81	59.83	94.24	50.01
Dec	4.74	17.45	0.63	22.82	17.84	21.40	0.00	0.38	61.61	0.00	61.61	14.10	1.69	14.27	17.12	33.08	35.68	82.86	21.25
Jan	9.20	33.89	1.22	44.32	17.84	21.40	0.00	0.00	82.51	0.00	82.51	27.74	3.28	14.27	17.12	34.68	0.00	62.42	-20.10
Feb	11.86	43.68	1.58	57.11	16.11	19.33	0.00	0.00	91.24	0.00	91.24	35.77	4.23	12.89	15.47	32.59	0.00	68.36	-22.89
Mar	13.13	48.37	1.75	63.24	17.84	21.40	0.00	0.00	101.03	0.00	101.03	39.61	4.69	14.27	17.12	36.08	0.00	75.69	-25.34
Apr	9.99	36.79	1.33	48.11	17.26	20.71	0.00	0.00	84.98	0.00	84.98	30.13	3.57	13.81	16.57	33.94	0.00	64.08	-20.90
May	26.29	96.83	3.50	126.62	17.84	21.40	0.00	0.00	160.56	0.00	160.56	77.77	9.38	14.27	17.12	40.77	0.00	118.54	-42.01
Total	148.47	546.89	19.74	715.10	210.00	252.00	0.00	2.25	1160.00	0.00	1160.0	446.0	53.0	168.0	201.6	422.6	213.0	1081.6	-78.40

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no 19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.10(f): Noyil Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	31.84	117.29	4.23	153.36	20.71	20.71	0.00	0.00	194.79	0.00	194.79	96.26	11.37	16.57	16.57	44.51	0.36	11.62	152.75	-42.04
Jul	18.05	66.49	2.40	86.94	21.40	21.40	0.00	0.01	129.76	0.00	129.76	54.35	6.45	17.12	17.12	40.69	1.09	6.59	102.72	-27.03
Aug	14.08	51.85	1.87	67.80	21.40	21.40	0.00	0.00	110.60	0.00	110.60	42.35	5.03	17.12	17.12	39.27	0.00	5.14	86.76	-23.84
Sep	7.13	26.26	0.95	34.34	20.71	20.71	0.00	0.06	75.82	0.00	75.82	21.40	2.55	16.57	16.57	35.69	5.59	2.60	65.28	-10.54
Oct	0.97	3.57	0.13	4.66	21.40	21.40	0.00	1.17	48.64	0.00	48.64	2.91	0.35	17.12	17.12	34.59	110.5	0.35	148.31	99.68
Nov	1.20	4.41	0.16	5.77	20.71	20.71	0.00	0.63	47.83	0.00	47.83	3.60	0.43	16.57	16.57	33.57	59.83	0.44	97.44	49.61
Dec	4.74	17.45	0.63	22.82	21.40	21.40	0.00	0.38	66.00	0.00	66.00	14.10	1.69	17.12	17.12	35.94	35.68	1.73	87.45	21.45
Jan	9.20	33.89	1.22	44.32	21.40	21.40	0.00	0.00	87.12	0.00	87.12	27.74	3.29	17.12	17.12	37.53	0.00	3.36	68.63	-18.49
Feb	11.86	43.68	1.58	57.11	19.33	19.33	0.00	0.00	95.78	0.00	95.78	35.77	4.24	15.47	15.47	35.17	0.00	4.33	75.27	-20.51
Mar	13.13	48.37	1.75	63.24	21.40	21.40	0.00	0.00	106.05	0.00	106.05	39.61	4.69	17.12	17.12	38.93	0.00	4.79	83.34	-22.71
Apr	9.99	36.79	1.33	48.11	20.71	20.71	0.00	0.00	89.54	0.00	89.54	30.13	3.57	16.57	16.57	36.71	0.00	3.65	70.49	-19.05
May	26.29	96.83	3.50	126.62	21.40	21.40	0.00	0.00	169.42	0.00	169.42	77.77	9.39	17.12	17.12	43.63	0.00	9.60	131.00	-38.42
Total	148.47	546.89	19.74	715.10	252.00	252.00	0.00	2.25	1221.3	0.00	1221.3	446.0	53.03	201.6	201.6	456.2	213.0	54.20	1169.4	-51.92

Note : Column no.10 = Column no.(5+6+7+8+9) Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19) Column no. 21 = Column no.(20-12).

Table 4.10.10(g): Noyil Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	31.84	117.29	4.23	153.36	17.26	20.71	0.00	0.00	188.14	0.00	188.14	96.26	11.37	13.81	16.57	41.74	0.34	138.34	-49.79
Jul	18.05	66.49	2.40	86.94	17.84	21.40	0.00	0.01	124.04	0.00	124.04	54.35	6.44	14.27	17.12	37.83	1.03	93.22	-30.82
Aug	14.08	51.85	1.87	67.80	17.84	21.40	0.00	0.00	105.30	0.00	105.30	42.35	5.02	14.27	17.12	36.42	0.00	78.77	-26.54
Sep	7.13	26.26	0.95	34.34	17.26	20.71	0.00	0.06	71.42	0.00	71.42	21.40	2.55	13.81	16.57	32.92	5.27	59.60	-11.82
Oct	0.97	3.57	0.13	4.66	17.84	21.40	0.00	1.17	44.95	0.00	44.95	2.91	0.35	14.27	17.12	31.74	104.2	138.89	93.94
Nov	1.20	4.41	0.16	5.77	17.26	20.71	0.00	0.63	44.22	0.00	44.22	3.60	0.43	13.81	16.57	30.81	56.46	90.87	46.64
Dec	4.74	17.45	0.63	22.82	17.84	21.40	0.00	0.38	61.61	0.00	61.61	14.10	1.69	14.27	17.12	33.08	33.67	80.85	19.24
Jan	9.20	33.89	1.22	44.32	17.84	21.40	0.00	0.00	82.51	0.00	82.51	27.74	3.28	14.27	17.12	34.68	0.00	62.42	-20.10
Feb	11.86	43.68	1.58	57.11	16.11	19.33	0.00	0.00	91.24	0.00	91.24	35.77	4.23	12.89	15.47	32.59	0.00	68.36	-22.89
Mar	13.13	48.37	1.75	63.24	17.84	21.40	0.00	0.00	101.03	0.00	101.03	39.61	4.69	14.27	17.12	36.08	0.00	75.69	-25.34
Apr	9.99	36.79	1.33	48.11	17.26	20.71	0.00	0.00	84.98	0.00	84.98	30.13	3.57	13.81	16.57	33.94	0.00	64.08	-20.90
May	26.29	96.83	3.50	126.62	17.84	21.40	0.00	0.00	160.56	0.00	160.56	77.77	9.38	14.27	17.12	40.77	0.00	118.54	-42.01
Total	148.47	546.89	19.74	715.10	210.00	252.00	0.00	2.25	1160.00	0.00	1160.0	446.0	53.0	168.0	201.6	422.6	201.0	1069.6	-90.40

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.10(h): Noyil Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	31.84	117.29	4.23	153.36	20.71	20.71	0.00	0.00	194.79	0.00	194.79	96.26	11.37	16.57	16.57	44.51	0.34	11.62	152.73	-42.06
Jul	18.05	66.49	2.40	86.94	21.40	21.40	0.00	0.01	129.76	0.00	129.76	54.35	6.45	17.12	17.12	40.69	1.03	6.59	102.66	-27.09
Aug	14.08	51.85	1.87	67.80	21.40	21.40	0.00	0.00	110.60	0.00	110.60	42.35	5.03	17.12	17.12	39.27	0.00	5.14	86.76	-23.84
Sep	7.13	26.26	0.95	34.34	20.71	20.71	0.00	0.06	75.82	0.00	75.82	21.40	2.55	16.57	16.57	35.69	5.27	2.60	64.96	-10.86
Oct	0.97	3.57	0.13	4.66	21.40	21.40	0.00	1.17	48.64	0.00	48.64	2.91	0.35	17.12	17.12	34.59	104.2	0.35	142.09	93.46
Nov	1.20	4.41	0.16	5.77	20.71	20.71	0.00	0.63	47.83	0.00	47.83	3.60	0.43	16.57	16.57	33.57	56.46	0.44	94.07	46.24
Dec	4.74	17.45	0.63	22.82	21.40	21.40	0.00	0.38	66.00	0.00	66.00	14.10	1.69	17.12	17.12	35.94	33.67	1.73	85.44	19.44
Jan	9.20	33.89	1.22	44.32	21.40	21.40	0.00	0.00	87.12	0.00	87.12	27.74	3.29	17.12	17.12	37.53	0.00	3.36	68.63	-18.49
Feb	11.86	43.68	1.58	57.11	19.33	19.33	0.00	0.00	95.78	0.00	95.78	35.77	4.24	15.47	15.47	35.17	0.00	4.33	75.27	-20.51
Mar	13.13	48.37	1.75	63.24	21.40	21.40	0.00	0.00	106.05	0.00	106.05	39.61	4.69	17.12	17.12	38.93	0.00	4.79	83.34	-22.71
Apr	9.99	36.79	1.33	48.11	20.71	20.71	0.00	0.00	89.54	0.00	89.54	30.13	3.57	16.57	16.57	36.71	0.00	3.65	70.49	-19.05
May	26.29	96.83	3.50	126.62	21.40	21.40	0.00	0.00	169.42	0.00	169.42	77.77	9.39	17.12	17.12	43.63	0.00	9.60	131.00	-38.42
Total	148.47	546.89	19.74	715.10	252.00	252.00	0.00	2.25	1221.3	0.00	1221.3	446.0	53.03	201.6	201.6	456.2	201.0	54.20	1157.4	-63.92

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.11(a): Amaravathi Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements												Regeneration from uses						
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Import	Irriga-tion	Dome-stic	Indus-trial	Total	Surface water yields	Gross water available	
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	87.98	185.68	5.17	278.84	18.90	25.07	0.08	0.03	322.93	0.00	322.93	62.33	16.97	15.12	20.05	52.14	3.46	117.94	-204.99
Jul	117.26	247.48	6.90	371.64	19.53	25.90	0.08	0.84	418.00	0.00	418.00	82.79	22.61	15.63	20.72	58.96	83.99	225.75	-192.25
Aug	101.98	215.22	6.00	323.20	19.53	25.90	0.08	0.87	369.59	0.00	369.59	72.00	19.66	15.63	20.72	56.02	87.40	215.42	-154.17
Sep	52.60	111.02	3.09	166.72	18.90	25.07	0.08	0.89	211.66	0.00	211.66	37.14	10.14	15.12	20.05	45.32	88.89	171.35	-40.31
Oct	5.56	11.73	0.33	17.62	19.53	25.90	0.08	1.48	64.61	0.00	64.61	3.92	1.07	15.63	20.72	37.42	147.54	188.89	124.28
Nov	3.86	8.14	0.23	12.23	18.90	25.07	0.08	2.10	58.37	0.00	58.37	2.74	0.74	15.12	20.05	35.92	209.50	248.16	189.79
Dec	20.69	43.67	1.22	65.59	19.53	25.90	0.08	2.00	113.10	0.00	113.10	14.63	3.99	15.63	20.72	40.34	199.57	254.54	141.44
Jan	52.10	109.96	3.06	165.12	19.53	25.90	0.08	0.29	210.93	0.00	210.93	36.71	10.05	15.63	20.72	46.40	28.89	111.99	-98.93
Feb	77.37	163.30	4.55	245.22	17.64	23.40	0.08	0.15	286.50	0.00	286.50	54.63	14.92	14.12	18.72	47.75	15.47	117.85	-168.65
Mar	88.94	187.70	5.23	281.87	19.53	25.90	0.08	0.04	327.43	0.00	327.43	62.79	17.15	15.63	20.72	53.50	3.85	120.15	-207.29
Apr	32.44	68.47	1.91	102.83	18.90	25.07	0.08	0.05	146.93	0.00	146.93	22.86	6.26	15.12	20.05	41.43	4.79	69.08	-77.85
May	32.11	67.78	1.89	101.78	19.53	25.90	0.08	0.24	147.54	0.00	147.54	22.45	6.19	15.63	20.72	42.54	24.25	89.24	-58.30
Total	672.91	1420.2	39.58	2132.6	230.0	305.0	1.00	8.98	2677.6	0.00	2677.6	475.0	129.8	184.0	244.0	557.8	898.0	1931	-746.87

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.11(b): Amaravathi Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements												Regeneration from uses							
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Import	Irriga-tion	Dome-stic	Indus-trial	Total	Surface water yields	Ground water yields	Gross water available	
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	87.98	185.68	5.17	278.84	25.07	25.07	0.08	0.03	329.09	0.00	329.09	62.33	12.98	20.05	20.05	53.09	3.46	40.27	159.15	-169.94
Jul	117.26	247.48	6.90	371.64	25.90	25.90	0.08	0.84	424.37	0.00	424.37	82.79	17.24	20.72	20.72	58.69	83.99	53.67	279.14	-145.23
Aug	101.98	215.22	6.00	323.20	25.90	25.90	0.08	0.87	375.96	0.00	375.96	72.00	14.99	20.72	20.72	56.44	87.40	46.68	262.52	-113.44
Sep	52.60	111.02	3.09	166.72	25.07	25.07	0.08	0.89	217.82	0.00	217.82	37.14	7.73	20.05	20.05	47.84	88.89	24.08	197.95	-19.87
Oct	5.56	11.73	0.33	17.62	25.90	25.90	0.08	1.48	70.98	0.00	70.98	3.92	0.82	20.72	20.72	42.26	147.54	2.54	196.27	125.29
Nov	3.86	8.14	0.23	12.23	25.07	25.07	0.08	2.10	64.54	0.00	64.54	2.74	0.57	20.05	20.05	40.68	209.50	1.77	254.69	190.15
Dec	20.69	43.67	1.22	65.59	25.90	25.90	0.08	2.00	119.47	0.00	119.47	14.63	3.05	20.72	20.72	44.49	199.57	9.47	268.17	148.70
Jan	52.10	109.96	3.06	165.12	25.90	25.90	0.08	0.29	217.30	0.00	217.30	36.71	7.64	20.72	20.72	49.09	28.89	23.85	138.53	-78.76
Feb	77.37	163.30	4.55	245.22	23.40	23.40	0.08	0.15	292.25	0.00	292.25	54.63	11.37	18.72	18.72	48.81	15.47	35.42	154.32	-137.93
Mar	88.94	187.70	5.23	281.87	25.90	25.90	0.08	0.04	333.80	0.00	333.80	62.79	13.08	20.72	20.72	54.52	3.85	40.71	161.88	-171.93
Apr	32.44	68.47	1.91	102.83	25.07	25.07	0.08	0.05	153.09	0.00	153.09	22.86	4.76	20.05	20.05	44.87	4.79	14.85	87.36	-65.73
May	32.11	67.78	1.89	101.78	25.90	25.90	0.08	0.24	153.91	0.00	153.91	22.45	4.67	20.72	20.72	46.12	24.25	14.70	107.52	-46.39
Total	672.91	1420.2	39.58	2132.6	305.0	305.0	1.00	8.98	2752.6	0.00	2752.6	475.0	130.0	244.0	244.0	618.0	898.0	308.0	2299.0	-453.63

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.11(c): Amaravathi Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	87.98	185.68	5.17	278.84	18.90	25.07	0.1	0.03	322.93	0.00	322.93	62.33	16.97	15.12	20.05	52.14	34.40	148.88	-174.05
Jul	117.26	247.48	6.90	371.64	19.53	25.90	0.1	0.84	418.00	0.00	418.00	82.79	22.61	15.63	20.72	58.96	26.60	168.36	-249.64
Aug	101.98	215.22	6.00	323.20	19.53	25.90	0.1	0.87	369.59	0.00	369.59	72.00	19.66	15.63	20.72	56.02	56.30	184.32	-185.27
Sep	52.60	111.02	3.09	166.72	18.90	25.07	0.1	0.89	211.66	0.00	211.66	37.14	10.14	15.12	20.05	45.32	261.50	343.96	132.30
Oct	5.56	11.73	0.33	17.62	19.53	25.90	0.1	1.48	64.61	0.00	64.61	3.92	1.07	15.63	20.72	37.42	164.00	205.35	140.74
Nov	3.86	8.14	0.23	12.23	18.90	25.07	0.1	2.10	58.37	0.00	58.37	2.74	0.74	15.12	20.05	35.92	219.60	258.26	199.89
Dec	20.69	43.67	1.22	65.59	19.53	25.90	0.1	2.00	113.10	0.00	113.10	14.63	3.99	15.63	20.72	40.34	48.70	103.67	-9.43
Jan	52.10	109.96	3.06	165.12	19.53	25.90	0.1	0.29	210.93	0.00	210.93	36.71	10.05	15.63	20.72	46.40	100.90	184.00	-26.92
Feb	77.37	163.30	4.55	245.22	17.64	23.40	0.1	0.15	286.50	0.00	286.50	54.63	14.92	14.12	18.72	47.75	4.80	107.18	-179.32
Mar	88.94	187.70	5.23	281.87	19.53	25.90	0.1	0.04	327.43	0.00	327.43	62.79	17.15	15.63	20.72	53.50	42.60	158.90	-168.54
Apr	32.44	68.47	1.91	102.83	18.90	25.07	0.1	0.05	146.93	0.00	146.93	22.86	6.26	15.12	20.05	41.43	49.10	113.39	-33.54
May	32.11	67.78	1.89	101.78	19.53	25.90	0.1	0.24	147.54	0.00	147.54	22.45	6.19	15.63	20.72	42.54	99.50	164.49	16.95
Total	672.91	1420.2	39.58	2132.6	230.0	305.0	1.00	8.98	2677.60	0.00	2677.6	475.0	129.8	184.0	244.0	557.8	1108.0	2141	-536.87

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.11(d): Amaravathi Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	87.98	185.68	5.17	278.84	25.07	25.07	0.1	0.03	329.09	0.00	329.09	62.33	12.98	15.12	20.05	48.16	34.40	40.27	185.16	-143.93
Jul	117.26	247.48	6.90	371.64	25.90	25.90	0.1	0.84	424.37	0.00	424.37	82.79	17.24	15.63	20.72	53.59	26.60	53.67	216.66	-207.71
Aug	101.98	215.22	6.00	323.20	25.90	25.90	0.1	0.87	375.96	0.00	375.96	72.00	14.99	15.63	20.72	51.34	56.30	46.68	226.32	-149.64
Sep	52.60	111.02	3.09	166.72	25.07	25.07	0.1	0.89	217.82	0.00	217.82	37.14	7.73	15.12	20.05	42.91	261.50	24.08	365.63	147.81
Oct	5.56	11.73	0.33	17.62	25.90	25.90	0.1	1.48	70.98	0.00	70.98	3.92	0.82	15.63	20.72	37.17	164.00	2.54	207.64	136.66
Nov	3.86	8.14	0.23	12.23	25.07	25.07	0.1	2.10	64.54	0.00	64.54	2.74	0.57	15.12	20.05	35.75	219.60	1.77	259.86	195.32
Dec	20.69	43.67	1.22	65.59	25.90	25.90	0.1	2.00	119.47	0.00	119.47	14.63	3.05	15.63	20.72	39.40	48.70	9.47	112.20	-7.27
Jan	52.10	109.96	3.06	165.12	25.90	25.90	0.1	0.29	217.30	0.00	217.30	36.71	7.64	15.63	20.72	43.99	100.90	23.85	205.45	-11.85
Feb	77.37	163.30	4.55	245.22	23.40	23.40	0.1	0.15	292.25	0.00	292.25	54.63	11.37	14.12	18.72	44.21	4.80	35.42	139.05	-153.20
Mar	88.94	187.70	5.23	281.87	25.90	25.90	0.1	0.04	333.80	0.00	333.80	62.79	13.08	15.63	20.72	49.43	42.60	40.71	195.53	-138.27
Apr	32.44	68.47	1.91	102.83	25.07	25.07	0.1	0.05	153.09	0.00	153.09	22.86	4.76	15.12	20.05	39.94	49.10	14.85	126.74	-26.35
May	32.11	67.78	1.89	101.78	25.90	25.90	0.1	0.24	153.91	0.00	153.91	22.45	4.67	15.63	20.72	41.03	99.50	14.70	177.68	23.77
Total	672.91	1420.2	39.6	2132.6	305.0	305.0	1.0	9.0	2752.6	0.00	2752.6	475.0	130.0	184.0	244.0	558.0	1108.0	308.0	2449.0	-303.63

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.11(e): Amaravathi Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	87.98	185.68	5.17	278.84	18.90	25.07	0.1	0.03	322.93	0.00	322.93	62.33	16.97	15.12	20.05	52.14	50.99	165.47	-157.46
Jul	117.26	247.48	6.90	371.64	19.53	25.90	0.1	0.84	418.00	0.00	418.00	82.79	22.61	15.63	20.72	58.96	67.91	209.67	-208.33
Aug	101.98	215.22	6.00	323.20	19.53	25.90	0.1	0.87	369.59	0.00	359.59	72.00	19.66	15.63	20.72	56.02	92.63	220.65	-148.94
Sep	52.60	111.02	3.09	166.72	18.90	25.07	0.1	0.89	211.66	0.00	211.66	37.14	10.14	15.12	20.05	45.32	94.22	176.68	-34.98
Oct	5.56	11.73	0.33	17.62	19.53	25.90	0.1	1.48	64.61	0.00	64.61	3.92	1.07	15.63	20.72	37.42	64.26	105.61	41.00
Nov	3.86	8.14	0.23	12.23	18.90	25.07	0.1	2.10	58.37	0.00	58.37	2.74	0.74	15.12	20.05	35.92	167.00	205.66	147.29
Dec	20.69	43.67	1.22	65.59	19.53	25.90	0.1	2.00	113.10	0.00	113.10	14.63	3.99	15.63	20.72	40.34	69.60	124.57	11.47
Jan	52.10	109.96	3.06	165.12	19.53	25.90	0.1	0.29	210.93	0.00	210.93	36.71	10.05	15.63	20.72	46.40	48.25	131.35	-79.57
Feb	77.37	163.30	4.55	245.22	17.64	23.40	0.1	0.15	286.50	0.00	286.50	54.63	14.92	14.12	18.72	47.75	5.24	107.62	-178.88
Mar	88.94	187.70	5.23	281.87	19.53	25.90	0.1	0.04	327.43	0.00	327.43	62.79	17.15	15.63	20.72	53.50	6.08	122.38	-205.06
Apr	32.44	68.47	1.91	102.83	18.90	25.07	0.1	0.05	146.93	0.00	146.93	22.86	6.26	15.12	20.05	41.43	33.61	97.90	-49.03
May	32.11	67.78	1.89	101.78	19.53	25.90	0.1	0.24	147.54	0.06	147.54	22.45	6.19	15.63	20.72	42.54	105.23	170.22	22.68
Total	672.91	1420.2	39.58	2132.6	230.0	305.0	1.00	8.98	2677.60	0.00	2677.6	475.0	129.8	184.0	244.0	557.8	805.0	1838	-839.87

Note : Column no. 10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.11(f): Amaravathi Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	87.98	185.68	5.17	278.84	25.07	25.07	0.1	0.03	329.09	0.00	329.09	62.33	12.98	20.05	20.05	53.09	50.99	40.27	206.68	-122.41
Jul	117.26	247.48	6.90	371.64	25.90	25.90	0.1	0.84	424.37	0.00	424.37	82.79	17.24	20.72	20.72	58.69	67.91	53.67	263.06	-161.31
Aug	101.98	215.22	6.00	323.20	25.90	25.90	0.1	0.87	375.96	0.00	375.96	72.00	14.99	20.72	20.72	56.44	92.63	46.68	267.75	-108.21
Sep	52.60	111.02	3.09	166.72	25.07	25.07	0.1	0.89	217.82	0.00	217.82	37.14	7.73	20.05	20.05	47.84	94.22	24.08	203.28	-14.54
Oct	5.56	11.73	0.33	17.62	25.90	25.90	0.1	1.48	70.98	0.00	70.98	3.92	0.82	20.72	20.72	42.26	64.26	2.54	112.99	42.01
Nov	3.86	8.14	0.23	12.23	25.07	25.07	0.1	2.10	64.54	0.00	64.54	2.74	0.57	20.05	20.05	40.68	167.00	1.77	212.19	147.65
Dec	20.69	43.67	1.22	65.59	25.90	25.90	0.1	2.00	119.47	0.00	119.47	14.63	3.05	20.72	20.72	44.49	69.60	9.47	138.20	18.73
Jan	52.10	109.96	3.06	165.12	25.90	25.90	0.1	0.29	217.30	0.00	217.30	36.71	7.64	20.72	20.72	49.09	48.25	23.85	157.89	-59.40
Feb	77.37	163.30	4.55	245.22	23.40	23.40	0.1	0.15	292.25	0.00	292.25	54.63	11.37	18.72	18.72	48.81	5.24	35.42	144.09	-148.16
Mar	88.94	187.70	5.23	281.87	25.90	25.90	0.1	0.04	333.80	0.00	333.80	62.79	13.08	20.72	20.72	54.52	6.08	40.71	164.11	-169.70
Apr	32.44	68.47	1.91	102.83	25.07	25.07	0.1	0.05	153.09	0.00	153.09	22.86	4.76	20.05	20.05	44.87	33.61	14.85	116.18	-36.91
May	32.11	67.78	1.89	101.78	25.90	25.90	0.1	0.24	153.91	0.00	153.91	22.45	4.67	20.72	20.72	46.12	105.23	14.70	188.50	34.59
Total	672.91	1420.2	39.58	2132.6	305.0	305.0	1.0	9.0	2752.6	0.00	2752.6	475.0	130.0	244	244.0	618.0	805.0	308.0	2206.0	-546.63

Note : Column no. 10 = Column no (5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19) Column no. 21 = Column no.(20-12).

Table 4.10.11(g): Amaravathi Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	87.98	185.68	5.17	278.84	18.90	25.07	0.1	0.03	322.93	0.00	322.93	62.33	16.97	15.12	20.05	52.14	42.09	156.57	-166.36
Jul	117.26	247.48	6.90	371.64	19.53	25.90	0.1	0.84	418.00	0.00	418.00	82.79	22.61	15.63	20.72	58.96	91.85	233.61	-184.39
Aug	101.98	215.22	6.00	323.20	19.53	25.90	0.1	0.87	369.59	0.00	369.59	72.00	19.66	15.63	20.72	56.02	97.27	225.29	-144.30
Sep	52.60	111.02	3.09	166.72	18.90	25.07	0.1	0.89	211.66	0.00	211.66	37.14	10.14	15.12	20.05	45.32	69.71	152.17	-59.49
Oct	5.56	11.73	0.33	17.62	19.53	25.90	0.1	1.48	64.61	0.00	64.61	3.92	1.07	15.63	20.72	37.42	56.41	97.76	33.15
Nov	3.86	8.14	0.23	12.23	18.90	25.07	0.1	2.10	58.37	0.00	58.37	2.74	0.74	15.12	20.05	35.92	32.44	71.10	12.73
Dec	20.69	43.67	1.22	65.59	19.53	25.90	0.1	2.00	113.10	0.00	113.10	14.63	3.99	15.63	20.72	40.34	50.18	105.15	-7.95
Jan	52.10	109.96	3.06	165.12	19.53	25.90	0.1	0.29	210.93	0.00	210.93	36.71	10.05	15.63	20.72	46.40	34.43	117.53	-93.39
Feb	77.37	163.30	4.55	245.22	17.64	23.40	0.1	0.15	286.50	0.00	286.50	54.63	14.92	14.12	18.72	47.75	7.96	110.34	-176.16
Mar	88.94	187.70	5.23	281.87	19.53	25.90	0.1	0.04	327.43	0.00	327.43	62.79	17.15	15.63	20.72	53.50	32.48	148.78	-178.66
Apr	32.44	68.47	1.91	102.83	18.90	25.07	0.1	0.05	146.93	0.00	146.93	22.86	6.26	15.12	20.05	41.43	81.01	145.30	-1.63
May	32.11	67.78	1.89	101.78	19.53	25.90	0.1	0.24	147.54	0.00	147.54	22.45	6.19	15.63	20.72	42.54	45.65	110.64	-36.90
Total	672.91	1420.2	39.58	2132.6	230.0	305.0	1.00	8.98	2677.60	0.00	2677.6	475.0	129.8	184.0	244.0	557.8	641.0	1674	-1003.9

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.11(h): Amaravathi Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	87.98	185.68	5.17	278.84	25.07	25.07	0.1	0.03	329.09	0.00	329.09	62.33	12.98	20.05	20.05	53.09	42.09	40.27	137.69	-191.40
Jul	117.26	247.48	6.90	371.64	25.90	25.90	0.1	0.84	424.37	0.00	424.37	82.79	17.24	20.72	20.72	58.69	91.85	53.67	237.24	-187.13
Aug	101.98	215.22	6.00	323.20	25.90	25.90	0.1	0.87	375.96	0.00	375.96	72.00	14.99	20.72	20.72	56.44	97.27	46.68	266.97	-108.99
Sep	52.60	111.02	3.09	166.72	25.07	25.07	0.1	0.89	217.82	0.00	217.82	37.14	7.73	20.05	20.05	47.84	69.71	24.08	206.33	-11.49
Oct	5.56	11.73	0.33	17.62	25.90	25.90	0.1	1.48	70.98	0.00	70.98	3.92	0.82	20.72	20.72	42.26	56.41	2.54	118.44	47.46
Nov	3.86	8.14	0.23	12.23	25.07	25.07	0.1	2.10	64.54	0.00	64.54	2.74	0.57	20.05	20.05	40.68	32.44	1.77	101.60	37.06
Dec	20.69	43.67	1.22	65.59	25.90	25.90	0.1	2.00	119.47	0.00	119.47	14.63	3.05	20.72	20.72	44.49	50.18	9.47	101.04	-18.43
Jan	52.10	109.96	3.06	165.12	25.90	25.90	0.1	0.29	217.30	0.00	217.30	36.71	7.64	20.72	20.72	49.09	34.43	23.85	159.82	-57.47
Feb	77.37	163.30	4.55	245.22	23.40	23.40	0.1	0.15	292.25	0.00	292.25	54.63	11.37	18.72	18.72	48.81	7.96	35.42	173.28	-118.97
Mar	88.94	187.70	5.23	281.87	25.90	25.90	0.1	0.04	333.80	0.00	333.80	62.79	13.08	20.72	20.72	54.52	32.48	40.71	165.99	-167.82
Apr	32.44	68.47	1.91	102.83	25.07	25.07	0.1	0.05	153.09	0.00	153.09	22.86	4.76	20.05	20.05	44.87	81.01	14.85	115.05	-38.04
May	32.11	67.78	1.89	101.78	25.90	25.90	0.1	0.24	153.91	0.00	153.91	22.45	4.67	20.72	20.72	46.12	45.65	14.70	164.28	10.37
Total	672.91	1420.2	39.6	2132.6	305.0	305.0	1.0	9.0	2752.6	0.00	2752.6	475.0	130.0	244.0	244.0	618.0	641.0	308.0	2042.0	-710.63

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.12(a): Tirumanimuttar Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	23.10	126.36	0.00	149.46	33.86	43.56	0.00	0.01	226.90	0.00	226.71	96.90	15.14	27.09	34.85	77.08	1.10	175.08	-51.62
Jul	17.45	95.46	0.00	112.91	34.99	45.01	0.00	0.03	192.95	0.00	192.81	73.21	11.44	27.99	36.01	75.44	3.30	151.95	-40.86
Aug	30.50	166.85	0.00	197.35	34.99	45.01	0.00	0.00	277.36	0.00	277.11	127.96	19.99	27.99	36.01	83.99	0.00	211.95	-65.16
Sep	38.59	211.05	0.00	249.64	33.86	43.56	0.00	0.17	327.23	0.00	326.91	161.85	25.28	27.09	34.85	87.22	17.00	266.08	-60.84
Oct	30.86	168.79	0.00	199.64	34.99	45.01	0.00	3.37	283.02	0.00	282.76	129.41	20.22	27.99	36.01	84.23	336.57	550.23	267.48
Nov	35.55	194.47	0.00	230.03	33.86	43.56	0.00	1.82	309.27	0.00	308.98	149.14	23.30	27.09	34.85	85.24	182.30	416.67	107.70
Dec	25.52	139.59	0.00	165.11	34.99	45.01	0.00	1.09	246.20	0.00	245.99	107.05	16.72	27.99	36.01	80.73	108.70	296.47	50.49
Jan	13.14	71.85	0.00	84.98	34.99	45.01	0.00	0.00	164.99	0.00	164.88	55.10	8.61	27.99	36.01	72.61	0.00	127.71	-37.17
Feb	54.94	300.52	0.00	355.47	31.61	40.66	0.00	0.00	427.73	0.00	427.27	230.47	36.00	25.28	32.53	93.81	0.00	324.28	-102.99
Mar	81.48	445.64	0.00	527.11	34.99	45.01	0.00	0.00	607.12	0.00	606.44	341.75	53.39	27.99	36.01	117.4	0.00	459.14	-147.29
Apr	41.73	228.26	0.00	270.00	33.86	43.56	0.00	0.00	347.42	0.00	347.08	175.06	27.35	27.09	34.85	89.29	0.00	264.34	-82.74
May	28.87	157.89	0.00	186.76	34.99	45.01	0.00	0.00	266.77	0.00	266.53	121.09	18.92	27.99	36.01	82.92	0.00	204.01	-62.52
Total	421.74	2306.7	0.00	2728.47	412.0	530.00	0.00	6.49	3676.96	0.00	3673.5	1769.0	276.4	329.6	424.00	1030	649.00	3447.92	-225.54

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.12(b): Tirumanimuttar Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	23.10	126.21	0.00	149.27	43.56	43.56	0.00	0.01	226.71	0.00	226.71	96.90	15.12	34.85	34.85	84.82	1.10	19.18	202.00	-24.71
Jul	17.45	95.35	0.00	112.77	45.01	45.01	0.00	0.03	192.81	0.00	192.81	73.21	11.42	36.01	36.01	83.44	3.30	14.49	174.44	-18.37
Aug	30.50	166.65	0.00	197.10	45.01	45.01	0.00	0.00	277.11	0.00	277.11	127.96	19.96	36.01	36.01	91.99	0.00	25.32	245.26	-31.84
Sep	38.59	210.80	0.00	249.32	43.56	43.56	0.00	0.17	326.91	0.00	326.91	161.85	25.25	34.85	34.85	94.95	17.00	32.03	305.84	-21.08
Oct	30.86	168.58	0.00	199.39	45.01	45.01	0.00	3.37	282.76	0.00	282.76	129.44	20.20	36.01	36.01	92.22	336.57	25.62	583.84	301.08
Nov	35.55	194.24	0.00	229.73	43.56	43.56	0.00	1.82	308.98	0.00	308.98	149.14	23.27	34.85	34.85	92.97	182.30	29.52	453.92	144.94
Dec	25.52	139.42	0.00	164.89	45.01	45.01	0.00	1.09	245.99	0.00	245.99	107.05	16.70	36.01	36.01	88.72	108.70	21.19	325.66	79.67
Jan	13.14	71.76	0.00	84.87	45.01	45.01	0.00	0.00	164.88	0.00	164.88	55.10	8.60	36.01	36.01	80.62	0.00	10.90	146.62	-18.26
Feb	54.94	300.16	0.00	355.01	40.66	40.66	0.00	0.00	427.27	0.00	427.27	230.47	35.96	32.53	32.53	101.0	0.00	45.61	377.09	-50.19
Mar	81.48	445.10	0.00	526.43	45.01	45.01	0.00	0.00	606.44	0.00	606.44	341.75	53.32	36.01	36.01	125.3	0.00	67.64	534.73	-71.71
Apr	41.73	228.00	0.00	269.66	43.56	43.56	0.00	0.00	347.08	0.00	347.08	175.06	27.31	34.85	34.85	97.01	0.00	34.64	306.71	-40.37
May	28.87	157.71	0.00	186.53	45.01	45.01	0.00	0.00	266.53	0.00	266.53	121.09	18.89	36.01	36.01	90.91	0.00	23.96	235.97	-30.56
Total	421.74	2304.0	0.00	2724.97	530.0	530.0	0.00	6.49	3791.46	0.00	3791.5	1769.0	276.0	424	424.0	1124	649.0	350.1	3892.1	100.64

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.12(c): Tirumanimuttar Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability								
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	Monthly water balance
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	23.10	126.36	0.00	149.46	33.86	43.56	0.00	0.01	226.90	0.00	226.71	96.90	15.14	27.09	34.85	77.08	1.88	175.86	-50.85
Jul	17.45	95.46	0.00	112.91	34.99	45.01	0.00	0.03	192.95	0.00	192.81	73.21	11.44	27.99	36.01	75.44	5.63	154.28	-38.52
Aug	30.50	166.85	0.00	197.35	34.99	45.01	0.00	0.00	277.36	0.00	277.11	127.96	19.99	27.99	36.01	83.99	0.00	211.95	-65.16
Sep	38.59	211.05	0.00	249.64	33.86	43.56	0.00	0.17	327.23	0.00	326.91	161.85	25.28	27.09	34.85	87.22	29.02	278.10	-48.81
Oct	30.86	168.79	0.00	199.64	34.99	45.01	0.00	3.37	283.02	0.00	282.76	129.44	20.22	27.99	36.01	84.23	574.61	788.27	505.51
Nov	35.55	194.47	0.00	230.03	33.86	43.56	0.00	1.82	309.27	0.00	308.98	149.14	23.30	27.09	34.85	85.24	311.23	545.60	236.63
Dec	25.52	139.59	0.00	165.11	34.99	45.01	0.00	1.09	246.20	0.00	245.99	107.05	16.72	27.99	36.01	80.73	185.58	373.35	127.36
Jan	13.14	71.85	0.00	84.98	34.99	45.01	0.00	0.00	164.99	0.00	164.88	55.10	8.61	27.99	36.01	72.61	0.00	127.71	-37.17
Feb	54.94	300.52	0.00	355.47	31.61	40.66	0.00	0.00	427.73	0.00	427.27	230.47	36.00	25.28	32.53	93.81	0.00	324.28	-102.99
Mar	81.48	445.64	0.00	527.11	34.99	45.01	0.00	0.00	607.12	0.00	606.44	341.75	53.39	27.99	36.01	117.39	0.00	459.14	-147.29
Apr	41.73	228.26	0.00	270.00	33.86	43.56	0.00	0.00	347.42	0.00	347.08	175.06	27.35	27.09	34.85	89.29	0.00	264.34	-82.74
May	28.87	157.89	0.00	186.76	34.99	45.01	0.00	0.00	266.77	0.00	266.53	121.09	18.92	27.99	36.01	82.92	0.00	204.01	-62.52
Total	421.74	2306.7	0.00	2728.5	412.0	530.0	0.00	6.49	3676.96	0.00	3673.5	1769.0	276.4	329.6	424.0	1030.0	1108.0	3906.90	233.44

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.12(d): Tirumanimuttar Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability									
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	Monthly water balance
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	23.10	126.21	0.00	149.27	43.56	43.56	0.00	0.01	226.71	0.00	226.71	96.90	15.12	27.09	34.85	77.06	1.88	19.18	195.02	-31.69
Jul	17.45	95.35	0.00	112.77	45.01	45.01	0.00	0.03	192.81	0.00	192.81	73.21	11.42	27.99	36.01	75.43	5.63	14.49	168.75	-24.05
Aug	30.50	166.65	0.00	197.10	45.01	45.01	0.00	0.00	277.11	0.00	277.11	127.96	19.96	27.99	36.01	83.97	0.00	25.32	237.25	-39.86
Sep	38.59	210.80	0.00	249.32	43.56	43.56	0.00	0.17	326.91	0.00	326.91	161.85	25.25	27.09	34.85	87.19	29.02	32.03	310.10	-16.81
Oct	30.86	168.58	0.00	199.39	45.01	45.01	0.00	3.37	282.76	0.00	282.76	129.44	20.20	27.99	36.01	84.20	574.61	25.62	813.86	531.10
Nov	35.55	194.24	0.00	229.73	43.56	43.56	0.00	1.82	308.98	0.00	308.98	149.14	23.27	27.09	34.85	85.21	311.23	29.52	575.09	266.11
Dec	25.52	139.42	0.00	164.89	45.01	45.01	0.00	1.09	245.99	0.00	245.99	107.05	16.70	27.99	36.01	80.71	185.58	21.19	394.51	148.53
Jan	13.14	71.76	0.00	84.87	45.01	45.01	0.00	0.00	164.88	0.00	164.88	55.10	8.60	27.99	36.01	72.60	0.00	10.90	138.60	-26.28
Feb	54.94	300.16	0.00	355.01	40.66	40.66	0.00	0.00	427.27	0.00	427.27	230.47	35.96	25.28	32.53	93.77	0.00	45.61	369.84	-57.43
Mar	81.48	445.10	0.00	526.43	45.01	45.01	0.00	0.00	606.44	0.00	606.44	341.75	53.32	27.99	36.01	117.32	0.00	67.64	526.71	-79.73
Apr	41.73	228.00	0.00	269.66	43.56	43.56	0.00	0.00	347.08	0.00	347.08	175.06	27.31	27.09	34.85	89.25	0.00	34.64	298.95	-48.13
May	28.87	157.71	0.00	186.53	45.01	45.01	0.00	0.00	266.53	0.00	266.53	121.09	18.89	27.99	36.01	82.90	0.00	23.96	227.95	-38.58
Total	421.74	2304.0	0.0	2725.0	530.0	530.0	0.00	6.49	3791.46	0.00	3791.5	1769.0	276.0	329.6	424.0	1029.6	1108.0	350.10	4256.70	465.24

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.12(e): Tirumanimuttar Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	23.10	126.36	0.00	149.46	33.86	43.56	0.00	0.01	226.90	0.00	226.71	96.90	15.14	27.09	34.85	77.08	1.06	175.04	-51.66
Jul	17.45	95.46	0.00	112.91	34.99	45.01	0.00	0.03	192.95	0.00	192.81	73.21	11.44	27.99	36.01	75.44	3.17	151.82	-40.99
Aug	30.50	166.85	0.00	197.35	34.99	45.01	0.00	0.00	277.36	0.00	277.11	127.96	19.99	27.99	36.01	83.99	0.00	211.95	-65.16
Sep	38.59	211.05	0.00	249.64	33.86	43.56	0.00	0.17	327.23	0.00	326.91	161.85	25.28	27.09	34.85	87.22	16.35	265.43	-61.49
Oct	30.86	168.79	0.00	199.64	34.99	45.01	0.00	3.37	283.02	0.00	282.76	129.44	20.22	27.99	36.01	84.23	323.62	537.28	254.53
Nov	35.55	194.47	0.00	230.03	33.86	43.56	0.00	1.82	309.27	0.00	308.98	149.14	23.30	27.09	34.85	85.24	175.29	409.66	100.69
Dec	25.52	139.59	0.00	165.11	34.99	45.01	0.00	1.09	246.20	0.00	245.99	107.05	16.72	27.99	36.01	80.73	104.52	292.29	46.31
Jan	13.14	71.85	0.00	84.98	34.99	45.01	0.00	0.00	164.99	0.00	164.88	55.10	8.61	27.99	36.01	72.61	0.00	127.71	-37.17
Feb	54.94	300.52	0.00	355.47	31.61	40.66	0.00	0.00	427.73	0.00	427.27	230.47	36.00	25.28	32.53	93.81	0.00	324.28	-102.99
Mar	81.48	445.64	0.00	527.11	34.99	45.01	0.00	0.00	607.12	0.00	606.44	341.75	53.39	27.99	36.01	117.4	0.00	459.14	-147.29
Apr	41.73	228.26	0.00	270.00	33.86	43.56	0.00	0.00	347.42	0.00	347.08	175.06	27.35	27.09	34.85	89.29	0.00	264.34	-82.74
May	28.87	157.89	0.00	186.76	34.99	45.01	0.00	0.00	266.77	0.00	266.53	121.09	18.92	27.99	36.01	82.92	0.00	204.01	-62.52
Total	421.74	2306.7	0.0	2728.5	412.0	530.0	0.00	6.49	3676.96	0.00	3673.5	1769.0	276.4	329.6	424.0	1030	624.00	3423.0	-250.50

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no (13+17+18). Column no.20 = Column no.(19-12)

Table 4.10.12(f): Tirumanimuttar Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	23.10	126.21	0.00	149.27	43.56	43.56	0.00	0.01	236.40	0.00	236.40	96.90	15.12	34.85	34.85	84.82	1.06	19.18	201.96	-34.45
Jul	17.45	95.35	0.00	112.77	45.01	45.01	0.00	0.03	202.83	0.00	202.83	73.21	11.42	36.01	36.01	83.44	3.17	14.49	174.31	-28.52
Aug	30.50	166.65	0.00	197.10	45.01	45.01	0.00	0.00	287.13	0.00	287.13	127.96	19.96	36.01	36.01	91.99	0.00	25.32	245.26	-41.87
Sep	38.59	210.80	0.00	249.32	43.56	43.56	0.00	0.17	336.61	0.00	336.61	161.85	25.25	34.85	34.85	94.95	16.35	32.03	305.19	-31.43
Oct	30.86	168.58	0.00	199.39	45.01	45.01	0.00	3.37	292.78	0.00	292.78	129.44	20.20	36.01	36.01	92.22	323.62	25.62	570.89	278.11
Nov	35.55	194.24	0.00	229.73	43.56	43.56	0.00	1.82	318.67	0.00	318.67	149.14	23.27	34.85	34.85	92.97	175.29	29.52	446.91	128.23
Dec	25.52	139.42	0.00	164.89	45.01	45.01	0.00	1.09	256.01	0.00	256.01	107.05	16.70	36.01	36.01	88.72	104.52	21.19	321.48	65.47
Jan	13.14	71.76	0.00	84.87	45.01	45.01	0.00	0.00	174.90	0.00	174.90	55.10	8.60	36.01	36.01	80.62	0.00	10.90	146.62	-28.28
Feb	54.94	300.16	0.00	355.01	40.66	40.66	0.00	0.00	436.32	0.00	436.32	230.47	35.96	32.53	32.53	101.0	0.00	45.61	377.09	-59.24
Mar	81.48	445.10	0.00	526.43	45.01	45.01	0.00	0.00	616.46	0.00	616.46	341.75	53.32	36.01	36.01	125.3	0.00	67.64	534.73	-81.73
Apr	41.73	228.00	0.00	269.66	43.56	43.56	0.00	0.00	356.78	0.00	356.78	175.06	27.31	34.85	34.85	97.01	0.00	34.64	306.71	-50.07
May	28.87	157.71	0.00	186.53	45.01	45.01	0.00	0.00	276.56	0.00	276.56	121.09	18.89	36.01	36.01	90.91	0.00	23.96	235.97	-40.59
Total	421.74	2304.0	0.00	2725.0	530.0	530.0	0.00	6.49	3791.46	0.00	3791.5	1769.0	276.0	424.0	424.0	1124	624.00	350.10	3867.1	75.64

Note . Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no (13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.12(g): Tirumanimuttar Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	23.10	126.36	0.00	149.46	33.86	43.56	0.00	0.01	226.90	0.00	226.71	96.90	15.14	27.09	34.85	77.08	0.96	174.94	-51.76
Jul	17.45	95.46	0.00	112.91	34.99	45.01	0.00	0.03	192.95	0.00	192.81	73.21	11.44	27.99	36.01	75.44	2.87	151.52	-41.29
Aug	30.50	166.85	0.00	197.35	34.99	45.01	0.00	0.00	277.36	0.00	277.11	127.96	19.99	27.99	36.01	83.99	0.00	211.95	-65.16
Sep	38.59	211.05	0.00	249.64	33.86	43.56	0.00	0.17	327.23	0.00	326.91	161.85	25.28	27.09	34.85	87.22	14.80	263.88	-63.04
Oct	30.86	168.79	0.00	199.64	34.99	45.01	0.00	3.37	283.02	0.00	282.76	129.44	20.22	27.99	36.01	84.23	293.02	506.68	223.93
Nov	35.55	194.47	0.00	230.03	33.86	43.56	0.00	1.82	309.27	0.00	308.98	149.14	23.30	27.09	34.85	85.24	158.71	393.08	84.11
Dec	25.52	139.59	0.00	165.11	34.99	45.01	0.00	1.09	246.20	0.00	245.99	107.05	16.72	27.99	36.01	80.73	94.64	282.41	36.43
Jan	13.14	71.85	0.00	84.98	34.99	45.01	0.00	0.00	164.99	0.00	164.88	55.10	8.61	27.99	36.01	72.61	0.00	127.71	-37.17
Feb	54.94	300.52	0.00	355.47	31.61	40.66	0.00	0.00	427.73	0.00	427.27	230.47	36.00	25.28	32.53	93.81	0.00	324.28	-103.0
Mar	81.48	445.64	0.00	527.11	34.99	45.01	0.00	0.00	607.12	0.00	606.44	341.75	53.39	27.99	36.01	117.4	0.00	459.14	-147.3
Apr	41.73	228.26	0.00	270.00	33.86	43.56	0.00	0.00	347.42	0.00	347.08	175.06	27.35	27.09	34.85	89.29	0.00	264.34	-82.74
May	28.87	157.89	0.00	186.76	34.99	45.01	0.00	0.00	266.77	0.00	266.53	121.09	18.92	27.99	36.01	82.92	0.00	204.01	-62.52
Total	421.74	2306.7	0.0	2728.5	412.0	530.0	0.00	6.49	3676.96	0.00	3673.5	1769.0	276.4	329.6	424.0	1030	565.0	3364.0	-309.5

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.12(h): Tirumanimuttar Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	23.10	126.21	0.00	149.27	43.56	43.56	0.00	0.01	236.40	0.00	236.40	96.90	15.12	34.85	34.85	84.82	0.96	19.18	201.86	-34.55
Jul	17.45	95.35	0.00	112.77	45.01	45.01	0.00	0.03	202.83	0.00	202.83	73.21	11.42	36.01	36.01	83.44	2.87	14.49	174.01	-28.82
Aug	30.50	166.65	0.00	197.10	45.01	45.01	0.00	0.00	287.13	0.00	287.13	127.96	19.96	36.01	36.01	91.99	0.00	25.32	245.26	-41.87
Sep	38.59	210.80	0.00	249.32	43.56	43.56	0.00	0.17	336.61	0.00	336.61	161.85	25.25	34.85	34.85	94.95	14.80	32.03	303.64	-32.98
Oct	30.86	168.58	0.00	199.39	45.01	45.01	0.00	3.37	292.78	0.00	292.78	129.44	20.20	36.01	36.01	92.22	293.02	25.62	540.29	247.51
Nov	35.55	194.24	0.00	229.73	43.56	43.56	0.00	1.82	318.67	0.00	318.67	149.14	23.27	34.85	34.85	92.97	158.71	29.52	430.33	111.65
Dec	25.52	139.42	0.00	164.89	45.01	45.01	0.00	1.09	256.01	0.00	256.01	107.05	16.70	36.01	36.01	88.72	94.64	21.19	311.60	55.59
Jan	13.14	71.76	0.00	84.87	45.01	45.01	0.00	0.00	174.90	0.00	174.90	55.10	8.60	36.01	36.01	80.62	0.00	10.90	146.62	-28.28
Feb	54.94	300.16	0.00	355.01	40.66	40.66	0.00	0.00	436.32	0.00	436.32	230.47	35.96	32.53	32.53	101.0	0.00	45.61	377.09	-59.24
Mar	81.48	445.10	0.00	526.43	45.01	45.01	0.00	0.00	616.46	0.00	616.46	341.75	53.32	36.01	36.01	125.3	0.00	67.64	534.73	-81.73
Apr	41.73	228.00	0.00	269.66	43.56	43.56	0.00	0.00	356.78	0.00	356.78	175.06	27.31	34.85	34.85	97.01	0.00	34.64	306.71	-50.07
May	28.87	157.71	0.00	186.53	45.01	45.01	0.00	0.00	276.56	0.00	276.56	121.09	18.89	36.01	36.01	90.91	0.00	23.96	235.97	-40.59
Total	421.74	2304.0	0.00	2725.0	530.0	530.0	0.00	6.49	3791.46	0.00	3791.5	1769.0	276.0	424.0	424.0	1124	565.00	350.10	3808.1	16.64

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.13(a): Ponnanai Ar Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.31	46.82	0.00	49.13	10.36	12.74	0.00	0.02	72.28	0.00	72.28	33.10	5.67	8.28	10.19	24.14	2.31	59.55	-12.73
Jul	3.63	73.65	0.00	77.28	10.70	13.16	0.00	0.02	101.23	0.00	101.23	52.08	8.91	8.56	10.53	28.01	2.31	82.39	-18.84
Aug	2.17	44.11	0.00	46.29	10.70	13.16	0.00	0.03	70.18	0.00	70.18	31.16	5.34	8.56	10.53	24.43	3.08	58.67	-11.51
Sep	1.90	38.61	0.00	40.51	10.36	12.74	0.00	0.22	63.90	0.00	63.90	27.32	4.67	8.28	10.19	23.15	22.33	72.80	8.90
Oct	4.58	93.00	0.00	97.58	10.70	13.16	0.00	0.36	121.83	0.00	121.83	65.72	11.26	8.56	10.53	30.35	35.54	131.61	9.78
Nov	3.77	76.51	0.00	80.28	10.36	12.74	0.00	0.66	104.05	0.00	104.05	54.06	9.26	8.28	10.19	27.74	66.03	147.83	43.78
Dec	5.10	103.45	0.00	108.55	10.70	13.16	0.00	0.26	132.70	0.00	132.70	73.10	12.52	8.56	10.53	31.61	26.40	131.12	-1.59
Jan	4.03	81.73	0.00	85.76	10.70	13.16	0.00	0.09	109.74	0.00	109.74	57.76	9.89	8.56	10.53	28.98	9.27	96.01	-13.73
Feb	0.88	17.78	0.00	18.66	9.67	11.89	0.00	0.09	40.31	0.00	40.31	12.57	2.15	7.73	9.51	19.40	8.53	40.50	0.19
Mar	1.76	35.62	0.00	37.38	10.70	13.16	0.00	0.06	61.31	0.00	61.31	25.17	4.31	8.56	10.53	23.40	5.56	54.14	-7.17
Apr	1.45	29.52	0.00	30.98	10.36	12.74	0.00	0.02	54.11	0.00	54.11	20.87	3.57	8.28	10.19	22.05	2.36	45.28	-8.83
May	0.98	19.95	0.00	20.93	10.70	13.16	0.00	0.07	44.87	0.00	44.87	14.09	2.41	8.56	10.53	21.51	7.28	42.88	-1.99
Total	32.56	660.76	0.00	693.32	126.0	155.0	0.00	1.91	976.51	0.00	976.51	467.0	80.0	100.8	124.0	304.8	191.0	962.8	-13.74

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.13(b): Ponnanai Ar Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.31	46.82	0.00	49.13	12.74	12.74	0.00	0.02	72.28	0.00	72.28	33.10	5.67	10.19	10.19	26.05	2.31	14.70	76.16	3.88
Jul	3.63	73.65	0.00	77.28	13.16	13.16	0.00	0.02	101.23	0.00	101.23	52.08	8.92	10.53	10.53	29.98	2.31	23.12	107.49	6.25
Aug	2.17	44.11	0.00	46.29	13.16	13.16	0.00	0.03	70.18	0.00	70.18	31.16	5.34	10.53	10.53	26.40	3.08	13.85	74.49	4.31
Sep	1.90	38.61	0.00	40.51	12.74	12.74	0.00	0.22	63.90	0.00	63.90	27.32	4.68	10.19	10.19	25.06	22.33	12.12	86.84	22.94
Oct	4.58	93.00	0.00	97.58	13.16	13.16	0.00	0.36	121.83	0.00	121.83	65.72	11.26	10.53	10.53	32.32	35.54	29.19	162.77	40.94
Nov	3.77	76.51	0.00	80.28	12.74	12.74	0.00	0.66	104.05	0.00	104.05	54.06	9.26	10.19	10.19	29.64	66.03	24.01	173.75	69.70
Dec	5.10	103.45	0.00	108.55	13.16	13.16	0.00	0.26	132.70	0.00	132.70	73.10	12.52	10.53	10.53	33.59	26.40	32.47	165.56	32.86
Jan	4.03	81.73	0.00	85.76	13.16	13.16	0.00	0.09	109.74	0.00	109.74	57.76	9.89	10.53	10.53	30.96	9.27	25.65	123.64	13.90
Feb	0.88	17.78	0.00	18.66	11.89	11.89	0.00	0.09	40.31	0.00	40.31	12.57	2.15	9.51	9.51	21.18	8.53	5.58	47.86	7.55
Mar	1.76	35.62	0.00	37.38	13.16	13.16	0.00	0.06	61.31	0.00	61.31	25.17	4.31	10.53	10.53	25.38	5.56	11.18	67.29	5.98
Apr	1.45	29.52	0.00	30.98	12.74	12.74	0.00	0.02	54.11	0.00	54.11	20.87	3.57	10.19	10.19	23.96	2.36	9.27	56.45	2.34
May	0.98	19.95	0.00	20.93	13.16	13.16	0.00	0.07	44.87	0.00	44.87	14.09	2.41	10.53	10.53	23.48	7.28	6.26	51.11	6.24
Total	32.56	660.76	0.00	693.32	155.0	155.0	0.00	1.91	1005.23	0.00	1005.2	467.0	80.0	124.0	124.0	328.0	191.0	207.4	1193.4	188.17

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.13(c): Ponnanai Ar Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.31	46.82	0.00	49.13	10.36	12.74	0.00	0.02	72.28	0.00	72.28	33.10	5.67	8.28	10.19	24.14	2.91	60.16	-12.12
Jul	3.63	73.65	0.00	77.28	10.70	13.16	0.00	0.02	101.23	0.00	101.23	52.08	8.91	8.56	10.53	28.01	2.91	83.00	-18.24
Aug	2.17	44.11	0.00	46.29	10.70	13.16	0.00	0.03	70.18	0.00	70.18	31.16	5.34	8.56	10.53	24.43	3.89	59.48	-10.70
Sep	1.90	38.61	0.00	40.51	10.36	12.74	0.00	0.22	63.90	0.00	63.90	27.32	4.67	8.28	10.19	23.15	28.18	78.65	14.75
Oct	4.58	93.00	0.00	97.58	10.70	13.16	0.00	0.36	121.83	0.00	121.83	65.72	11.26	8.56	10.53	30.35	44.84	140.91	19.08
Nov	3.77	76.51	0.00	80.28	10.36	12.74	0.00	0.66	104.05	0.00	104.05	54.06	9.26	8.28	10.19	27.74	83.32	165.11	61.06
Dec	5.10	103.45	0.00	108.55	10.70	13.16	0.00	0.26	132.70	0.00	132.70	73.10	12.52	8.56	10.53	31.61	33.31	138.03	5.32
Jan	4.03	81.73	0.00	85.76	10.70	13.16	0.00	0.09	109.74	0.00	109.74	57.76	9.89	8.56	10.53	28.98	11.70	98.44	-11.30
Feb	0.88	17.78	0.00	18.66	9.67	11.89	0.00	0.09	40.31	0.00	40.31	12.57	2.15	7.73	9.51	19.40	10.76	42.73	2.42
Mar	1.76	35.62	0.00	37.38	10.70	13.16	0.00	0.06	61.31	0.00	61.31	25.17	4.31	8.56	10.53	23.40	7.02	55.59	-5.72
Apr	1.45	29.52	0.00	30.98	10.36	12.74	0.00	0.02	54.11	0.00	54.11	20.87	3.57	8.28	10.19	22.05	2.98	45.89	-8.22
May	0.98	19.95	0.00	20.93	10.70	13.16	0.00	0.07	44.87	0.00	44.87	14.09	2.41	8.56	10.53	21.51	9.19	44.79	-0.08
Total	32.56	660.76	0.00	693.32	126.0	155.0	0.00	1.91	976.51	0.00	976.51	467.0	80.0	100.8	124.0	304.8	241.00	1012.8	36.26

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.13(d): Ponnanai Ar Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.31	46.82	0.00	49.13	12.74	12.74	0.00	0.02	72.28	0.00	72.28	33.10	5.67	8.28	10.19	24.15	2.91	14.70	74.86	2.58
Jul	3.63	73.65	0.00	77.28	13.16	13.16	0.00	0.02	101.23	0.00	101.23	52.08	8.92	8.56	10.53	28.01	2.91	23.12	106.12	4.89
Aug	2.17	44.11	0.00	46.29	13.16	13.16	0.00	0.03	70.18	0.00	70.18	31.16	5.34	8.56	10.53	24.43	3.89	13.85	73.32	3.15
Sep	1.90	38.61	0.00	40.51	12.74	12.74	0.00	0.22	63.90	0.00	63.90	27.32	4.68	8.28	10.19	23.16	28.18	12.12	90.77	26.87
Oct	4.58	93.00	0.00	97.58	13.16	13.16	0.00	0.36	121.83	0.00	121.83	65.72	11.26	8.56	10.53	30.35	44.84	29.19	170.10	48.28
Nov	3.77	76.51	0.00	80.28	12.74	12.74	0.00	0.66	104.05	0.00	104.05	54.06	9.26	8.28	10.19	27.74	83.32	24.01	189.13	85.08
Dec	5.10	103.45	0.00	108.55	13.16	13.16	0.00	0.26	132.70	0.00	132.70	73.10	12.52	8.56	10.53	31.62	33.31	32.47	170.50	37.80
Jan	4.03	81.73	0.00	85.76	13.16	13.16	0.00	0.09	109.74	0.00	109.74	57.76	9.89	8.56	10.53	28.99	11.70	25.65	124.09	14.35
Feb	0.88	17.78	0.00	18.66	11.89	11.89	0.00	0.09	40.31	0.00	40.31	12.57	2.15	7.73	9.51	19.40	10.76	5.58	48.31	8.00
Mar	1.76	35.62	0.00	37.38	13.16	13.16	0.00	0.06	61.31	0.00	61.31	25.17	4.31	8.56	10.53	23.41	7.02	11.18	66.78	5.46
Apr	1.45	29.52	0.00	30.98	12.74	12.74	0.00	0.02	54.11	0.00	54.11	20.87	3.57	8.28	10.19	22.05	2.98	9.27	55.16	1.05
May	0.98	19.95	0.00	20.93	13.16	13.16	0.00	0.07	44.87	0.00	44.87	14.09	2.41	8.56	10.53	21.51	9.19	6.26	51.05	6.18
Total	32.56	660.76	0.00	693.32	155.0	155.0	0.00	1.91	1005.23	0.00	1005.2	467.0	80.0	100.8	124.0	304.8	241.00	207.4	1220.2	214.97

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.13(e): Ponnanai Ar Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.31	46.82	0.00	49.13	10.36	12.74	0.00	0.02	72.28	0.00	72.28	33.10	5.67	8.28	10.19	24.14	1.94	59.18	-13.10
Jul	3.63	73.65	0.00	77.28	10.70	13.16	0.00	0.02	101.23	0.00	101.23	52.08	8.91	8.56	10.53	28.01	1.94	82.02	-19.21
Aug	2.17	44.11	0.00	46.29	10.70	13.16	0.00	0.03	70.18	0.00	70.18	31.16	5.34	8.56	10.53	24.43	2.58	58.17	-12.01
Sep	1.90	38.61	0.00	40.51	10.36	12.74	0.00	0.22	63.90	0.00	63.90	27.32	4.67	8.28	10.19	23.15	18.71	69.18	5.28
Oct	4.58	93.00	0.00	97.58	10.70	13.16	0.00	0.36	121.83	0.00	121.83	65.72	11.26	8.56	10.53	30.35	29.77	125.84	4.01
Nov	3.77	76.51	0.00	80.28	10.36	12.74	0.00	0.66	104.05	0.00	104.05	54.06	9.26	8.28	10.19	27.74	55.31	137.11	33.06
Dec	5.10	103.45	0.00	108.55	10.70	13.16	0.00	0.26	132.70	0.00	132.70	73.10	12.52	8.56	10.53	31.61	22.12	126.84	-5.87
Jan	4.03	81.73	0.00	85.76	10.70	13.16	0.00	0.09	109.74	0.00	109.74	57.76	9.89	8.56	10.53	28.98	7.77	94.51	-15.23
Feb	0.88	17.78	0.00	18.66	9.67	11.89	0.00	0.09	40.31	0.00	40.31	12.57	2.15	7.73	9.51	19.40	7.15	39.12	-1.19
Mar	1.76	35.62	0.00	37.38	10.70	13.16	0.00	0.06	61.31	0.00	61.31	25.17	4.31	8.56	10.53	23.40	4.66	53.24	-8.07
Apr	1.45	29.52	0.00	30.98	10.36	12.74	0.00	0.02	54.11	0.00	54.11	20.87	3.57	8.28	10.19	22.05	1.98	44.90	-9.21
May	0.98	19.95	0.00	20.93	10.70	13.16	0.00	0.07	44.87	0.00	44.87	14.09	2.41	8.56	10.53	21.51	6.10	41.70	-3.17
Total	32.56	660.76	0.00	693.32	126.0	155.0	0.00	1.91	976.51	0.00	976.51	467.0	80.0	100.8	124.0	304.8	160.0	931.8	-44.71

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12)

Table 4.10.13(f): Ponnanai Ar Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.31	46.82	0.00	49.13	12.74	12.74	0.00	0.02	74.63	0.00	74.63	33.10	5.67	10.19	10.19	26.05	1.94	14.70	75.79	1.15
Jul	3.63	73.65	0.00	77.28	13.16	13.16	0.00	0.02	103.63	0.00	103.63	52.08	8.92	10.53	10.53	29.98	1.94	23.12	107.12	3.48
Aug	2.17	44.11	0.00	46.29	13.16	13.16	0.00	0.03	72.64	0.00	72.64	31.16	5.34	10.53	10.53	26.40	2.58	13.85	73.99	1.34
Sep	1.90	38.61	0.00	40.51	12.74	12.74	0.00	0.22	66.21	0.00	66.21	27.32	4.68	10.19	10.19	25.06	18.71	12.12	83.22	17.00
Oct	4.58	93.00	0.00	97.58	13.16	13.16	0.00	0.36	124.27	0.00	124.27	65.72	11.26	10.53	10.53	32.32	29.77	29.19	157.00	32.73
Nov	3.77	76.51	0.00	80.28	12.74	12.74	0.00	0.66	106.42	0.00	106.42	54.06	9.26	10.19	10.19	29.64	55.31	24.01	163.03	56.61
Dec	5.10	103.45	0.00	108.55	13.16	13.16	0.00	0.26	135.14	0.00	135.14	73.10	12.52	10.53	10.53	33.59	22.12	32.47	161.28	26.14
Jan	4.03	81.73	0.00	85.76	13.16	13.16	0.00	0.09	112.18	0.00	112.18	57.76	9.89	10.53	10.53	30.96	7.77	25.65	122.14	9.96
Feb	0.88	17.78	0.00	18.66	11.89	11.89	0.00	0.09	42.52	0.00	42.52	12.57	2.15	9.51	9.51	21.18	7.15	5.58	46.48	3.96
Mar	1.76	35.62	0.00	37.38	13.16	13.16	0.00	0.06	63.76	0.00	63.76	25.17	4.31	10.53	10.53	25.38	4.66	11.18	66.39	2.63
Apr	1.45	29.52	0.00	30.98	12.74	12.74	0.00	0.02	56.48	0.00	56.48	20.87	3.57	10.19	10.19	23.96	1.98	9.27	56.07	-0.41
May	0.98	19.95	0.00	20.93	13.16	13.16	0.00	0.07	47.34	0.00	47.34	14.09	2.41	10.53	10.53	23.48	6.10	6.26	49.93	2.60
Total	32.56	660.76	0.00	693.32	155.0	155.0	0.00	1.91	1005.23	0.00	1005.23	467.0	80.0	124.0	124.0	328.0	160.0	207.4	1162.4	157.17

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.13(g): Ponnanai Ar Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	2.31	46.82	0.00	49.13	10.36	12.74	0.00	0.02	72.28	0.00	72.28	33.10	5.67	8.28	10.19	24.14	0.77	58.01	-14.27
Jul	3.63	73.65	0.00	77.28	10.70	13.16	0.00	0.02	101.23	0.00	101.23	52.08	8.91	8.56	10.53	28.01	0.77	80.85	-20.38
Aug	2.17	44.11	0.00	46.29	10.70	13.16	0.00	0.03	70.18	0.00	70.18	31.16	5.34	8.56	10.53	24.43	1.03	56.62	-13.56
Sep	1.90	38.61	0.00	40.51	10.36	12.74	0.00	0.22	63.90	0.00	63.90	27.32	4.67	8.28	10.19	23.15	7.48	57.95	-5.95
Oct	4.58	93.00	0.00	97.58	10.70	13.16	0.00	0.36	121.83	0.00	121.83	65.72	11.26	8.56	10.53	30.35	11.91	107.98	-13.85
Nov	3.77	76.51	0.00	80.28	10.36	12.74	0.00	0.66	104.05	0.00	104.05	54.06	9.26	8.28	10.19	27.74	22.13	103.93	-0.12
Dec	5.10	103.45	0.00	108.55	10.70	13.16	0.00	0.26	132.70	0.00	132.70	73.10	12.52	8.56	10.53	31.61	8.85	113.57	-19.14
Jan	4.03	81.73	0.00	85.76	10.70	13.16	0.00	0.09	109.74	0.00	109.74	57.76	9.89	8.56	10.53	28.98	3.11	89.85	-19.89
Feb	0.88	17.78	0.00	18.66	9.67	11.89	0.00	0.09	40.31	0.00	40.31	12.57	2.15	7.73	9.51	19.40	2.86	34.83	-5.48
Mar	1.76	35.62	0.00	37.38	10.70	13.16	0.00	0.06	61.31	0.00	61.31	25.17	4.31	8.56	10.53	23.40	1.86	50.44	-10.87
Apr	1.45	29.52	0.00	30.98	10.36	12.74	0.00	0.02	54.11	0.00	54.11	20.87	3.57	8.28	10.19	22.05	0.79	43.71	-10.40
May	0.98	19.95	0.00	20.93	10.70	13.16	0.00	0.07	44.87	0.00	44.87	14.09	2.41	8.56	10.53	21.51	2.44	38.04	-6.83
Total	32.56	660.76	0.00	693.32	126.0	155.0	0.00	1.91	976.51	0.00	976.51	467.0	80.0	100.8	124.0	304.8	64.0	835.8	-140.74

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.13(h): Ponnanai Ar Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	2.31	46.82	0.00	49.13	12.74	12.74	0.00	0.02	74.63	0.00	74.63	33.10	5.67	10.19	10.19	26.05	0.77	14.70	74.62	-0.02
Jul	3.63	73.65	0.00	77.28	13.16	13.16	0.00	0.02	103.63	0.00	103.63	52.08	8.92	10.53	10.53	29.98	0.77	23.12	105.95	2.31
Aug	2.17	44.11	0.00	46.29	13.16	13.16	0.00	0.03	72.64	0.00	72.64	31.16	5.34	10.53	10.53	26.40	1.03	13.85	72.44	-0.21
Sep	1.90	38.61	0.00	40.51	12.74	12.74	0.00	0.22	66.21	0.00	66.21	27.32	4.68	10.19	10.19	25.06	7.48	12.12	71.99	5.77
Oct	4.58	93.00	0.00	97.58	13.16	13.16	0.00	0.36	124.27	0.00	124.27	65.72	11.26	10.53	10.53	32.32	11.91	29.19	139.14	14.87
Nov	3.77	76.51	0.00	80.28	12.74	12.74	0.00	0.66	106.42	0.00	106.42	54.06	9.26	10.19	10.19	29.64	22.13	24.01	129.85	23.43
Dec	5.10	103.45	0.00	108.55	13.16	13.16	0.00	0.26	135.14	0.00	135.14	73.10	12.52	10.53	10.53	33.59	8.85	32.47	148.01	12.87
Jan	4.03	81.73	0.00	85.76	13.16	13.16	0.00	0.09	112.18	0.00	112.18	57.76	9.89	10.53	10.53	30.96	3.11	25.65	117.48	5.30
Feb	0.88	17.78	0.00	18.66	11.89	11.89	0.00	0.09	42.52	0.00	42.52	12.57	2.15	9.51	9.51	21.18	2.86	5.58	42.19	-0.33
Mar	1.76	35.62	0.00	37.38	13.16	13.16	0.00	0.06	63.76	0.00	63.76	25.17	4.31	10.53	10.53	25.38	1.86	11.18	63.59	-0.17
Apr	1.45	29.52	0.00	30.98	12.74	12.74	0.00	0.02	56.48	0.00	56.48	20.87	3.57	10.19	10.19	23.96	0.79	9.27	54.88	-1.60
May	0.98	19.95	0.00	20.93	13.16	13.16	0.00	0.07	47.34	0.00	47.34	14.09	2.41	10.53	10.53	23.48	2.44	6.26	46.27	-1.06
Total	32.56	660.76	0.00	693.32	155.0	155.0	0.00	1.91	1005.2	0.00	1005.2	467.0	80.0	124.0	124.0	328.0	64.0	207.4	1066.4	61.17

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.14(a): Upper Coleroon Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	3.71	11.03	0.00	14.75	9.04	11.01	0.00	0.07	34.87	0.00	34.87	7.81	0.93	7.23	8.81	16.97	7.29	32.07	-2.80
Jul	62.11	184.55	0.00	246.66	9.34	11.38	0.00	0.36	267.75	0.00	267.75	130.67	15.49	7.47	9.10	32.07	35.94	198.68	-69.07
Aug	66.47	197.49	0.00	263.96	9.34	11.38	0.00	0.51	285.19	0.00	285.19	139.83	16.58	7.47	9.10	33.16	51.05	224.04	-61.16
Sep	64.98	193.07	0.00	258.05	9.04	11.01	0.00	0.93	279.03	0.00	279.03	136.70	16.21	7.23	8.81	32.25	92.59	261.54	-17.49
Oct	19.47	57.87	0.00	77.34	9.34	11.38	0.00	0.82	98.88	0.00	98.88	40.97	4.86	7.47	9.10	21.44	82.18	144.59	45.70
Nov	17.13	50.91	0.00	68.05	9.04	11.01	0.00	1.66	89.76	0.00	89.76	36.05	4.27	7.23	8.81	20.32	165.9	222.26	132.50
Dec	13.49	40.09	0.00	53.58	9.34	11.38	0.00	0.94	75.24	0.00	75.24	28.38	3.37	7.47	9.10	19.94	93.55	141.88	66.63
Jan	4.68	13.90	0.00	18.57	9.34	11.38	0.00	0.22	39.52	0.00	39.52	9.84	1.17	7.47	9.10	17.75	21.63	49.21	9.70
Feb	8.16	24.25	0.00	32.41	8.44	10.28	0.00	0.13	51.26	0.00	51.26	17.17	2.04	6.75	8.22	17.01	13.25	47.43	-3.83
Mar	12.33	36.63	0.00	48.96	9.34	11.38	0.00	0.11	69.80	0.00	69.80	25.94	3.08	7.47	9.10	19.65	10.71	56.30	-13.49
Apr	3.44	10.22	0.00	13.66	9.04	11.01	0.00	0.06	33.77	0.00	33.77	7.24	0.86	7.23	8.81	16.90	5.78	29.92	-3.86
May	0.67	1.99	0.00	2.67	9.34	11.38	0.00	0.10	23.49	0.00	23.49	1.41	0.17	7.47	9.10	16.75	10.13	28.29	4.80
Total	276.65	822.0	0.00	1098.65	110.0	134.0	0.00	5.91	1348.6	0.00	1348.6	582.0	69.0	88.0	107.2	264.2	589.0	1435.2	86.64

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.14(b): Upper Coleroon Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	3.71	11.03	0.00	14.75	11.01	11.01	0.00	0.07	34.87	0.00	34.87	7.81	0.93	8.81	8.81	18.55	7.29	3.39	37.04	2.17
Jul	62.11	184.55	0.00	246.66	11.38	11.38	0.00	0.36	267.75	0.00	267.75	130.67	15.49	9.10	9.10	33.70	35.94	56.71	257.02	-10.73
Aug	66.47	197.49	0.00	263.96	11.38	11.38	0.00	0.51	285.19	0.00	285.19	139.83	16.58	9.10	9.10	34.79	51.05	60.69	286.36	1.16
Sep	64.98	193.07	0.00	258.05	11.01	11.01	0.00	0.93	279.03	0.00	279.03	136.70	16.21	8.81	8.81	33.83	92.59	59.33	322.45	43.41
Oct	19.47	57.87	0.00	77.34	11.38	11.38	0.00	0.82	98.88	0.00	98.88	40.97	4.86	9.10	9.10	23.07	82.18	17.78	164.00	65.12
Nov	17.13	50.91	0.00	68.05	11.01	11.01	0.00	1.66	89.76	0.00	89.76	36.05	4.27	8.81	8.81	21.90	165.9	15.65	239.49	149.73
Dec	13.49	40.09	0.00	53.58	11.38	11.38	0.00	0.94	75.24	0.00	75.24	28.38	3.37	9.10	9.10	21.57	93.55	12.32	155.83	80.58
Jan	4.68	13.90	0.00	18.57	11.38	11.38	0.00	0.22	39.52	0.00	39.52	9.84	1.17	9.10	9.10	19.38	21.63	4.27	55.11	15.60
Feb	8.16	24.25	0.00	32.41	10.28	10.28	0.00	0.13	51.26	0.00	51.26	17.17	2.04	8.22	8.22	18.48	13.25	7.45	56.36	5.09
Mar	12.33	36.63	0.00	48.96	11.38	11.38	0.00	0.11	69.80	0.00	69.80	25.94	3.08	9.10	9.10	21.28	10.71	11.26	69.19	-0.61
Apr	3.44	10.22	0.00	13.66	11.01	11.01	0.00	0.06	33.77	0.00	33.77	7.24	0.86	8.81	8.81	18.48	5.78	3.14	34.64	0.86
May	0.67	1.99	0.00	2.67	11.38	11.38	0.00	0.10	23.49	0.00	23.49	1.41	0.17	9.10	9.10	18.38	10.13	0.61	30.53	7.04
Total	276.65	822.0	0.00	1098.65	134.0	134.0	0.00	5.91	1372.6	0.00	1372.6	582.0	69.0	107.2	107.2	283.4	589.0	252.6	1707.0	334.44

Note : Column no.10 = Column no.(5+6+7+8+9) Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.14(c): Upper Coleroon Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	3.71	11.03	0.00	14.75	9.04	11.01	0.00	0.07	34.87	0.00	34.87	7.81	0.93	7.23	8.81	16.97	9.15	33.93	-0.94
Jul	62.11	184.55	0.00	246.66	9.34	11.38	0.00	0.36	267.75	0.00	267.75	130.67	15.49	7.47	9.10	32.07	45.09	207.83	-59.92
Aug	66.47	197.49	0.00	263.96	9.34	11.38	0.00	0.51	285.19	0.00	285.19	139.83	16.58	7.47	9.10	33.16	64.05	237.04	-48.15
Sep	64.98	193.07	0.00	258.05	9.04	11.01	0.00	0.93	279.03	0.00	279.03	136.70	16.21	7.23	8.81	32.25	116.17	285.12	6.09
Oct	19.47	57.87	0.00	77.34	9.34	11.38	0.00	0.82	98.88	0.00	98.88	40.97	4.86	7.47	9.10	21.44	103.11	165.51	66.63
Nov	17.13	50.91	0.00	68.05	9.04	11.01	0.00	1.66	89.76	0.00	89.76	36.05	4.27	7.23	8.81	20.32	208.15	264.51	174.75
Dec	13.49	40.09	0.00	53.58	9.34	11.38	0.00	0.94	75.24	0.00	75.24	28.38	3.37	7.47	9.10	19.94	117.37	165.70	90.46
Jan	4.68	13.90	0.00	18.57	9.34	11.38	0.00	0.22	39.52	0.00	39.52	9.84	1.17	7.47	9.10	17.75	27.14	54.72	15.21
Feb	8.16	24.25	0.00	32.41	8.44	10.28	0.00	0.13	51.26	0.00	51.26	17.17	2.04	6.75	8.22	17.01	16.62	50.80	-0.46
Mar	12.33	36.63	0.00	48.96	9.34	11.38	0.00	0.11	69.80	0.00	69.80	25.94	3.08	7.47	9.10	19.65	13.44	59.03	-10.77
Apr	3.44	10.22	0.00	13.66	9.04	11.01	0.00	0.06	33.77	0.00	33.77	7.24	0.86	7.23	8.81	16.90	7.25	31.39	-2.38
May	0.67	1.99	0.00	2.67	9.34	11.38	0.00	0.10	23.49	0.00	23.49	1.41	0.17	7.47	9.10	16.75	12.71	30.87	7.38
Total	276.65	822.0	0.00	1098.65	110.0	134.0	0.00	5.91	1348.6	0.00	1348.56	582.0	69.0	88.0	107.2	264.2	739.00	1585.2	236.64

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.14(d): Upper Coleroon Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	3.71	11.03	0.00	14.75	11.01	11.01	0.00	0.07	34.87	0.00	34.87	7.81	0.93	8.81	8.81	18.55	9.15	3.39	38.90	4.03
Jul	62.11	184.55	0.00	246.66	11.38	11.38	0.00	0.36	267.75	0.00	267.75	130.67	15.49	9.10	9.10	33.70	45.09	56.71	266.17	-1.57
Aug	66.47	197.49	0.00	263.96	11.38	11.38	0.00	0.51	285.19	0.00	285.19	139.83	16.58	9.10	9.10	34.79	64.05	60.69	299.36	14.16
Sep	64.98	193.07	0.00	258.05	11.01	11.01	0.00	0.93	279.03	0.00	279.03	136.70	16.21	8.81	8.81	33.83	116.17	59.33	346.03	66.99
Oct	19.47	57.87	0.00	77.34	11.38	11.38	0.00	0.82	98.88	0.00	98.88	40.97	4.86	9.10	9.10	23.07	103.11	17.78	184.93	86.04
Nov	17.13	50.91	0.00	68.05	11.01	11.01	0.00	1.66	89.76	0.00	89.76	36.05	4.27	8.81	8.81	21.90	208.15	15.65	281.74	191.98
Dec	13.49	40.09	0.00	53.58	11.38	11.38	0.00	0.94	75.24	0.00	75.24	28.38	3.37	9.10	9.10	21.57	117.37	12.32	179.65	104.41
Jan	4.68	13.90	0.00	18.57	11.38	11.38	0.00	0.22	39.52	0.00	39.52	9.84	1.17	9.10	9.10	19.38	27.14	4.27	60.62	21.11
Feb	8.16	24.25	0.00	32.41	10.28	10.28	0.00	0.13	51.26	0.00	51.26	17.17	2.04	8.22	8.22	18.48	16.62	7.45	59.73	8.47
Mar	12.33	36.63	0.00	48.96	11.38	11.38	0.00	0.11	69.80	0.00	69.80	25.94	3.08	9.10	9.10	21.28	13.44	11.26	71.92	2.12
Apr	3.44	10.22	0.00	13.66	11.01	11.01	0.00	0.06	33.77	0.00	33.77	7.24	0.86	8.81	8.81	18.48	7.25	3.14	36.11	2.33
May	0.67	1.99	0.00	2.67	11.38	11.38	0.00	0.10	23.49	0.00	23.49	1.41	0.17	9.10	9.10	18.38	12.71	0.61	33.11	9.62
Total	276.65	822.0	0.00	1098.65	134.0	134.0	0.00	5.91	1372.6	0.00	1372.56	582.0	69.0	107.2	107.2	283.4	739.00	252.6	1857.0	484.44

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.14(e): Upper Coleroon Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	3.71	11.03	0.00	14.75	9.04	11.01	0.00	0.07	34.87	0.00	34.87	7.81	0.93	7.23	8.81	16.97	5.86	30.64	-4.23
Jul	62.11	184.55	0.00	246.66	9.34	11.38	0.00	0.36	267.75	0.00	267.75	130.67	15.49	7.47	9.10	32.07	28.87	191.61	-76.14
Aug	66.47	197.49	0.00	263.96	9.34	11.38	0.00	0.51	285.19	0.00	285.19	139.83	16.58	7.47	9.10	33.16	41.01	214.00	-71.20
Sep	64.98	193.07	0.00	258.05	9.04	11.01	0.00	0.93	279.03	0.00	279.03	136.70	16.21	7.23	8.81	32.25	74.39	243.34	-35.69
Oct	19.47	57.87	0.00	77.34	9.34	11.38	0.00	0.82	98.88	0.00	98.88	40.97	4.86	7.47	9.10	21.44	66.02	128.43	29.54
Nov	17.13	50.91	0.00	68.05	9.04	11.01	0.00	1.66	89.76	0.00	89.76	36.05	4.27	7.23	8.81	20.32	133.3	189.66	99.90
Dec	13.49	40.09	0.00	53.58	9.34	11.38	0.00	0.94	75.24	0.00	75.24	28.38	3.37	7.47	9.10	19.94	75.16	123.49	48.24
Jan	4.68	13.90	0.00	18.57	9.34	11.38	0.00	0.22	39.52	0.00	39.52	9.84	1.17	7.47	9.10	17.75	17.38	44.96	5.45
Feb	8.16	24.25	0.00	32.41	8.44	10.28	0.00	0.13	51.26	0.00	51.26	17.17	2.04	6.75	8.22	17.01	10.64	44.82	-6.44
Mar	12.33	36.63	0.00	48.96	9.34	11.38	0.00	0.11	69.80	0.00	69.80	25.94	3.08	7.47	9.10	19.65	8.60	54.19	-15.60
Apr	3.44	10.22	0.00	13.66	9.04	11.01	0.00	0.06	33.77	0.00	33.77	7.24	0.86	7.23	8.81	16.90	4.64	28.78	-5.00
May	0.67	1.99	0.00	2.67	9.34	11.38	0.00	0.10	23.49	0.00	23.49	1.41	0.17	7.47	9.10	16.75	8.14	26.30	2.81
Total	276.65	822.0	0.00	1098.65	110.0	134.0	0.00	5.91	1348.6	0.00	1348.6	582.0	69.0	88.0	107.2	264.2	474.0	1320.2	-28.36

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.14(f): Upper Coleroon Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	3.71	11.03	0.00	14.75	11.01	11.01	0.00	0.07	36.84	0.00	34.87	7.81	0.93	8.81	8.81	18.55	5.86	3.39	35.61	0.74
Jul	62.11	184.55	0.00	246.66	11.38	11.38	0.00	0.36	269.78	0.00	267.75	130.67	15.49	9.10	9.10	33.70	28.87	56.71	249.95	-17.80
Aug	66.47	197.49	0.00	263.96	11.38	11.38	0.00	0.51	287.23	0.00	285.19	139.83	16.58	9.10	9.10	34.79	41.01	60.69	276.32	-8.88
Sep	64.98	193.07	0.00	258.05	11.01	11.01	0.00	0.93	281.00	0.00	279.03	136.70	16.21	8.81	8.81	33.83	74.39	59.33	304.25	25.21
Oct	19.47	57.87	0.00	77.34	11.38	11.38	0.00	0.82	100.92	0.00	98.88	40.97	4.86	9.10	9.10	23.07	66.02	17.78	147.84	48.96
Nov	17.13	50.91	0.00	68.05	11.01	11.01	0.00	1.66	91.73	0.00	89.76	36.05	4.27	8.81	8.81	21.90	133.3	15.65	206.89	117.13
Dec	13.49	40.09	0.00	53.58	11.38	11.38	0.00	0.94	77.28	0.00	75.24	28.38	3.37	9.10	9.10	21.57	75.16	12.32	137.44	62.19
Jan	4.68	13.90	0.00	18.57	11.38	11.38	0.00	0.22	41.55	0.00	39.52	9.84	1.17	9.10	9.10	19.38	17.38	4.27	50.86	11.35
Feb	8.16	24.25	0.00	32.41	10.28	10.28	0.00	0.13	53.10	0.00	51.36	17.17	2.04	8.22	8.22	18.48	10.64	7.45	53.75	2.48
Mar	12.33	36.63	0.00	48.96	11.38	11.38	0.00	0.11	71.83	0.00	69.80	25.94	3.08	9.10	9.10	21.28	8.60	11.26	67.08	-2.72
Apr	3.44	10.22	0.00	13.66	11.01	11.01	0.00	0.06	35.75	0.00	33.77	7.24	0.86	8.81	8.81	18.48	4.64	3.14	33.50	-0.28
May	0.67	1.99	0.00	2.67	11.38	11.38	0.00	0.10	25.53	0.00	23.49	1.41	0.17	9.10	9.10	18.38	8.14	0.61	28.54	5.05
Total	276.65	822.0	0.00	1098.65	134.0	134.0	0.00	5.91	1372.6	0.00	1372.6	582.0	69.0	107.2	107.2	283.4	474.0	252.6	1592.0	219.4

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.14(g): Upper Coleroon Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	3.71	11.03	0.00	14.75	9.04	11.01	0.00	0.07	34.87	0.00	34.87	7.81	0.93	7.23	8.81	16.97	2.35	27.13	-7.74
Jul	62.11	184.55	0.00	246.66	9.34	11.38	0.00	0.36	267.75	0.00	267.75	130.67	15.49	7.47	9.10	32.07	11.57	174.31	-93.44
Aug	66.47	197.49	0.00	263.96	9.34	11.38	0.00	0.51	285.19	0.00	285.19	139.83	16.58	7.47	9.10	33.16	16.44	189.43	-95.77
Sep	64.98	193.07	0.00	258.05	9.04	11.01	0.00	0.93	279.03	0.00	279.03	136.70	16.21	7.23	8.81	32.25	29.82	198.77	-80.26
Oct	19.47	57.87	0.00	77.34	9.34	11.38	0.00	0.82	98.88	0.00	98.88	40.97	4.86	7.47	9.10	21.44	26.46	88.87	-10.02
Nov	17.13	50.91	0.00	68.05	9.04	11.01	0.00	1.66	89.76	0.00	89.76	36.05	4.27	7.23	8.81	20.32	53.43	109.79	20.03
Dec	13.49	40.09	0.00	53.58	9.34	11.38	0.00	0.94	75.24	0.00	75.24	28.38	3.37	7.47	9.10	19.94	30.13	78.46	3.21
Jan	4.68	13.90	0.00	18.57	9.34	11.38	0.00	0.22	39.52	0.00	39.52	9.84	1.17	7.47	9.10	17.75	6.97	34.55	-4.96
Feb	8.16	24.25	0.00	32.41	8.44	10.28	0.00	0.13	51.26	0.00	51.26	17.17	2.04	6.75	8.22	17.01	4.27	38.45	-12.81
Mar	12.33	36.63	0.00	48.96	9.34	11.38	0.00	0.11	69.80	0.00	69.80	25.94	3.08	7.47	9.10	19.65	3.45	49.04	-20.75
Apr	3.44	10.22	0.00	13.66	9.04	11.01	0.00	0.06	33.77	0.00	33.77	7.24	0.86	7.23	8.81	16.90	1.86	26.00	-7.78
May	0.67	1.99	0.00	2.67	9.34	11.38	0.00	0.10	23.49	0.00	23.49	1.41	0.17	7.47	9.10	16.75	3.26	21.42	-2.07
Total	276.65	822.0	0.00	1098.65	110.0	134.0	0.00	5.91	1348.6	0.00	1348.6	582.0	69.0	88.0	107.2	264.2	190.0	1036.2	-312.4

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.14(h): Upper Coleroon Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	3.71	11.03	0.00	14.75	11.01	11.01	0.00	0.07	36.84	0.00	36.84	7.81	0.93	8.81	8.81	18.55	2.35	3.39	32.10	-4.74
Jul	62.11	184.55	0.00	246.66	11.38	11.38	0.00	0.36	269.78	0.00	269.78	130.67	15.49	9.10	9.10	33.70	11.57	56.71	232.65	-37.13
Aug	66.47	197.49	0.00	263.96	11.38	11.38	0.00	0.51	287.23	0.00	287.23	139.83	16.58	9.10	9.10	34.79	16.44	60.69	251.75	-35.48
Sep	64.98	193.07	0.00	258.05	11.01	11.01	0.00	0.93	281.00	0.00	281.00	136.70	16.21	8.81	8.81	33.83	29.82	59.33	259.68	-21.33
Oct	19.47	57.87	0.00	77.34	11.38	11.38	0.00	0.82	100.92	0.00	100.92	40.97	4.86	9.10	9.10	23.07	26.46	17.78	108.28	7.36
Nov	17.13	50.91	0.00	68.05	11.01	11.01	0.00	1.66	91.73	0.00	91.73	36.05	4.27	8.81	8.81	21.90	53.43	15.65	127.02	35.28
Dec	13.49	40.09	0.00	53.58	11.38	11.38	0.00	0.94	77.28	0.00	77.28	28.38	3.37	9.10	9.10	21.57	30.13	12.32	92.41	15.13
Jan	4.68	13.90	0.00	18.57	11.38	11.38	0.00	0.22	41.55	0.00	41.55	9.84	1.17	9.10	9.10	19.38	6.97	4.27	40.45	-1.10
Feb	8.16	24.25	0.00	32.41	10.28	10.28	0.00	0.13	53.10	0.00	53.10	17.17	2.04	8.22	8.22	18.48	4.27	7.45	47.38	-5.73
Mar	12.33	36.63	0.00	48.96	11.38	11.38	0.00	0.11	71.83	0.00	71.83	25.94	3.08	9.10	9.10	21.28	3.45	11.26	61.93	-9.90
Apr	3.44	10.22	0.00	13.66	11.01	11.01	0.00	0.06	35.75	0.00	35.75	7.24	0.86	8.81	8.81	18.48	1.86	3.14	30.72	-5.03
May	0.67	1.99	0.00	2.67	11.38	11.38	0.00	0.10	25.53	0.00	25.53	1.41	0.17	9.10	9.10	18.38	3.26	0.61	23.66	-1.87
Total	276.65	822.0	0.00	1098.65	134.0	134.0	0.00	5.91	1373	0.00	1373	582.0	69.0	107.2	107.2	283.4	190.0	252.6	1308.0	-64.56

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.15(a): Lower Coleroon Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	0.00	15.25	0.00	15.25	5.75	6.82	0.00	0.06	27.88	0.00	27.88	14.46	1.21	4.60	5.46	11.27	5.80	31.53	3.64
Jul	0.00	255.05	0.00	255.05	5.95	7.05	0.00	0.15	268.20	0.00	268.20	241.80	20.21	4.76	5.64	30.60	15.20	287.60	19.41
Aug	0.00	272.93	0.00	272.93	5.95	7.05	0.00	0.34	286.27	0.00	286.27	258.76	21.62	4.76	5.64	32.02	33.93	324.71	38.44
Sep	0.00	266.82	0.00	266.82	5.75	6.82	0.00	0.42	279.81	0.00	279.81	252.96	21.14	4.60	5.46	31.20	41.66	325.82	46.01
Oct	0.00	79.97	0.00	79.97	5.95	7.05	0.00	0.34	93.30	0.00	93.30	75.82	6.34	4.76	5.64	16.73	33.89	126.44	33.13
Nov	0.00	70.36	0.00	70.36	5.75	6.82	0.00	0.29	83.22	0.00	83.22	66.71	5.57	4.60	5.46	15.63	28.88	111.22	28.00
Dec	0.00	55.40	0.00	55.40	5.95	7.05	0.00	0.33	68.72	0.00	68.72	52.52	4.39	4.76	5.64	14.78	32.64	99.95	31.23
Jan	0.00	19.20	0.00	19.20	5.95	7.05	0.00	0.12	32.31	0.00	32.31	18.21	1.52	4.76	5.64	11.92	11.66	41.78	9.47
Feb	0.00	33.51	0.00	33.51	5.37	6.37	0.00	0.05	45.30	0.00	45.30	31.77	2.66	4.30	5.09	12.04	5.34	49.16	3.85
Mar	0.00	50.63	0.00	50.63	5.95	7.05	0.00	0.05	63.68	0.00	63.68	48.00	4.01	4.76	5.64	14.41	5.42	67.82	4.15
Apr	0.00	14.12	0.00	14.12	5.75	6.82	0.00	0.07	26.77	0.00	26.77	13.39	1.12	4.60	5.46	11.18	6.72	31.29	4.52
May	0.00	2.76	0.00	2.76	5.95	7.05	0.00	0.05	15.80	0.00	15.80	2.61	0.22	4.76	5.64	10.61	5.38	18.61	2.80
Total	0.00	1136.0	0.00	1136.0	70.00	83.00	0.00	2.24	1291.2	0.00	1291.2	1077.0	90.0	56.0	66.4	212.4	224.0	1513.4	222.16

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.15(b): Lower Coleroon Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	0.00	15.25	0.00	15.25	6.82	6.82	0.00	0.06	28.95	0.00	28.95	14.46	1.21	5.46	5.46	12.12	5.80	1.62	34.00	5.05
Jul	0.00	255.05	0.00	255.05	7.05	7.05	0.00	0.15	269.30	0.00	269.30	241.80	20.21	5.64	5.64	31.49	15.20	27.08	315.56	46.26
Aug	0.00	272.93	0.00	272.93	7.05	7.05	0.00	0.34	287.37	0.00	287.37	258.76	21.62	5.64	5.64	32.90	33.93	28.97	354.56	67.19
Sep	0.00	266.82	0.00	266.82	6.82	6.82	0.00	0.42	280.88	0.00	280.88	252.96	21.14	5.46	5.46	32.05	41.66	28.33	355.00	74.12
Oct	0.00	79.97	0.00	79.97	7.05	7.05	0.00	0.34	94.41	0.00	94.41	75.82	6.34	5.64	5.64	17.61	33.89	8.49	135.81	41.40
Nov	0.00	70.36	0.00	70.36	6.82	6.82	0.00	0.29	84.29	0.00	84.29	66.71	5.57	5.46	5.46	16.49	28.88	7.47	119.54	35.25
Dec	0.00	55.40	0.00	55.40	7.05	7.05	0.00	0.33	69.83	0.00	69.83	52.52	4.39	5.64	5.64	15.67	32.64	5.88	106.72	36.89
Jan	0.00	19.20	0.00	19.20	7.05	7.05	0.00	0.12	33.42	0.00	33.42	18.21	1.52	5.64	5.64	12.80	11.66	2.04	44.71	11.29
Feb	0.00	33.51	0.00	33.51	6.37	6.37	0.00	0.05	46.30	0.00	46.30	31.77	2.66	5.09	5.09	12.84	5.34	3.56	53.51	7.21
Mar	0.00	50.63	0.00	50.63	7.05	7.05	0.00	0.05	64.78	0.00	64.78	48.00	4.01	5.64	5.64	15.29	5.42	5.37	74.08	9.30
Apr	0.00	14.12	0.00	14.12	6.82	6.82	0.00	0.07	27.83	0.00	27.83	13.39	1.12	5.46	5.46	12.03	6.72	1.50	33.64	5.81
May	0.00	2.76	0.00	2.76	7.05	7.05	0.00	0.05	16.91	0.00	16.91	2.61	0.22	5.64	5.64	11.50	5.38	0.29	19.78	2.87
Total	0.00	1136.0	0.00	1136.0	83.00	83.00	0.00	2.24	1304.2	0.00	1304.2	1077.0	90.0	66.40	66.4	222.8	224.0	120.6	1644.4	340.16

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.15(c): Lower Coleroon Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	0.00	15.25	0.00	15.25	5.75	6.82	0.00	0.10	27.92	0.00	27.92	14.46	1.21	4.60	5.46	11.27	9.87	35.59	7.67
Jul	0.00	255.05	0.00	255.05	5.95	7.05	0.00	0.26	268.30	0.00	268.30	241.80	20.21	4.76	5.64	30.60	25.85	298.26	29.96
Aug	0.00	272.93	0.00	272.93	5.95	7.05	0.00	0.58	286.50	0.00	286.50	258.76	21.62	4.76	5.64	32.02	57.71	348.49	61.98
Sep	0.00	266.82	0.00	266.82	5.75	6.82	0.00	0.71	280.10	0.00	280.10	252.96	21.14	4.60	5.46	31.20	70.86	355.02	74.92
Oct	0.00	79.97	0.00	79.97	5.95	7.05	0.00	0.58	93.54	0.00	93.54	75.82	6.34	4.76	5.64	16.73	57.64	150.19	56.65
Nov	0.00	70.36	0.00	70.36	5.75	6.82	0.00	0.49	83.43	0.00	83.43	66.71	5.57	4.60	5.46	15.63	49.12	131.46	48.04
Dec	0.00	55.40	0.00	55.40	5.95	7.05	0.00	0.56	68.95	0.00	68.95	52.52	4.39	4.76	5.64	14.78	55.52	122.83	53.88
Jan	0.00	19.20	0.00	19.20	5.95	7.05	0.00	0.20	32.40	0.00	32.40	18.21	1.52	4.76	5.64	11.92	19.83	49.96	17.56
Feb	0.00	33.51	0.00	33.51	5.37	6.37	0.00	0.09	45.34	0.00	45.34	31.77	2.66	4.30	5.09	12.04	9.08	52.90	7.56
Mar	0.00	50.63	0.00	50.63	5.95	7.05	0.00	0.09	63.71	0.00	63.71	48.00	4.01	4.76	5.64	14.41	9.22	71.62	7.91
Apr	0.00	14.12	0.00	14.12	5.75	6.82	0.00	0.11	26.81	0.00	26.81	13.39	1.12	4.60	5.46	11.18	11.43	36.00	9.19
May	0.00	2.76	0.00	2.76	5.95	7.05	0.00	0.09	15.84	0.00	15.84	2.61	0.22	4.76	5.64	10.61	9.15	22.38	6.54
Total	0.00	1136.0	0.00	1136.0	70.00	83.00	0.00	3.81	1292.8	0.00	1292.8	1077.0	90.0	56.0	66.4	212.4	381.00	1670.4	377.59

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.15(d): Lower Coleroon Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation												Water Availnbility								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	0.00	15.25	0.00	15.25	6.82	6.82	0.00	0.10	28.99	0.00	28.99	14.46	1.21	4.60	5.46	11.27	9.87	1.62	37.21	8.22
Jul	0.00	255.05	0.00	255.05	7.05	7.05	0.00	0.26	269.41	0.00	269.41	241.80	20.21	4.76	5.64	30.60	25.85	27.08	325.33	55.93
Aug	0.00	272.93	0.00	272.93	7.05	7.05	0.00	0.58	287.61	0.00	287.61	258.76	21.62	4.76	5.64	32.02	57.71	28.97	377.46	89.85
Sep	0.00	266.82	0.00	266.82	6.82	6.82	0.00	0.71	281.17	0.00	281.17	252.96	21.14	4.60	5.46	31.20	70.86	28.33	383.35	102.17
Oct	0.00	79.97	0.00	79.97	7.05	7.05	0.00	0.58	94.64	0.00	94.64	75.82	6.34	4.76	5.64	16.73	57.64	8.49	158.68	64.04
Nov	0.00	70.36	0.00	70.36	6.82	6.82	0.00	0.49	84.50	0.00	84.50	66.71	5.57	4.60	5.46	15.63	49.12	7.47	138.93	54.44
Dec	0.00	55.40	0.00	55.40	7.05	7.05	0.00	0.56	70.06	0.00	70.06	52.52	4.39	4.76	5.64	14.78	55.52	5.88	128.71	58.66
Jan	0.00	19.20	0.00	19.20	7.05	7.05	0.00	0.20	33.50	0.00	33.50	18.21	1.52	4.76	5.64	11.92	19.83	2.04	51.99	18.49
Feb	0.00	33.51	0.00	33.51	6.37	6.37	0.00	0.09	46.34	0.00	46.34	31.77	2.66	4.30	5.09	12.04	9.08	3.56	56.46	10.12
Mar	0.00	50.63	0.00	50.63	7.05	7.05	0.00	0.09	64.82	0.00	64.82	48.00	4.01	4.76	5.64	14.41	9.22	5.37	77.00	12.18
Apr	0.00	14.12	0.00	14.12	6.82	6.82	0.00	0.11	27.88	0.00	27.88	13.39	1.12	4.60	5.46	11.18	11.43	1.50	37.50	9.62
May	0.00	2.76	0.00	2.76	7.05	7.05	0.00	0.09	16.95	0.00	16.95	2.61	0.22	4.76	5.64	10.61	9.15	0.29	22.67	5.72
Total	0.00	1136.0	0.00	1136.0	83.00	83.00	0.00	3.81	1305.8	0.00	1305.8	1077.0	90.0	56.0	66.4	212.4	381.00	120.6	1791.0	485.19

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.15(e): Lower Coleroon Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	0.00	15.25	0.00	15.25	5.75	6.82	0.00	0.04	27.87	0.00	27.87	14.46	1.21	4.60	5.46	11.27	4.30	30.03	2.16
Jul	0.00	255.05	0.00	255.05	5.95	7.05	0.00	0.11	268.16	0.00	268.16	241.80	20.21	4.76	5.64	30.60	11.27	283.67	15.52
Aug	0.00	272.93	0.00	272.93	5.95	7.05	0.00	0.25	286.18	0.00	286.18	258.76	21.62	4.76	5.64	32.02	25.17	315.95	29.77
Sep	0.00	266.82	0.00	266.82	5.75	6.82	0.00	0.31	279.70	0.00	279.70	252.96	21.14	4.60	5.46	31.20	30.90	315.06	35.36
Oct	0.00	79.97	0.00	79.97	5.95	7.05	0.00	0.25	93.22	0.00	93.22	75.82	6.34	4.76	5.64	16.73	25.14	117.69	24.47
Nov	0.00	70.36	0.00	70.36	5.75	6.82	0.00	0.21	83.15	0.00	83.15	66.71	5.57	4.60	5.46	15.63	21.42	103.76	20.61
Dec	0.00	55.40	0.00	55.40	5.95	7.05	0.00	0.24	68.64	0.00	68.64	52.52	4.39	4.76	5.64	14.78	24.21	91.52	22.88
Jan	0.00	19.20	0.00	19.20	5.95	7.05	0.00	0.09	32.28	0.00	32.28	18.21	1.52	4.76	5.64	11.92	8.65	38.77	6.49
Feb	0.00	33.51	0.00	33.51	5.37	6.37	0.00	0.04	45.29	0.00	45.29	31.77	2.66	4.30	5.09	12.04	3.96	47.78	2.49
Mar	0.00	50.63	0.00	50.63	5.95	7.05	0.00	0.04	63.66	0.00	63.66	48.00	4.01	4.76	5.64	14.41	4.02	66.42	2.76
Apr	0.00	14.12	0.00	14.12	5.75	6.82	0.00	0.05	26.75	0.00	26.75	13.39	1.12	4.60	5.46	11.18	4.98	29.55	2.80
May	0.00	2.76	0.00	2.76	5.95	7.05	0.00	0.04	15.79	0.00	15.79	2.61	0.22	4.76	5.64	10.61	3.99	17.22	1.43
Total	0.00	1136.0	0.00	1136.0	70.00	83.00	0.00	1.68	1290.7	0.00	1290.7	1077.0	90.0	56.0	66.4	212.4	168.0	1457.4	166.72

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.15(f): Lower Coleroon Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	0.00	15.25	0.00	15.25	6.82	6.82	0.00	0.04	28.94	0.00	28.94	14.46	1.21	5.46	5.46	12.12	4.30	1.62	32.50	3.56
Jul	0.00	255.05	0.00	255.05	7.05	7.05	0.00	0.11	269.26	0.00	269.26	241.80	20.21	5.64	5.64	31.49	11.27	27.08	311.63	42.37
Aug	0.00	272.93	0.00	272.93	7.05	7.05	0.00	0.25	287.28	0.00	287.28	258.76	21.62	5.64	5.64	32.90	25.17	28.97	345.80	58.52
Sep	0.00	266.82	0.00	266.82	6.82	6.82	0.00	0.31	280.77	0.00	280.77	252.96	21.14	5.46	5.46	32.05	30.90	28.33	344.24	63.47
Oct	0.00	79.97	0.00	79.97	7.05	7.05	0.00	0.25	94.32	0.00	94.32	75.82	6.34	5.64	5.64	17.61	25.14	8.49	127.06	32.74
Nov	0.00	70.36	0.00	70.36	6.82	6.82	0.00	0.21	84.22	0.00	84.22	66.71	5.57	5.46	5.46	16.49	21.42	7.47	112.08	27.87
Dec	0.00	55.40	0.00	55.40	7.05	7.05	0.00	0.24	69.74	0.00	69.74	52.52	4.39	5.64	5.64	15.67	24.21	5.88	98.28	28.54
Jan	0.00	19.20	0.00	19.20	7.05	7.05	0.00	0.09	33.39	0.00	33.39	18.21	1.52	5.64	5.64	12.80	8.65	2.04	41.70	8.31
Feb	0.00	33.51	0.00	33.51	6.37	6.37	0.00	0.04	46.29	0.00	46.29	31.77	2.66	5.09	5.09	12.84	3.96	3.56	52.13	5.85
Mar	0.00	50.63	0.00	50.63	7.05	7.05	0.00	0.04	64.77	0.00	64.77	48.00	4.01	5.64	5.64	15.29	4.02	5.37	72.68	7.92
Apr	0.00	14.12	0.00	14.12	6.82	6.82	0.00	0.05	27.82	0.00	27.82	13.39	1.12	5.46	5.46	12.03	4.98	1.50	31.90	4.09
May	0.00	2.76	0.00	2.76	7.05	7.05	0.00	0.04	16.89	0.00	16.89	2.61	0.22	5.64	5.64	11.50	3.99	0.29	18.39	1.50
Total	0.00	1136.0	0.00	1136.0	83.00	83.00	0.00	1.68	1303.7	0.00	1303.7	1077.0	90.0	66.4	66.4	222.8	168.0	120.6	1588.4	284.72

Note : Column no. 10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.15(g): Lower Coleroon Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	0.00	15.25	0.00	15.25	5.75	6.82	0.00	0.02	27.84	0.00	27.84	14.46	1.21	4.60	5.46	11.27	1.66	27.39	-0.46
Jul	0.00	255.05	0.00	255.05	5.95	7.05	0.00	0.04	268.09	0.00	268.09	241.80	20.21	4.76	5.64	30.60	4.36	276.76	8.68
Aug	0.00	272.93	0.00	272.93	5.95	7.05	0.00	0.10	286.02	0.00	286.02	258.76	21.62	4.76	5.64	32.02	9.74	300.52	14.49
Sep	0.00	266.82	0.00	266.82	5.75	6.82	0.00	0.12	279.51	0.00	279.51	252.96	21.14	4.60	5.46	31.20	11.96	296.12	16.61
Oct	0.00	79.97	0.00	79.97	5.95	7.05	0.00	0.10	93.06	0.00	93.06	75.82	6.34	4.76	5.64	16.73	9.73	102.28	9.22
Nov	0.00	70.36	0.00	70.36	5.75	6.82	0.00	0.08	83.02	0.00	83.02	66.71	5.57	4.60	5.46	15.63	8.29	90.63	7.61
Dec	0.00	55.40	0.00	55.40	5.95	7.05	0.00	0.09	68.49	0.00	68.49	52.52	4.39	4.76	5.64	14.78	9.37	76.68	8.19
Jan	0.00	19.20	0.00	19.20	5.95	7.05	0.00	0.03	32.23	0.00	32.23	18.21	1.52	4.76	5.64	11.92	3.35	33.47	1.24
Feb	0.00	33.51	0.00	33.51	5.37	6.37	0.00	0.02	45.27	0.00	45.27	31.77	2.66	4.30	5.09	12.04	1.53	45.35	0.08
Mar	0.00	50.63	0.00	50.63	5.95	7.05	0.00	0.02	63.64	0.00	63.64	48.00	4.01	4.76	5.64	14.41	1.56	63.96	0.33
Apr	0.00	14.12	0.00	14.12	5.75	6.82	0.00	0.02	26.72	0.00	26.72	13.39	1.12	4.60	5.46	11.18	1.93	26.50	-0.22
May	0.00	2.76	0.00	2.76	5.95	7.05	0.00	0.02	15.77	0.00	15.77	2.61	0.22	4.76	5.64	10.61	1.54	14.77	-1.00
Total	0.00	1136.0	0.00	1136.0	70.00	83.00	0.00	0.65	1289.7	0.00	1289.7	1077.0	90.0	56.0	66.4	212.4	65.0	1354.4	64.75

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.15(h): Lower Coleroon Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	0.00	15.25	0.00	15.25	6.82	6.82	0.00	0.02	28.91	0.00	28.91	14.46	1.21	5.46	5.46	12.12	1.66	1.62	29.86	0.95
Jul	0.00	255.05	0.00	255.05	7.05	7.05	0.00	0.04	269.19	0.00	269.19	241.80	20.21	5.64	5.64	31.49	4.36	27.08	304.72	35.53
Aug	0.00	272.93	0.00	272.93	7.05	7.05	0.00	0.10	287.13	0.00	287.13	258.76	21.62	5.64	5.64	32.90	9.74	28.97	330.37	43.25
Sep	0.00	266.82	0.00	266.82	6.82	6.82	0.00	0.12	280.58	0.00	280.58	252.96	21.14	5.46	5.46	32.05	11.96	28.33	325.30	44.72
Oct	0.00	79.97	0.00	79.97	7.05	7.05	0.00	0.10	94.17	0.00	94.17	75.82	6.34	5.64	5.64	17.61	9.73	8.49	111.65	17.48
Nov	0.00	70.36	0.00	70.36	6.82	6.82	0.00	0.08	84.09	0.00	84.09	66.71	5.57	5.46	5.46	16.49	8.29	7.47	98.95	14.87
Dec	0.00	55.40	0.00	55.40	7.05	7.05	0.00	0.09	69.59	0.00	69.59	52.52	4.39	5.64	5.64	15.67	9.37	5.88	83.44	13.85
Jan	0.00	19.20	0.00	19.20	7.05	7.05	0.00	0.03	33.34	0.00	33.34	18.21	1.52	5.64	5.64	12.80	3.35	2.04	36.40	3.06
Feb	0.00	33.51	0.00	33.51	6.37	6.37	0.00	0.02	46.26	0.00	46.26	31.77	2.66	5.09	5.09	12.84	1.53	3.56	49.70	3.44
Mar	0.00	50.63	0.00	50.63	7.05	7.05	0.00	0.02	64.74	0.00	64.74	48.00	4.01	5.64	5.64	15.29	1.56	5.37	70.22	5.48
Apr	0.00	14.12	0.00	14.12	6.82	6.82	0.00	0.02	27.79	0.00	27.79	13.39	1.12	5.46	5.46	12.03	1.93	1.50	28.85	1.07
May	0.00	2.76	0.00	2.76	7.05	7.05	0.00	0.02	16.87	0.00	16.87	2.61	0.22	5.64	5.64	11.50	1.54	0.29	15.94	-0.93
Total	0.00	1136.0	0.00	1136.0	83.00	83.00	0.00	0.65	1302.7	0.00	1302.7	1077.0	90.0	66.4	66.4	222.8	65.0	120.6	1485.4	182.75

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.16(a): Cauvery Delta Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irriga-tion	Dome-stic	Indus-trial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	0.00	121.80	0.00	121.80	31.97	37.89	0.00	0.88	192.55	0.00	192.55	116.55	9.72	25.58	30.31	65.61	26.86	209.02	16.48
Jul	0.00	2037.47	0.00	2037.47	33.04	39.15	0.00	0.88	2110.54	0.00	2110.54	1949.68	162.55	26.43	31.32	220.30	70.45	2240.44	129.89
Aug	0.00	2180.33	0.00	2180.33	33.04	39.15	0.00	0.88	2253.41	0.00	2253.41	2086.39	173.95	26.43	31.32	231.70	157.17	2475.26	221.85
Sep	0.00	2131.49	0.00	2131.49	31.97	37.89	0.00	0.88	2202.24	0.00	2202.24	2039.66	170.05	25.58	30.31	225.94	193.02	2458.62	256.38
Oct	0.00	638.84	0.00	638.84	33.04	39.15	0.00	0.88	711.91	0.00	711.91	611.32	50.97	26.43	31.32	108.72	157.00	877.04	165.12
Nov	0.00	562.08	0.00	562.08	31.97	37.89	0.00	0.88	632.82	0.00	632.82	537.86	44.84	25.58	30.31	100.73	133.78	772.37	139.55
Dec	0.00	442.58	0.00	442.58	33.04	39.15	0.00	0.88	515.65	0.00	515.65	423.51	35.31	26.43	31.32	93.06	152.20	668.77	153.12
Jan	0.00	153.41	0.00	153.41	33.04	39.15	0.00	0.88	226.48	0.00	226.48	146.80	12.24	26.43	31.32	69.99	54.08	270.87	44.39
Feb	0.00	267.73	0.00	267.73	29.84	35.36	0.00	0.88	333.82	0.00	333.82	256.19	21.36	23.87	28.29	73.52	24.77	354.49	20.67
Mar	0.00	404.43	0.00	404.43	33.04	39.15	0.00	0.88	477.50	0.00	477.50	387.01	32.27	26.43	31.32	90.02	25.17	502.20	24.69
Apr	0.00	112.82	0.00	112.82	31.97	37.89	0.00	0.88	183.56	0.00	183.56	107.96	9.00	25.58	30.31	64.89	31.17	204.02	20.46
May	0.00	22.02	0.00	22.02	33.04	39.15	0.00	0.88	95.09	0.00	95.09	21.07	1.76	26.43	31.32	59.51	24.96	105.54	10.45
Total	0.00	9075.01	0.00	9075.01	389.0	461.0	0.00	10.56	9935.57	0.00	9935.57	8684.0	724.0	311.2	368.8	1404.0	1050.6	11138.6	1203.06

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.16(b): Cauvery Delta Sub-basin-Monthly Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation – Water requirements – Utilisation under irrigation projects – Proposed	Existing	Ongoing	Total	Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total	Export	Gross total utilisation	Water Availability – Import	Regeneration from uses – Irriga-tion	Dome-stic	Indus-trial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	0.00	121.80	0.00	121.80	37.89	37.89	0.00	0.88	192.55	0.00	198.46	116.55	9.72	30.31	30.31	70.34	26.86	3.01	216.77	18.31
Jul	0.00	2037.47	0.00	2037.47	39.15	39.15	0.00	0.88	2110.54	0.00	2116.66	1949.68	162.55	31.32	31.32	225.19	70.45	50.43	2295.75	179.10
Aug	0.00	2180.33	0.00	2180.33	39.15	39.15	0.00	0.88	2253.41	0.00	2259.52	2086.39	173.95	31.32	31.32	236.59	157.17	53.96	2534.11	274.59
Sep	0.00	2131.49	0.00	2131.49	37.89	37.89	0.00	0.88	2202.24	0.00	2208.16	2039.66	170.05	30.31	30.31	230.67	193.02	52.75	2516.10	307.95
Oct	0.00	638.84	0.00	638.84	39.15	39.15	0.00	0.88	711.91	0.00	718.03	611.32	50.97	31.32	31.32	113.61	157.00	15.81	897.74	179.71
Nov	0.00	562.08	0.00	562.08	37.89	37.89	0.00	0.88	632.82	0.00	638.74	537.86	44.84	30.31	30.31	105.47	133.78	13.91	791.02	152.28
Dec	0.00	442.58	0.00	442.58	39.15	39.15	0.00	0.88	515.65	0.00	521.77	423.51	35.31	31.32	31.32	97.95	152.20	10.95	684.62	162.85
Jan	0.00	153.41	0.00	153.41	39.15	39.15	0.00	0.88	226.48	0.00	232.60	146.80	12.24	31.32	31.32	74.88	54.08	3.80	279.56	46.96
Feb	0.00	267.73	0.00	267.73	35.36	35.36	0.00	0.88	333.82	0.00	339.34	256.19	21.36	28.29	28.29	77.94	24.77	6.63	365.53	26.19
Mar	0.00	404.43	0.00	404.43	39.15	39.15	0.00	0.88	477.50	0.00	483.62	387.01	32.27	31.32	31.32	94.91	25.17	10.01	517.10	33.48
Apr	0.00	112.82	0.00	112.82	37.89	37.89	0.00	0.88	183.56	0.00	189.48	107.96	9.00	30.31	30.31	69.63	31.17	2.79	211.55	22.07
May	0.00	22.02	0.00	22.02	39.15	39.15	0.00	0.88	95.09	0.00	101.21	21.07	1.76	31.32	31.32	64.40	24.96	0.54	110.98	9.77
Total	0.00	9075.01	0.00	9075.01	461.00	461.00	0.00	10.56	9935.57	0.00	10007.57	8684.00	724.00	368.80	368.8	1461.60	1050.63	224.6	11420.8	1413.3

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.16(c): Cauvery Delta Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	0.00	121.80	0.00	121.80	31.97	37.89	0.00	0.88	192.55	0.00	192.55	116.55	9.72	25.58	30.31	65.61	41.72	223.89	31.34
Jul	0.00	2037.5	0.00	2037.47	33.04	39.15	0.00	0.88	2110.54	0.00	2110.54	1949.68	162.55	26.43	31.32	220.30	109.43	2279.42	168.88
Aug	0.00	2180.3	0.00	2180.33	33.04	39.15	0.00	0.88	2253.41	0.00	2253.41	2086.39	173.95	26.43	31.32	231.70	244.14	2562.23	308.83
Sep	0.00	2131.5	0.00	2131.49	31.97	37.89	0.00	0.88	2202.24	0.00	2202.24	2039.66	170.05	25.58	30.31	225.9	299.83	2565.42	363.19
Oct	0.00	638.84	0.00	638.84	33.04	39.15	0.00	0.88	711.91	0.00	711.91	611.32	50.97	26.43	31.32	108.72	243.88	963.91	252.00
Nov	0.00	562.08	0.00	562.08	31.97	37.89	0.00	0.88	632.82	0.00	632.82	537.86	44.84	25.58	30.31	100.73	207.81	846.40	213.58
Dec	0.00	442.58	0.00	442.58	33.04	39.15	0.00	0.88	515.65	0.00	515.65	423.51	35.31	26.43	31.32	93.06	236.42	752.99	237.34
Jan	0.00	153.41	0.00	153.41	33.04	39.15	0.00	0.88	226.48	0.00	226.48	146.80	12.24	26.43	31.32	69.99	84.01	300.80	74.32
Feb	0.00	267.73	0.00	267.73	29.84	35.36	0.00	0.88	333.82	0.00	333.82	256.19	21.36	23.87	28.29	73.52	38.48	368.19	34.38
Mar	0.00	404.43	0.00	404.43	33.04	39.15	0.00	0.88	477.50	0.00	477.50	387.01	32.27	26.43	31.32	90.02	39.10	516.12	38.62
Apr	0.00	112.82	0.00	112.82	31.97	37.89	0.00	0.88	183.56	0.00	183.56	107.96	9.00	25.58	30.31	64.89	48.42	221.27	37.71
May	0.00	22.02	0.00	22.02	33.04	39.15	0.00	0.88	95.09	0.00	95.09	21.07	1.76	26.43	31.32	59.51	38.77	119.35	24.26
Total	0.00	9075.0	0.00	9075.01	389.0	461.00	0.00	10.56	9935.57	0.00	9935.57	8684.0	724.0	311.2	368.8	1404.0	1632.00	11720.0	1784.43

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.16(d): Cauvery Delta Sub-basin-Monthly Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation												Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	0.00	121.80	0.00	121.80	37.89	37.89	0.00	0.88	192.55	0.00	198.46	116.55	9.72	25.58	30.31	68.07	41.72	3.01	229.36	30.90
Jul	0.00	2037.5	0.00	2037.47	39.15	39.15	0.00	0.88	2110.54	0.00	2116.66	1949.68	162.55	26.43	31.32	261.50	109.43	50.43	2371.04	254.39
Aug	0.00	2180.3	0.00	2180.33	39.15	39.15	0.00	0.88	2253.41	0.00	2259.52	2086.39	173.95	26.43	31.32	275.79	244.14	53.96	2660.28	400.76
Sep	0.00	2131.5	0.00	2131.49	37.89	37.89	0.00	0.88	2202.24	0.00	2208.16	2039.66	170.05	25.58	30.31	269.04	299.83	52.75	2661.28	453.12
Oct	0.00	638.84	0.00	638.84	39.15	39.15	0.00	0.88	711.91	0.00	718.03	611.32	50.97	26.43	31.32	121.64	243.88	15.81	992.64	274.61
Nov	0.00	562.08	0.00	562.08	37.89	37.89	0.00	0.88	632.82	0.00	638.74	537.86	44.84	25.58	30.31	112.10	207.81	13.91	871.67	232.94
Dec	0.00	442.58	0.00	442.58	39.15	39.15	0.00	0.88	515.65	0.00	521.77	423.51	35.31	26.43	31.32	102.01	236.42	10.95	772.90	251.13
Jan	0.00	153.41	0.00	153.41	39.15	39.15	0.00	0.88	226.48	0.00	232.60	146.80	12.24	26.43	31.32	73.09	84.01	3.80	307.70	75.10
Feb	0.00	267.73	0.00	267.73	35.36	35.36	0.00	0.88	333.82	0.00	339.34	256.19	21.36	23.87	28.29	78.94	38.48	6.63	380.23	40.90
Mar	0.00	404.43	0.00	404.43	39.15	39.15	0.00	0.88	477.50	0.00	483.62	387.01	32.27	26.43	31.32	98.20	39.10	10.01	534.31	50.69
Apr	0.00	112.82	0.00	112.82	37.89	37.89	0.00	0.88	183.56	0.00	189.48	107.96	9.00	25.58	30.31	67.17	48.42	2.79	226.34	36.86
May	0.00	22.02	0.00	22.02	39.15	39.15	0.00	0.88	95.09	0.00	101.21	21.07	1.76	26.43	31.32	59.96	38.77	0.54	120.34	19.14
Total	0.00	9075.0	0.00	9075.01	461.0	461.00	0.00	10.56	9935.57	0.00	10007.6	8684.00	724.00	311.2	368.8	1587.5	1632.00	224.6	12128.1	2120.5

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.16(e): Cauvery Delta Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	0.00	121.80	0.00	121.80	31.97	37.89	0.00	0.88	192.55	0.00	192.55	116.55	9.72	25.58	30.31	65.61	15.06	197.22	4.68
Jul	0.00	2037.47	0.00	2037.47	33.04	39.15	0.00	0.88	2110.54	0.00	2110.54	1949.68	162.55	26.43	31.32	220.30	39.50	2209.49	98.94
Aug	0.00	2180.33	0.00	2180.33	33.04	39.15	0.00	0.88	2253.41	0.00	2253.41	2086.39	173.95	26.43	31.32	231.70	88.11	2406.20	152.79
Sep	0.00	2131.49	0.00	2131.49	31.97	37.89	0.00	0.88	2202.24	0.00	2202.24	2039.66	170.05	25.58	30.31	225.94	108.21	2373.81	171.57
Oct	0.00	638.84	0.00	638.84	33.04	39.15	0.00	0.88	711.91	0.00	711.91	611.32	50.97	26.43	31.32	108.72	88.02	808.06	96.14
Nov	0.00	562.08	0.00	562.08	31.97	37.89	0.00	0.88	632.82	0.00	632.82	537.86	44.84	25.58	30.31	100.73	75.00	713.59	80.77
Dec	0.00	442.58	0.00	442.58	33.04	39.15	0.00	0.88	515.65	0.00	515.65	423.51	35.31	26.43	31.32	93.06	85.33	601.90	86.25
Jan	0.00	153.41	0.00	153.41	33.04	39.15	0.00	0.88	226.48	0.00	226.48	146.80	12.24	26.43	31.32	69.99	30.32	247.11	20.63
Feb	0.00	267.73	0.00	267.73	29.84	35.36	0.00	0.88	333.82	0.00	333.82	256.19	21.36	23.87	28.29	73.52	13.89	343.61	9.79
Mar	0.00	404.43	0.00	404.43	33.04	39.15	0.00	0.88	477.50	0.00	477.50	387.01	32.27	26.43	31.32	90.02	14.11	491.14	13.63
Apr	0.00	112.82	0.00	112.82	31.97	37.89	0.00	0.88	183.56	0.00	183.56	107.96	9.00	25.58	30.31	64.89	17.45	190.30	6.74
May	0.00	22.02	0.00	22.02	33.04	39.15	0.00	0.88	95.09	0.00	95.09	21.07	1.76	26.43	31.32	59.51	14.00	94.58	-0.51
Total	0.00	9075.01	0.00	9075.01	389.0	461.0	0.00	10.56	9935.57	0.00	9935.57	8684.0	724.0	311.2	368.8	1404.0	589.00	10677.0	741.43

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.16(f): Cauvery Delta Sub-basin-Monthly Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	0.00	121.80	0.00	121.80	37.89	37.89	0.00	0.88	192.55	0.00	198.46	116.55	9.72	30.31	30.31	70.34	15.06	3.01	204.97	6.51
Jul	0.00	2037.47	0.00	2037.47	39.15	39.15	0.00	0.88	2110.54	0.00	2116.66	1949.68	162.55	31.32	31.32	225.19	39.50	50.43	2264.80	148.15
Aug	0.00	2180.33	0.00	2180.33	39.15	39.15	0.00	0.88	2253.41	0.00	2259.52	2086.39	173.95	31.32	31.32	236.59	88.11	53.96	2465.05	205.53
Sep	0.00	2131.49	0.00	2131.49	37.89	37.89	0.00	0.88	2202.24	0.00	2208.16	2039.66	170.05	30.31	30.31	230.67	108.21	52.75	2431.29	223.14
Oct	0.00	638.84	0.00	638.84	39.15	39.15	0.00	0.88	711.91	0.00	718.03	611.32	50.97	31.32	31.32	113.61	88.02	15.81	828.76	110.73
Nov	0.00	562.08	0.00	562.08	37.89	37.89	0.00	0.88	632.82	0.00	638.74	537.86	44.84	30.31	30.31	105.47	75.00	13.91	732.24	93.50
Dec	0.00	442.58	0.00	442.58	39.15	39.15	0.00	0.88	515.65	0.00	521.77	423.51	35.31	31.32	31.32	97.95	85.33	10.95	617.75	95.98
Jan	0.00	153.41	0.00	153.41	39.15	39.15	0.00	0.88	226.48	0.00	232.60	146.80	12.24	31.32	31.32	74.88	30.32	3.80	255.80	23.20
Feb	0.00	267.73	0.00	267.73	35.36	35.36	0.00	0.88	333.82	0.00	339.34	256.19	21.36	28.29	28.29	77.94	13.89	6.63	354.65	15.31
Mar	0.00	404.43	0.00	404.43	39.15	39.15	0.00	0.88	477.50	0.00	483.62	387.01	32.27	31.32	31.32	94.91	14.11	10.01	506.04	22.42
Apr	0.00	112.82	0.00	112.82	37.89	37.89	0.00	0.88	183.56	0.00	189.48	107.96	9.00	30.31	30.31	69.63	17.45	2.79	197.83	8.35
May	0.00	22.02	0.00	22.02	39.15	39.15	0.00	0.88	95.09	0.00	101.21	21.07	1.76	31.32	31.32	64.40	14.00	0.54	100.02	-1.19
Total	0.00	9075.01	0.00	9075.01	461.0	461.0	0.00	10.56	9935.57	0.00	10007.6	8684.00	724.00	368.8	368.8	1461.6	589.00	224.6	10959.2	951.6

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.16(g): Cauvery Delta Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Jun	0.00	121.80	0.00	121.80	31.97	37.89	0.00	0.88	192.55	0.00	192.55	116.55	9.72	25.58	30.31	65.61	4.96	187.12	-5.42
Jul	0.00	2037.5	0.00	2037.47	33.04	39.15	0.00	0.88	2110.54	0.00	2110.54	1949.68	162.55	26.43	31.32	220.30	13.01	2183.0	72.45
Aug	0.00	2180.3	0.00	2180.33	33.04	39.15	0.00	0.88	2253.41	0.00	2253.41	2086.39	173.95	26.43	31.32	231.70	29.02	2347.1	93.70
Sep	0.00	2131.5	0.00	2131.49	31.97	37.89	0.00	0.88	2202.24	0.00	2202.24	2039.66	170.05	25.58	30.31	225.94	35.64	2301.24	99.00
Oct	0.00	638.84	0.00	638.84	33.04	39.15	0.00	0.88	711.91	0.00	711.91	611.32	50.97	26.43	31.32	108.72	26.00	746.04	34.12
Nov	0.00	562.08	0.00	562.08	31.97	37.89	0.00	0.88	632.82	0.00	632.82	537.86	44.84	25.58	30.31	100.73	24.70	663.29	30.47
Dec	0.00	442.58	0.00	442.58	33.04	39.15	0.00	0.88	515.65	0.00	515.65	423.51	35.31	26.43	31.32	93.06	28.10	544.67	29.02
Jan	0.00	153.41	0.00	153.41	33.04	39.15	0.00	0.88	226.48	0.00	226.48	146.80	12.24	26.43	31.32	69.99	9.99	226.78	0.30
Feb	0.00	267.73	0.00	267.73	29.84	35.36	0.00	0.88	333.82	0.00	333.82	256.19	21.36	23.87	28.29	73.52	4.57	334.29	0.47
Mar	0.00	404.43	0.00	404.43	33.04	39.15	0.00	0.88	477.50	0.00	477.50	387.01	32.27	26.43	31.32	90.02	4.65	481.68	4.17
Apr	0.00	112.82	0.00	112.82	31.97	37.89	0.00	0.88	183.56	0.00	183.56	107.96	9.00	25.58	30.31	64.89	5.75	178.60	-4.96
May	0.00	22.02	0.00	22.02	33.04	39.15	0.00	0.88	95.09	0.00	95.09	21.07	1.76	26.43	31.32	59.51	4.61	85.19	-9.90
Total	0.00	9075.0	0.00	9075.01	389.0	461.0	0.00	10.56	9935.57	0.00	9935.57	8684.0	724.0	311.2	368.8	1404.0	191.00	10279.0	343.43

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.10.16(h): Cauvery Delta Sub-basin-Monthly Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Month	Water Utilisation											Water Availability									Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Jun	0.00	121.80	0.00	121.80	37.89	37.89	0.00	0.88	198.46	0.00	198.46	116.55	9.72	30.31	30.31	70.34	4.96	3.01	194.87	-3.59
Jul	0.00	2037.5	0.00	2037.47	39.15	39.15	0.00	0.88	2116.66	0.00	2116.66	1949.68	162.55	31.32	31.32	225.19	13.01	50.43	2238.31	121.66
Aug	0.00	2180.3	0.00	2180.33	39.15	39.15	0.00	0.88	2259.52	0.00	2259.52	2086.39	173.95	31.32	31.32	236.59	29.02	53.96	2405.96	146.44
Sep	0.00	2131.5	0.00	2131.49	37.89	37.89	0.00	0.88	2208.16	0.00	2208.16	2039.66	170.05	30.31	30.31	230.67	35.64	52.75	2358.72	150.57
Oct	0.00	638.84	0.00	638.84	39.15	39.15	0.00	0.88	718.03	0.00	718.03	611.32	50.97	31.32	31.32	113.61	26.00	15.81	766.74	48.71
Nov	0.00	562.08	0.00	562.08	37.89	37.89	0.00	0.88	638.74	0.00	638.74	537.86	44.84	30.31	30.31	105.47	24.70	13.91	681.94	43.20
Dec	0.00	442.58	0.00	442.58	39.15	39.15	0.00	0.88	521.77	0.00	521.77	423.51	35.31	31.32	31.32	97.95	28.10	10.95	560.52	38.75
Jan	0.00	153.41	0.00	153.41	39.15	39.15	0.00	0.88	232.60	0.00	232.60	146.80	12.24	31.32	31.32	74.88	9.99	3.80	235.47	2.87
Feb	0.00	267.73	0.00	267.73	35.36	35.36	0.00	0.88	339.34	0.00	339.34	256.19	21.36	28.29	28.29	77.94	4.57	6.63	345.33	5.99
Mar	0.00	404.43	0.00	404.43	39.15	39.15	0.00	0.88	483.62	0.00	483.62	387.01	32.27	31.32	31.32	94.91	4.65	10.01	496.58	12.96
Apr	0.00	112.82	0.00	112.82	37.89	37.89	0.00	0.88	189.48	0.00	189.48	107.96	9.00	30.31	30.31	69.63	5.75	2.79	186.13	-3.35
May	0.00	22.02	0.00	22.02	39.15	39.15	0.00	0.88	101.21	0.00	101.21	21.07	1.76	31.32	31.32	64.40	4.61	0.54	90.63	-10.58
Total	0.00	9075.0	0.00	9075.01	461.0	461.0	0.00	10.56	10007.6	0.00	10007.6	8684.00	724.00	368.8	368.8	1461.6	191.00	224.6	10561.2	553.6

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.10.17(a): Cauvery Basin-Sub-basinwise Monthly Water Balance (surplus or deficit) for 75% Water Year Dependable Flow, Without Ground Water

Sub-basinwise Monthly surplus or deficit.

Month	Up.Cau.	Kabini	Shims.	Arkav.	Mid.Ca.	Suvar.	Palar	Chinn.	Bhava.	Noyil	Amara.	Thiru.	Ponna.	Up.Col.	L.Cole.	Cau.Del.	Total
Jun	-284.3	276.8	-0.1	-30.4	-4.4	-1.1	6.0	-460.2	-128.2	-49.7	-143.5	-51.6	-12.7	-2.8	3.6	16.5	-866.0
Jul	1221.7	261.4	-36.8	-66.8	-27.5	-17.1	-30.7	-156.7	55.0	-30.7	-109.3	-40.9	-18.8	-69.1	19.4	129.9	1083.0
Aug	765.9	285.3	-38.6	-79.9	4.1	-17.0	-21.5	-170.1	-65.4	-26.5	-82.1	-65.2	-11.5	-61.2	38.4	221.9	676.5
Sep	-536.6	-78.9	47.5	-5.2	47.0	-6.0	-10.0	-3203.5	-8.1	-11.2	-3.1	-60.9	8.9	-17.5	46.0	256.4	-3535.0
Oct	-733.2	252.2	302.3	9.3	65.9	6.5	1.8	-4322.6	178.8	106.4	128.2	267.4	9.8	45.7	33.1	165.1	-3483.2
Nov	-23.8	24.9	90.6	-53.2	58.5	3.8	-13.7	-2940.8	230.9	53.4	192.5	107.7	43.8	132.5	28.0	139.6	-1925.4
Dec	-99.2	-247.1	-41.0	-146.1	-0.9	-9.9	-19.1	-656.2	100.0	23.2	156.0	50.5	-1.6	66.6	31.2	153.1	-640.3
Jan	-169.8	-474.7	-71.6	-167.3	-22.7	-14.6	-24.8	-219.1	-134.0	-20.1	-61.8	-37.2	-13.7	9.7	9.5	44.4	-1367.7
Feb	-216.8	-431.4	-57.9	-112.3	-23.2	-12.9	-27.3	-196.3	-247.2	-22.9	-113.9	-103.0	0.2	-3.8	3.9	20.7	-1544.4
Mar	-217.0	-206.5	-36.4	-77.2	-18.5	-8.2	-16.2	-222.5	-296.4	-25.3	-144.4	-147.4	-7.2	-13.5	4.1	24.7	-1407.8
Apr	-27.1	-0.1	-16.6	-43.5	-8.3	-2.9	-5.4	-168.4	-89.2	-20.9	-54.7	-82.8	-8.8	-3.9	4.5	20.5	-507.5
May	44.8	69.9	9.3	-26.5	-3.1	-0.5	-0.6	-386.7	-24.9	-42.2	-34.9	-62.5	-2.0	4.8	2.8	10.4	-441.9
Total	-275.5	-271.1	150.7	-799.2	66.9	-79.6	-161.5	-13103.1	-423.6	-66.4	-750.6	-225.9	-13.7	86.6	222.2	1203.1	-14441

Table 4.10.17(b): Cauvery Basin-Sub-basinwise Monthly Water Balance (surplus or deficit) for 75% Water Year Dependable Flow, With Ground Water

Sub-basinwise Monthly surplus or deficit.

Month	Up.Cau.	Kabini	Shims.	Arkav.	Mid.Ca.	Suvar.	Palar	Chinn.	Bhava.	Noyil	Amara.	Thiru.	Ponna.	Up.Col.	L.Cole.	Cau.Del.	Total
Jun	-238.6	284.7	8.0	-27.6	-2.4	-0.4	7.6	-460.2	-104.7	-42.1	-112.7	-32.5	2.0	0.6	5.3	22.0	-691.1
Jul	1328.4	330.2	16.7	-60.1	11.3	-5.0	-3.1	-156.7	86.5	-26.4	-68.5	-26.4	4.3	-12.4	46.5	221.5	1687.0
Aug	873.5	352.6	21.4	-70.9	39.7	-5.9	4.0	-170.1	-36.7	-23.2	-46.5	-39.9	2.3	-0.5	67.4	319.9	1287.1
Sep	-431.1	-25.1	93.2	5.1	75.6	3.1	10.6	-3203.5	4.7	-9.5	15.2	-28.8	21.0	41.8	74.3	352.2	-3001.1
Oct	-618.0	258.2	309.0	16.7	68.5	7.3	4.3	-4322.6	179.8	106.6	130.1	293.1	39.0	63.5	41.6	193.9	-3229.0
Nov	-16.1	42.7	128.2	-44.5	67.2	6.5	-6.5	-2940.8	231.9	53.7	193.8	137.2	67.8	148.1	35.5	164.8	-1730.6
Dec	-82.3	-211.9	28.3	-129.8	17.0	-4.2	-7.0	-656.2	104.8	24.4	163.2	71.7	30.9	79.0	37.1	173.0	-362.1
Jan	-149.9	-423.7	20.2	-149.2	2.8	-6.1	-10.1	-219.1	-117.4	-17.9	-43.7	-26.3	11.9	14.0	11.5	51.3	-1051.7
Feb	-191.8	-385.1	14.4	-100.7	-0.1	-5.3	-11.8	-196.3	-222.9	-20.0	-87.0	-57.4	5.8	3.6	7.4	32.7	-1214.5
Mar	-192.9	-182.4	2.7	-69.9	-2.5	-3.9	-7.0	-222.5	-269.3	-22.2	-113.4	-79.7	4.0	-2.2	9.5	42.9	-1108.7
Apr	-23.0	5.6	-1.4	-40.1	-2.7	-1.7	-2.9	-168.4	-79.3	-18.5	-43.5	-48.1	0.4	-0.7	6.0	25.5	-392.7
May	44.8	72.5	16.1	-24.6	-2.1	-0.2	0.2	-386.7	-18.2	-36.0	-23.8	-38.6	4.3	5.4	3.1	11.4	-372.5
Total	303.0	115.3	656.7	-695.7	272.5	-15.7	-21.8	-13103	-235.9	-31.2	-442.6	124.2	193.7	339.2	342.8	1611.2	-10587

Table 4.10.17(c): Cauvery Basin-Sub-basinwise Monthly Water Balance (surplus or deficit) for 90% Water Year Dependable Flow, Without Ground Water

Sub-basinwise Monthly surplus or deficit.

Month	Up.Cau.	Kabini	Shims.	Arkav.	Mid.Ca.	Suvar.	Palar	Chinn.	Bhava.	Noyil	Amara.	Thiru.	Ponna.	Up.Col.	L.Cole.	Cau.Del.	Total
Jun	-60.12	124.43	-3.01	-32.01	-2.98	-2.22	2.90	-355.25	-111.54	-49.77	-157.5	-51.66	-13.1	-4.23	2.16	4.68	-709.17
Jul	-40.05	-115.47	-37.19	-31.73	0.02	-19.28	-37.27	-124.16	-179.61	-30.76	-208.3	-40.99	-19.2	-76.14	15.52	98.94	-845.71
Aug	-341.94	-83.38	-39.34	-41.34	8.43	-18.15	-29.63	-131.97	-91.56	-26.54	-148.9	-65.16	-12.0	-71.20	29.77	152.79	-910.15
Sep	-255.04	-161.60	30.85	-152.09	19.23	-12.96	-19.02	-2399.1	-33.01	-11.50	-34.98	-61.49	5.28	-35.69	35.36	171.57	-2914.19
Oct	-171.40	257.47	237.62	-138.94	17.73	-0.48	-0.49	-3228.5	44.94	100.16	41.00	254.53	4.01	29.54	24.47	96.14	-2432.20
Nov	165.97	-3.14	65.98	-70.38	17.27	-3.26	-13.78	-2203.2	43.97	50.01	147.29	100.69	33.06	99.90	20.61	80.77	-1468.23
Dec	-45.15	-166.18	-42.21	-41.15	2.23	-10.27	-20.33	-506.72	45.14	21.25	11.47	46.31	-5.87	48.24	22.88	86.25	-554.10
Jan	-94.52	-262.22	-68.96	-34.47	-2.13	-14.55	-25.67	-172.58	-9.54	-20.10	-79.57	-37.17	-15.2	5.45	6.49	20.63	-804.15
Feb	-122.16	-239.02	-55.79	-26.85	-2.69	-13.00	-27.87	-165.32	-95.23	-22.89	-178.9	-103.0	-1.19	-6.44	2.49	9.79	-1048.04
Mar	-128.36	-84.99	-35.26	-24.91	-3.43	-8.27	-16.68	-188.67	-172.38	-25.34	-205.1	-147.3	-8.07	-15.60	2.76	13.63	-1047.92
Apr	229.58	33.43	-16.85	-23.06	-3.15	-3.23	-5.50	-143.32	-48.21	-20.90	-49.03	-82.74	-9.21	-5.00	2.80	6.74	-137.66
May	311.32	133.96	4.51	-29.11	-2.94	-1.75	-1.15	-304.84	-3.63	-42.01	22.68	-62.52	-3.17	2.81	1.43	-0.51	25.08
Total	-551.86	-863.02	37.79	-883.19	12.43	-108.4	-194.49	-13183	-829.10	-78.40	-839.9	-250.5	-44.7	-28.36	166.72	741.43	-16896.7

Table 4.10.17(d): Cauvery Basin-Sub-basinwise Monthly Water Balance (surplus or deficit) for 90% Water Year Dependable Flow, With Ground Water

Sub-basinwise Monthly surplus or deficit.

Month	Up.Cau.	Kabini	Shims.	Arkav.	Mid.Ca.	Suvar.	Palar	Chinn.	Bhava.	Noyil	Amara.	Thiru.	Ponna.	Up.Col.	L.Cole.	Cau.Del.	Total
Jun	-14.39	132.43	6.73	-30.60	-0.91	-1.57	4.47	-342.28	-88.14	-41.35	-121.2	-32.51	1.60	-0.84	3.78	7.69	-517.04
Jul	66.65	-45.80	27.11	-62.30	38.96	-7.21	-9.64	-117.26	-148.11	-26.32	-160.0	-26.52	3.91	-19.43	42.59	149.37	-294.03
Aug	-234.23	-15.22	32.77	-74.99	44.26	-7.06	-4.24	-127.25	-62.87	-23.13	-106.9	-39.86	1.84	-10.51	58.74	206.76	-361.94
Sep	-149.59	-107.21	85.83	-23.99	47.99	-3.93	1.57	-2382.5	-20.25	-9.85	-13.31	-29.49	17.41	23.64	63.68	224.32	-2275.65
Oct	-56.20	263.51	246.28	-9.68	20.32	0.32	2.01	-3214.9	45.93	100.39	43.29	280.12	33.20	47.32	32.96	111.95	-2053.19
Nov	173.72	14.85	111.35	-55.36	25.98	-0.58	-6.63	-2187.1	44.89	50.30	148.88	130.17	57.07	115.5	28.08	94.68	-1254.13
Dec	-28.29	-130.61	40.92	-132.72	20.22	-4.54	-8.26	-487.77	49.95	22.16	20.00	67.47	26.61	60.56	28.76	97.20	-358.33
Jan	-74.65	-210.71	41.11	-150.31	23.57	-6.09	-11.04	-163.23	7.03	-17.78	-58.13	-26.28	10.43	9.72	8.53	24.43	-593.41
Feb	-97.17	-192.16	31.03	-101.43	20.59	-5.43	-12.40	-145.93	-70.98	-19.87	-147.0	-57.43	4.39	1.01	6.05	16.42	-770.31
Mar	-104.24	-60.64	11.61	-70.50	12.74	-3.92	-7.45	-165.00	-145.23	-22.00	-168.4	-79.73	3.11	-4.35	8.14	23.64	-772.25
Apr	233.70	39.15	1.32	-40.92	2.48	-2.09	-2.91	-125.10	-38.34	-18.36	-35.68	-48.13	0.05	-1.86	4.30	9.53	-22.84
May	311.32	136.54	12.72	-26.86	-1.90	-1.42	-0.37	-287.70	3.02	-37.71	35.87	-38.58	3.09	3.42	1.72	0.03	113.20
Total	-244.59	-476.37	646.06	-779.69	219.15	-44.52	-54.79	-13005	-641.57	-43.52	-531.6	99.24	162.7	224.2	287.32	966.03	-13217.4

Table 4.10.17(e): Cauvery Basin-Sub-basinwise Monthly Water Balance (surplus or deficit) for 100% Water Year Dependable Flow, Without Ground Water

Sub-basinwise Monthly surplus or deficit.

Month	Up.Cau.	Kabini	Shims.	Arkav.	Mid.Ca.	Suvar.	Palar	Chinn.	Bhava.	Noyil	Amara.	Thiru.	Ponna.	Up.Col.	L.Cole.	Cau.Del.	Total
Jun	-83.48	10.28	-7.62	-26.88	-3.07	-2.63	-2.17	-168.06	-120.69	-49.79	-166.4	-51.76	-14.3	-7.74	-0.46	-5.42	-700.11
Jul	-95.77	-172.78	-40.07	-27.92	-1.64	-20.09	-47.94	-65.74	-148.77	-30.82	-184.4	-41.29	-20.4	-93.44	8.68	72.45	-909.90
Aug	-396.86	-170.23	-42.99	-34.32	4.10	-18.59	-43.02	-63.62	-171.34	-26.54	-144.3	-65.16	-13.6	-95.77	14.49	93.70	-1174.00
Sep	-276.52	-174.77	4.28	-101.55	11.54	-15.48	-33.79	-960.76	-54.01	-11.82	-59.49	-63.04	-5.95	-80.26	16.61	99.00	-1706.02
Oct	-381.83	55.33	142.20	-93.08	10.90	-2.98	-4.29	-1272.3	54.29	93.94	33.15	223.93	-13.9	-10.02	9.22	34.12	-1121.31
Nov	33.12	40.77	28.09	-51.60	10.52	-5.79	-13.91	-884.49	6.10	46.64	12.73	84.11	-0.12	20.03	7.61	30.47	-635.72
Dec	-92.91	-172.39	-47.01	-36.06	0.18	-10.41	-22.32	-240.05	79.71	19.24	-7.95	36.43	-19.1	3.21	8.19	29.02	-472.26
Jan	-107.76	-261.15	-69.10	-32.46	-2.89	-14.57	-27.15	-89.92	-92.03	-20.10	-93.39	-37.17	-19.9	-4.96	1.24	0.30	-871.00
Feb	-83.64	-240.86	-55.83	-25.55	-3.13	-13.05	-28.76	-109.68	-142.24	-22.89	-176.2	-103.0	-5.48	-12.81	0.08	0.47	-1022.52
Mar	-128.79	-111.89	-35.33	-23.93	-3.63	-8.30	-17.48	-128.66	-167.30	-25.34	-178.7	-147.3	-10.9	-20.75	0.33	4.17	-1003.71
Apr	63.81	6.62	-17.93	-21.62	-3.24	-3.36	-5.59	-98.81	13.97	-20.90	-1.63	-82.74	-10.4	-7.78	-0.22	-4.96	-194.78
May	153.72	98.65	-2.75	-25.14	-3.06	-2.18	-2.07	-158.19	-27.18	-42.01	-36.90	-62.52	-6.83	-2.07	-1.00	-9.90	-129.41
Total	-1398.8	-1910.4	-151.19	-963.19	-73.57	-118.4	-248.48	-13326	-1124.1	-90.40	-1004	-309.5	-141	-312.4	64.75	343.43	-20763.0

Table 4.10.17(f): Cauvery Basin-Sub-basinwise Monthly Water Balance (surplus or deficit) for 100% Water Year Dependable Flow, With Ground Water

Sub-basinwise Monthly surplus or deficit.

Month	Up.Cau.	Kabini	Shims.	Arkav.	Mid.Ca.	Suvar.	Palar	Chinn.	Bhava.	Noyil	Amara.	Thiru.	Ponna.	Up.Col.	L.Cole.	Cau.Del.	Total
Jun	-37.75	18.29	0.57	-33.41	-1.00	-1.98	-0.60	-155.09	-97.29	-41.37	-190.2	-32.61	0.43	-4.35	1.16	0.05	-575.09
Jul	10.93	-103.11	13.67	-64.39	37.29	-8.02	-20.31	-58.84	-117.28	-26.38	-185.9	-26.82	2.74	-36.73	35.75	164.08	-333.25
Aug	-289.16	-102.07	17.29	-78.84	39.92	-7.50	-17.63	-58.90	-142.66	-23.13	-107.7	-39.86	0.29	-35.08	43.47	191.75	-609.83
Sep	-171.06	-120.38	50.50	-51.71	40.31	-6.45	-13.20	-944.16	-41.25	-10.17	-10.26	-31.04	6.18	-20.93	44.93	194.85	-1083.84
Oct	-266.63	61.37	150.51	-34.83	13.49	-2.18	-1.79	-1258.7	55.27	94.17	48.74	249.52	15.34	7.76	17.71	62.85	-787.45
Nov	40.86	58.76	66.41	-65.66	19.24	-3.11	-6.76	-868.40	7.03	46.93	38.29	113.59	23.89	35.68	15.08	55.75	-422.41
Dec	-76.05	-136.83	22.48	-135.51	18.17	-4.68	-10.25	-221.09	84.52	20.15	-17.16	57.59	13.34	15.53	14.07	48.92	-306.79
Jan	-87.89	-209.63	22.83	-151.41	22.81	-6.11	-12.52	-80.57	-75.46	-17.78	-56.20	-26.28	5.77	-0.69	3.28	7.20	-662.64
Feb	-58.65	-194.00	16.69	-102.14	20.15	-5.48	-13.29	-90.29	-118.00	-19.87	-117.8	-57.43	0.10	-5.36	3.64	12.51	-729.22
Mar	-104.68	-87.53	3.82	-71.04	12.55	-3.95	-8.25	-104.99	-140.16	-22.00	-166.5	-79.73	0.31	-9.50	5.70	22.36	-753.62
Apr	67.94	12.34	-2.74	-41.71	2.39	-2.22	-3.00	-80.59	23.85	-18.36	-36.81	-48.13	-1.14	-4.64	1.28	0.11	-131.41
May	153.72	101.24	4.19	-29.04	-2.02	-1.85	-1.29	-141.05	-20.53	-37.71	11.65	-38.58	-0.57	-1.46	-0.71	-8.91	-12.91
Total	-1917.7	-1523.8	358.97	-859.69	133.15	-54.52	-108.78	-13148	-936.57	-55.52	-695.6	40.24	66.69	-59.76	185.35	751.53	-17824.5

Table 4.11.1(a): Abstract : Cauvery Basin-Sub-basinwise Water Balance for 75% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Name of Sub-basin	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Upper Cauvery	463	1489	1101	3053	233	321	0	54	3661	2640	6301	0	189	186	257	632	5394	6026	-274
Kabini	1035	666	872	2573	225	280	9	36	3124	1795	4919	359	247	180	224	651	3641	4651	-268
Shimsha	263	1830	1056	3151	259	348	0	6	3764	15	3779	2490	335	207	278	821	619	3930	151
Arkavathi	196	181	122	496	479	559	0	3	1536	810	2347	409	21	383	447	851	287	1547	-799
Middle Cauvery	205	790	795	1790	83	109	0	3	1985	211	2196	1587	193	66	87	347	330	2264	67
Suvarnavathi	302	136	203	640	35	63	0	0	739	0	739	492	50	28	50	128	38	658	-80
Palar	220	12	35	268	11	44	0	1	323	0	323	0	13	9	35	57	105	162	-161
Chinnar	534	148	0	682	87	123	0	3	896	12712	13608	0	25	70	98	193	312	505	-13103
Bhavani	170	1033	126	1330	179	229	35	19	1792	1036	2828	12	147	143	183	474	1917	2403	-425
Noyil	148	547	20	715	210	252	0	2	1160	0	1160	446	53	168	202	423	225	1094	-66
Amaravathi	673	1420	40	2133	230	305	1	9	2678	0	2678	475	130	184	244	558	898	1931	-747
Tirumanimuttar	422	2307	0	2728	412	530	0	6	3677	0	3673	1769	276	330	424	1030	649	3448	-226
Ponnanai Ar	33	661	0	693	126	155	0	2	977	0	977	467	80	101	124	305	191	963	-14
Upper Colerron	277	822	0	1099	110	134	0	6	1349	0	1349	582	69	88	107	264	589	1435	87
Lower Coleroon	0	1136	0	1136	70	83	0	2	1291	0	1291	1077	90	56	66	212	224	1513	222
Cauvery Delta	0	9075	0	9075	389	461	0	11	9936	0	9936	8684	724	311	369	1404	1051	11139	1203
Total	4941	22254	4369	31562	3138	3996	45	165	38887	19219	58102	18849	2642	2510	3197	8349	16470	43669	-14434

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.11.1(b): Abstract : Cauvery Basin-Sub-basinwise Water Balance for 75% Water Year Dependable Flow, With Ground Water

Unit : MCM

Name of Sub-basin	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Upper Cauvery	463	1489	1101	3053	321	321	0	54	3749	2640	6389	0	189	257	257	703	5394	579	6675	286
Kabini	1035	666	872	2573	280	280	9	36	3179	1795	4974	359	247	224	224	695	3641	386	5081	108
Shimsha	263	1831	1056	3150	348	348	0	6	3852	15	3867	2490	335	278	278	892	619	506	4507	640
Arkavathi	196	181	122	496	559	559	0	3	1617	810	2427	409	21	447	447	915	287	104	1715	-713
Middle Cauvery	205	790	794	1789	109	109	0	3	2010	211	2221	1587	193	87	87	367	330	206	2490	269
Suvarnavathi	302	136	203	640	63	63	0	0	767	0	767	492	50	50	50	151	38	64	745	-22
Palar	220	12	35	268	44	44	0	1	357	0	357	0	13	35	35	83	105	140	328	-28
Chinnar	534	148	0	682	123	123	0	3	932	12712	13644	0	25	98	98	222	312	178	711	-12932
Bhavani	170	1033	126	1330	229	229	35	19	1842	1036	2878	12	147	183	183	513	1917	188	2630	-247
Noyil	148	547	20	715	252	252	0	2	1221	0	1221	446	53	202	202	456	225	54	1181	-40
Amaravathi	673	1420	40	2133	305	305	1	9	2753	0	2753	475	130	244	244	618	898	308	2299	-454
Tirumanimuttar	422	2304	0	2725	530	530	0	6	3791	0	3791	1769	276	424	424	1124	649	350	3892	101
Ponnanai Ar	33	661	0	693	155	155	0	2	1005	0	1005	467	80	124	124	328	191	207	1193	188
Upper Colerron	277	822	0	1099	134	134	0	6	1373	0	1373	582	69	107	107	283	589	253	1707	334
Lower Coleroon	0	1136	0	1136	83	83	0	2	1304	0	1304	1077	90	66	66	223	224	121	1644	340
Cauvery Delta	0	9075	0	9075	461	461	0	11	9936	0	10008	8684	724	369	369	1462	1051	225	11421	1413
Total	4941	22252	4367	31557	3996	3996	45	165	39686	19219	58978	18849	2642	3197	3197	9036	16470	3866	48221	-10756

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.11.2(a): Abstract : Cauvery Basin-Sub-basinwise Water Balance for 50% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Name of Sub-basin	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses			Total	Surface water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial				
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Upper Cauvery	463	1489	1100.8	3053	233	321	0	63.19	3670	3092	6762.43	0	188.9	186.4	256.8	632.1	6318.6	6950.7	188.3
Kabini	1035	666	872	2573	225	280	9	44	3131	1795	4926	359	247	180	224	651	4376	5386	460
Shimsha	263	1830	1056	3151	259	348	6	0	3764	15	3779	2490	335	207	278	821	763	4074	295
Arkavathi	196	181	122	496	479	559	3	2	1536	810	2347	409	21	383	447	851	389	1649	-697
Middle Cauvery	205	790	795	1790	83	109	0	3	1985	211	2196	1587	193	66	87	347	392	2326	129
Suvarnavathi	302	136	203	640	35	63	0	0	739	0	739	492	50	28	50	128	95	715	-23
Palar	220	12	35	268	11	44	0	1	323	0	323	0	13	9	35	57	171	228	-95
Chinnar	534	148	0	682	87	123	0	3	896	15646	16542	0	25	70	98	193	384	577	-15965
Bhavani	170	1033	126	1330	179	229	35	19	1792	1036	2828	12	147	143	183	474	2444	2930	102
Noyil	148	547	20	715	210	252	0	2	1160	0	1160	446	53	168	202	423	234	1103	-57
Amaravathi	673	1420	40	2133	230	305	1	9	2678	0	2678	475	130	184	244	558	1108	2141	-537
Tirumanimuttar	422	2307	0	2728	412	530	0	6	3677	0	3673	1769	276	330	424	1030	1108	3907	233
Ponnanai Ar	33	661	0	693	126	155	0	2	977	0	977	467	80	101	124	305	241	1013	36
Upper Colerron	276.65	822	0	1099	110	134	0	5.91	1349	0	1348.56	582	69	88	107.2	264.2	739	1585.2	236.64
Lower Coleroon	0	1136	0	1136	70	83	0	4	1293	0	1293	1077	90	56	66	212	381	1670	378
Cauvery Delta	0	9075	0	9075	389	461	0	11	9936	0	9936	8684	724	311	369	1404	1632	11720	1784
Total	4941	22254	4369	31562	3138	3996	54	176	38905	22605	61507	18849	2642	2510	3197	8349	20776	47974	-13532

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.11.2(b): Abstract : Cauvery Basin-Sub-basinwise Water Balance for 50% Water Year Dependable Flow, With Ground Water

Unit : MCM

Name of Sub-basin	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses			Total	Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Domestic	Industrial	Hydro-power	Environmental	Total				Irrigation	Domestic	Industrial					
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Upper Cauvery	463	1489	1101	3053	321	321	0	62	3757	2640	6850	0	189	257	257	703	6230	579	7511.3	661
Kabini	1035	666	872	2573	280	280	9	44	3186	1795	4981	359	247	224	224	695	4376	386	5816	835
Shimsha	263	1831	1056	3150	348	348	8	0	3853	15	3868	2490	335	278	278	892	763	506	4651	783
Arkavathi	196	181	122	496	559	559	3	2	1619	810	2429	409	21	383	447	851	389	104	1753	-676.6
Middle Cauvery	205	790	794	1789	109	109	0	3	2010	211	2221	1587	193	87	87	367	392	206	2552	330.95
Suvarnavathi	302	136	203	640	63	63	0	0	767	0	767	492	50	28	50	128	95	64	779	12
Palar	220	12	35	268	44	44	0	1	323	0	323	0	13	9	35	57	171	140	368	44
Chinnar	534	148	0	682	123	123	0	3	932	15646	16577	0	25	70	98	193	384	178	755	-15823
Bhavani	170	1033	126	1330	229	229	35	19	1842	1036	2878	12	147	143	183	473	2444	188	3117	239
Noyil	148	547	20	715	252	252	0	2	1221	0	1221	446	53	168	202	423	234	54	1157	-65
Amaravathi	673	1420	40	2133	305	305	1	9	2753	0	2753	475	130	184	244	558	1108	308	2449	-304
Tirumanimuttar	422	2304	0	2725	530	530	0	6	3791	0	3791	1769	276	330	424	1030	1108	350	4257	465.24
Ponnanai Ar	33	661	0	693	155	155	0	2	1005	0	1005	467	80	101	124	305	241	207	1220	214.97
Upper Coleron	277	822	0	1099	134	134	0	6	1373	0	1373	582	69	107	107	283	739	253	1857	484.44
Lower Coleroon	0	1136	0	1136	83	83	0	4	1306	0	1306	1077	90	56	66	212	381	121	1791	485
Cauvery Delta	0	9075	0	9075	461	461	0	11	9936	0	10008	8684	724	311	369	1588	1632	225	12128	2121
Total	4941	22252	4367	31557	3996	3996	56	175	39674	22153	62352	18849	2642	2736	3197	8758	20687	3866	52161	-10191

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.11.3(a): Abstract : Cauvery Basin-Sub-basinwise Water Balance for 90% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Name of Sub-basin	Water Utilisation											Water Availability							Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total			
	Proposed	Existing	Ongoing	Total															
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Upper Cauvery	463	1489	1101	3053	233	321	0	48	3655	2369	6024	0	189	186	257	632	4840	5472	-552
Kabini	1035	666	872	2573	225	280	9	30	3118	1795	4913	359	247	180	224	651	3040	4050	-863
Shimsha	263	1830	1056	3151	259	348	6	0	3764	15	3779	2490	335	207	278	821	506	3817	38
Arkavathi	196	181	122	496	479	559	0	2	1536	810	2347	409	21	383	447	851	203	1463	-883
Middle Cauvery	205	790	795	1790	83	109	0	3	1985	211	2196	1587	193	66	87	347	275	2209	13
Suvarnavathi	302	136	203	640	35	63	0	0	739	0	739	492	50	28	50	128	10	630	-108
Palar	220	12	35	268	11	44	0	1	323	0	323	0	13	9	35	57	72	129	-194
Chinnar	534	148	0	682	87	123	0	3	896	12712	13608	0	25	70	98	193	232	425	-13183
Bhavani	170	1033	126	1330	179	229	35	19	1792	1036	2828	12	147	143	183	474	1513	1999	-829
Noyil	148	547	20	715	210	252	0	2	1160	0	1160	446	53	168	202	423	213	1082	-78
Amaravathi	673	1420	40	2133	230	305	1	9	2678	0	2678	475	130	184	244	558	805	1838	-840
Tirumanimuttar	422	2307	0	2728	412	530	0	6	3677	0	3673	1769	276	330	424	1030	624	3423	-250
Ponnanai Ar	33	661	0	693	126	155	0	2	977	0	977	467	80	101	124	305	160	932	-45
Upper Coleroon	277	822	0	1099	110	134	0	6	1349	0	1349	582	69	88	107	264	474	1320	-28
Lower Coleroon	0	1136	0	1136	70	83	0	2	1291	0	1291	1077	90	56	66	212	168	1457	167
Cauvery Delta	0	9075	0	9075	389	461	0	11	9936	0	9936	8684	724	311	369	1404	589	10677	741
Total	4941	22254	4369	31562	3138	3996	51	145	38874	18948	57819	18849	2642	2510	3197	8349	13724	40923	-16896

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.11.3(b): Abstract : Cauvery Basin-Sub-basinwise Water Balance for 90% Water Year Dependable Flow, With Ground Water

Unit : MCM

Name of Sub-basin	Water Utilisation											Water Availability								Monthly water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Environ-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Upper Cauvery	463	1489	1101	3053	321	321	0	48	3743	2640	6112	0	189	257	257	703	4840	579	6121	-262
Kabini	1035	666	872	2573	280	280	9	30	3173	1795	4968	359	247	224	224	695	3040	386	4480	-487
Shimsha	263	1831	1056	3150	348	348	5	0	3851	15	3866	2490	335	278	278	892	506	606	4494	628
Arkavathi	196	181	122	496	559	559	0	2	1616	810	2427	409	21	447	447	915	203	104	1631	-796
Middle Cauvery	205	790	794	1789	109	109	0	3	2010	211	2221	1587	193	87	87	367	275	206	2435	215
Suvarnavathi	302	136	203	640	63	63	0	0	767	0	767	492	50	50	50	151	10	64	717	-50
Palar	220	12	35	268	44	44	0	1	357	0	357	0	13	35	35	83	72	140	295	-61
Chinnar	534	148	0	682	123	123	0	3	932	12712	13644	0	25	98	98	222	232	178	631	-13012
Bhavani	170	1033	126	1330	229	229	35	19	1842	1036	2878	12	147	183	183	513	1513	188	2226	-652
Noyil	148	547	20	715	252	252	0	2	1221	0	1221	446	53	202	202	456	213	54	1169	-52
Amaravathi	673	1420	40	2133	305	305	1	9	2753	0	2753	475	130	244	244	618	805	308	2206	-547
Tirumanimuttar	422	2304	0	2725	530	530	0	6	3791	0	3791	1769	276	424	424	1124	624	350	3867	76
Ponnanai Ar	33	661	0	693	155	155	0	2	1005	0	1005	467	80	124	124	328	160	207	1162	157
Upper Coleroon	277	822	0	1099	134	134	0	6	1373	0	1349	582	69	107	107	283	474	253	1592	243
Lower Coleroon	0	1136	0	1136	83	83	0	2	1304	0	1304	1077	90	66	66	223	168	121	1588	285
Cauvery Delta	0	9075	0	9075	461	461	0	11	9936	0	10008	8684	724	369	369	1462	589	225	10959	952
Total	4941	22252	4367	31557	3996	3996	50	145	39672	19219	58668	18849	2642	3197	3197	9036	13724	3966	45575	-13364

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.11.4(a): Abstract : Cauvery Basin-Sub-basinwise Water Balance for 100% Water Year Dependable Flow, Without Ground Water

Unit : MCM

Name of Sub-basin	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Upper Cauvery	463	1489	1101	3053	233	321	0.0	31.5	3638	1543	5181	0	189	186	257	632	3150	3782	-1399
Kabini	1035	666	872	2573	225	280	9.0	19.8	3107	1795	4902	359	247	180	224	651	1982	2992	-1910
Shimsha	263	1830	1056	3151	259	348	6.2	0.0	3764	15	3779	2490	335	207	278	821	317	3628	-151
Arkavathi	196	181	122	496	479	559	2.9	2.0	1536	347	1884	409	21	383	447	851	123	1383	-500
Middle Cauvery	205	790	795	1790	83	109	0.0	3.3	1985	211	2196	1587	193	66	87	347	189	2123	-74
Suvarnavathi	302	136	203	640	35	63	0.0	0.4	739	0	739	492	50	28	50	128	0	620	-118
Palar	220	12	35	268	11	44	0.0	1.0	323	0	323	0	13	9	35	57	18	75	-248
Chinnar	534	148	0	682	87	123	0.0	3.1	896	12712	13608	0	25	70	98	193	89	282	-13326
Bhavani	170	1033	126	1330	179	229	35.0	19.2	1792	1036	2828	12	147	143	183	474	1218	1704	-1124
Noyil	148	547	20	715	210	252	0.0	2.3	1160	0	1160	446	53	168	202	423	201	1070	-90
Amaravathi	673	1420	40	2133	230	305	1.0	9.0	2678	0	2678	475	130	184	244	558	641	1674	-1004
Tirumanimuttar	422	2307	0	2728	412	530	0.0	6.5	3677	0	3673	1769	276	330	424	1030	565	3364	-310
Ponnanai Ar	33	661	0	693	126	155	0.0	1.9	977	0	977	467	80	101	124	305	64	836	-141
Upper Colerron	277	822	0	1099	110	134	0.0	5.9	1349	0	1349	582	69	88	107	264	190	1036	-312
Lower Coleroon	0	1136	0	1136	70	83	0.0	0.7	1290	0	1290	1077	90	56	66	212	65	1354	65
Cauvery Delta	0	9075	0	9075	389	461	0.0	10.6	9936	0	9936	8684	724	311	369	1404	191	10279	343
Total	4941	22254	4369	31562	3138	3996	54	117	38846	17659	56501	18849	2642	2510	3197	8349	9003	36202	-20300

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.19 = Column no.(13+17+18). Column no.20 = Column no.(19-12).

Table 4.11.4(b): Abstract : Cauvery Basin-Sub-basinwise Water Balance for 100% Water Year Dependable Flow, With Ground Water

Unit : MCM

Name of Sub-basin	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Environmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Monthly water balance
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(19)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Upper Cauvery	463	1489	1101	3053	321	321	0	32	3726	2640	5269	0	189	257	257	703	3150	579	4431	-1935
Kabini	1035	666	872	2573	280	280	9	20	3162	1795	4957	359	247	224	224	695	1982	386	3422	-1535
Shimsha	263	1831	1056	3150	348	348	3	0	3849	15	3864	2490	335	278	278	892	317	506	4205	341
Arkavathi	196	181	122	496	559	559	3	2	1619	347	1966	409	21	447	447	915	123	104	1551	-415
Middle Cauvery	205	790	794	1789	109	109	0	3	2010	211	2221	1587	193	87	87	367	189	206	2349	128
Suvarnavathi	302	136	203	640	63	63	0	0	767	0	767	492	50	50	50	151	0	64	707	-60
Palar	220	12	35	268	44	44	0	1	357	0	357	0	13	35	35	83	18	140	241	-115
Chinnar	534	148	0	682	123	123	0	3	932	12712	13644	0	25	98	98	222	89	178	488	-13155
Bhavani	170	1033	126	1330	229	229	35	19	1842	1036	2878	12	147	183	183	513	1218	188	1931	-947
Noyil	148	547	20	715	252	252	0	2	1221	0	1221	446	53	202	202	456	201	54	1157	-64
Amaravathi	673	1420	40	2133	305	305	1	9	2753	0	2753	475	130	244	244	618	641	308	2042	-711
Tirumanimuttar	422	2304	0	2725	530	530	0	6	3791	0	3791	1769	276	424	424	1124	565	350	3808	17
Ponnanai Ar	33	661	0	693	155	155	0	2	1005	0	1005	467	80	124	124	328	64	207	1066	61
Upper Colerron	277	822	0	1099	134	134	0	6	1373	0	1373	582	69	107	107	283	190	253	1308	-65
Lower Coleroon	0	1136	0	1136	83	83	0	1	1303	0	1303	1077	90	66	66	223	65	121	1485	183
Cauvery Delta	0	9075	0	9075	461	461	0	11	10008	0	10008	8684	724	369	369	1462	191	225	10561	554
Total	4941	22252	4367	31557	3996	3996	51	117	39717	18756	57376	18849	2642	3197	3197	9036	9003	3866	40754	-17719

Note : Column no.10 = Column no.(5+6+7+8+9). Column No. 12 = Column no. (10 + 11) Column no.20 = Column no.(13+17+18+19). Column no. 21 = Column no.(20-12).

Table 4.11.5: Abstract of Annual Water Balance for Cauvery Basin for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Case of Water balance	Water Utilisation											Water Availability									Cauvery Basin water balance
	Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
	Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Enviorn-mental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
	Proposed	Existing	Ongoing	Total																
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
75% Dep. Without G.W.	4941	22254	4369	31562	3138	3996	45	165	38887	19219	58102	18849	2642	2510	3197	8349	16470	0	43669	-14434
75% Dep. With G.W.	4941	22252	4369	31562	3996	3996	45	165	39516	19219	58807	18849	2642	3197	3197	9036	16470	3866	48221	-10586
50% Dep. Without G.W.	4941	22254	4369	31562	3138	3996	45	176	38905	19219	61546	18849	2642	2510	3197	8349	20776	0	47974	-13572
50% Dep. With G.W.	4941	22252	4369	31562	3996	3996	45	176	36373	19219	61834	18849	2456	3197	3197	8572	20687	3866	51975	-9859
90% Dep. Without G.W.	4941	22254	4369	31562	3138	3996	45	145	38874	19219	57819	18849	2642	2510	3197	8349	13724	0	40923	-16896
90% Dep. With G.W.	4941	22252	4369	31562	3996	3996	45	145	39672	19219	58668	18849	2642	3197	3197	9036	13724	3966	45575	-13364
100% Dep. Without G.W.	4941	22254	4369	31562	3138	3996	45	117	38846	19219	56501	18849	2642	2510	3197	8349	9003	0	36202	-20300
100% Dep. With G.W.	4941	22252	4369	31562	3996	3996	45	117	39717	19219	57376	18849	2642	3197	3197	9036	9003	3866	40754	-17719

Table 4.12.1: Cauvery Basin-Sub-basinwise Annual Water Balance for 75%, 50%, 90% and 100% Water Year Dependable Flows, Without and with Ground Water (Upper Cauvery, Kabini, Shimsha and Arkavathi Sub-basins)

Sr. No.	Name of Sub-basin	Ground Water	% Dep	Water Utilisation											Water Availability								Annual water balance
				Water requirements									Export	Gross total utilisation	Import	Regeneration from uses				Surface water yields	Ground water yields	Gross water available	
				Utilisation under irrigation projects				Dome-stic	Indus-trial	Hydro-power	Envionmental	Total				Irriga-tion	Dome-stic	Indus-trial	Total				
				Proposed	Existing	Ongoing	Total																
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
1	Upper Cauvery	without ground water	75%	463.0	1489.0	1101	3052.8	233.0	321.0	0.0	53.9	3660.8	2640	6300.8	0.0	188.9	186.4	256.8	632.1	5394.2	0.0	6026.3	-274.4
			50%	463.0	1489.0	1101	3052.8	233.0	321.0	0.0	63.2	3670.0	3092	6762.4	0.0	188.9	186.4	256.8	632.1	6318.6	0.0	6950.7	188.3
			90%	463.0	1489.0	1101	3052.8	233.0	321.0	0.0	48.4	3655.2	2369	6024.0	0.0	188.9	186.4	256.8	632.1	4840.0	0.0	5472.1	-551.9
			100%	463.0	1489.0	1101	3052.8	233.0	321.0	0.0	31.5	3638.3	1543	5180.9	0.0	188.9	186.4	256.8	632.1	3150.0	0.0	3782.1	-1399
		with ground water	75%	463.0	1489.0	1101	3052.8	321.0	321.0	0.0	53.9	3748.8	2640	6388.8	0.0	188.9	256.8	256.8	702.5	5394.2	578.5	6675.2	286.5
			50%	463.0	1489.0	1100.8	3052.8	321.0	321.0	0.0	62.3	3757.1	2640	6850.4	0.0	188.9	256.8	256.8	702.5	6230.3	578.5	7511.3	660.9
			90%	463	1489	1101	3053	321	321	0	48	3743	2640	6112	0	189	257	257	703	4840	579	6121	-262.2
			100%	463.0	1489.0	1100.8	3052.8	321.0	321.0	0.0	31.5	3726.3	2640	5268.9	0.0	188.9	256.8	256.8	702.5	3150.0	578.5	4431.0	-1935
2	Kabini	without ground water	75%	1035.1	666.2	872.0	2573.3	225.0	280.0	9.0	36.4	3123.7	1795	4918.8	359.0	247.0	180.0	224.0	651.0	3641.0	0.0	4651.0	-267.8
			50%	1035.1	666.2	872.0	2573.3	225.0	280.0	9.0	43.8	3131.0	1795	4926.1	359.0	247.0	180.0	224.0	651.0	4376.0	0.0	5386.0	459.9
			90%	1035.1	666.2	872.0	2573.3	225.0	280.0	9.0	30.4	3117.7	1795	4912.8	359.0	247.0	180.0	224.0	651.0	3040.0	0.0	4050.0	-862.8
			100%	1035.1	666.2	872.0	2573.3	225.0	280.0	9.0	19.8	3107.1	1795	4902.2	359.0	247.0	180.0	224.0	651.0	1982.0	0.0	2992.0	-1910
		with ground water	75%	1035.1	666.2	872.0	2573.3	280.0	280.0	9.0	36.4	3178.7	1795	4973.8	359.0	247.0	224.0	224.0	695.0	3641.0	386.4	5081.4	107.6
			50%	1035.1	666.2	872.0	2573.3	280.0	280.0	9.0	43.8	3186.0	1795	4981.1	359.0	247.0	224.0	224.0	695.0	4376.0	386.4	5816.4	835.3
			90%	1035.1	666.2	872.0	2573.3	280.0	280.0	9.0	30.4	3172.7	1795	4967.8	359.0	247.0	224.0	224.0	695.0	3040.0	386.4	4480.4	-487.4
			100%	1035.1	666.2	872.0	2573.3	280.0	280.0	9.0	19.8	3162.1	1795	4957.2	359.0	247.0	224.0	224.0	695.0	1982.0	386.4	3422.4	-1535
3	Shimsha	without ground water	75%	263.0	1830.0	1056	3150.7	259.0	348.0	0.0	6.2	3763.9	14.9	3778.8	2490	335.0	207.2	278.4	820.6	619.0	0.0	3929.6	150.8
			50%	263.0	1830.0	1056	3150.7	259.0	348.0	6.2	0.0	3763.9	14.9	3778.8	2490	335.0	207.2	278.4	820.6	763.0	0.0	4073.6	294.8
			90%	263.0	1830.0	1056	3150.7	259.0	348.0	6.2	0.0	3763.9	14.9	3778.8	2490	335.0	207.2	278.4	820.6	506.0	0.0	3816.6	37.8
			100%	263.0	1830.0	1056	3150.7	259.0	348.0	6.2	0.0	3763.9	14.9	3778.8	2490	335.0	207.2	278.4	820.6	317.0	0.0	3627.6	-151.2
		with ground water	75%	263.0	1830.8	1056	3149.5	348.0	348.0	0.0	6.2	3851.7	14.9	3866.6	2490	335.0	278.4	278.4	891.8	619.0	506.0	4506.8	640.2
			50%	263.0	1830.8	1056	3149.5	348.0	348.0	7.6	0.0	3853.2	14.9	3868.1	2490	335.0	278.4	278.4	891.8	763.0	506.0	4650.8	782.7
			90%	263.0	1830.8	1055.7	3149.5	348.0	348.0	5.1	0.0	3850.6	14.9	3865.5	2490	335.0	278.4	278.4	891.8	506.0	606.0	4493.8	628.3
			100%	263.0	1830.8	1055.7	3149.5	348.0	348.0	3.2	0.0	3848.7	14.9	3863.6	2490	335.0	278.4	278.4	891.8	317.0	506.0	4204.8	341.2
4	Arkavathi	without ground water	75%	196.5	181.1	121.7	496.3	479.0	559.0	0.0	2.9	1536.3	810.3	2346.6	409.0	21.0	383.2	447.2	851.4	287.0	0.0	1547.4	-799.2
			50%	196.5	181.1	121.7	496.3	479.0	559.0	2.9	2.0	1536.3	810.3	2346.6	409.0	21.0	383.2	447.2	851.4	389.0	0.0	1649.4	-697.2
			90%	196.5	181.1	121.7	496.3	479.0	559.0	0.0	2.0	1536.3	810.3	2346.6	409.0	21.0	383.2	447.2	851.4	203.0	0.0	1463.4	-883.2
			100%	196.5	181.1	121.7	496.3	479.0	559.0	2.9	2.0	1536.3	347.2	1883.5	409.0	21.0	383.2	447.2	851.4	123.0	0.0	1383.4	-500.1
		with ground water	75%	196.5	181.1	121.6	496.3	559.0	559.0	0.0	2.9	1617.2	810.3	2427.5	409.0	21.0	447.2	447.2	915.4	287.0	103.5	1714.9	-712.6
			50%	196.5	181.1	121.6	496.3	559.0	559.0	2.9	2.0	1619.2	810.3	2429.5	409.0	21.0	383.2	447.2	851.4	389.0	103.5	1752.9	-676.6
			90%	196.5	181.1	121.6	496.3	559.0	559.0	0.0	2.0	1616.3	810.3	2426.6	409.0	21.0	447.2	447.2	915.4	203.0	103.5	1630.9	-795.7
			100%	196.5	181.1	121.6	496.3	559.0	559.0	2.9	2.0	1619.2	347.2	1966.4	409.0	21.0	447.2	447.2	915.4	123.0	103.5	1550.9	-415.5

Table 4.12.2: Cauvery Basin-Sub-basinwise Annual Water Balance for 75%, 50%, 90% and 100% Water Year Dependable Flows, Without and with Ground Water (Middle Cauvery, Suvarnavathi, Palar and Chinnar Sub-basins)

Sr. No.	Name of Sub-basin	Ground Water	% Dep	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Dome-stic	Indus-trial	Hydro-power	Enviorn-mental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irriga-tion	Dome-stic	Indus-trial	Total	Surface water yields	Ground water yields	Gross water available	Annual water balance
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
1	Middle Cauvery	without ground water	75%	205.00	790.48	794.71	1790.2	83.00	109.0	0.00	3.30	1985.5	211.0	2196.5	1587	193.0	66.4	87.2	346.6	330.0	0.0	2263.9	67.4
			50%	205.00	790.48	794.71	1790.2	83.00	109.0	0.00	3.30	1985.5	250.7	2236.1	1587	193.0	66.4	87.2	346.6	392.0	0.0	2325.9	89.8
			90%	205.00	790.48	794.71	1790.2	83.00	109.0	0.00	2.75	1984.9	211.0	2195.9	1587	193.0	66.4	87.2	346.6	275.0	0.0	2208.9	13.0
			100%	205.00	790.48	794.71	1790.2	83.00	109.0	0.00	3.30	1985.5	211.0	2196.5	1587	193.0	66.4	87.2	346.6	189.0	0.0	2122.9	-73.6
		with ground water	75%	205.00	790.48	793.59	1789.1	109.0	109.0	0.00	3.30	2010.4	211.0	2221.4	1587	193.0	87.2	87.2	367.4	330.0	205.6	2490.3	268.9
			50%	205.00	790.48	793.59	1789.1	109.0	109.0	0.00	3.30	2010.4	211.0	2221.4	1587	193.0	87.2	87.2	367.4	392.0	205.6	2552.3	331.0
			90%	205.00	790.48	793.59	1789.1	109.0	109.0	0.00	2.75	2009.8	211.0	2220.8	1587	193.0	87.2	87.2	367.4	275.0	205.6	2435.3	214.5
			100%	205.00	790.48	793.59	1789.1	109.0	109.0	0.00	3.30	2010.4	211.0	2221.4	1587	193.0	87.2	87.2	367.4	189.0	205.6	2349.3	128.0
2	Suvarnavathi	without ground water	75%	301.69	135.60	203.15	640.43	35.00	63.00	0.00	0.38	738.81	0.00	738.81	492.0	50.0	28.0	50.4	128.4	38.0	0.0	658.4	-80.4
			50%	301.69	135.60	203.15	640.43	35.00	63.00	0.00	0.38	738.81	0.00	738.81	492.0	50.0	28.0	50.4	128.4	95.0	0.0	715.4	-23.4
			90%	301.69	135.60	203.15	640.43	35.00	63.00	0.00	0.38	738.81	0.00	738.81	492.0	50.0	28.0	50.4	128.4	10.0	0.0	630.4	-108.4
			100%	301.69	135.60	203.15	640.43	35.00	63.00	0.00	0.38	738.81	0.00	738.81	492.0	50.0	28.0	50.4	128.4	0.0	0.0	620.4	-118.4
		with ground water	75%	301.69	135.60	203.15	640.43	63.00	63.00	0.00	0.38	766.81	0.00	766.81	492.0	50.0	50.4	50.4	150.8	38.0	63.9	744.7	-22.1
			50%	301.69	135.60	203.15	640.43	63.00	63.00	0.00	0.38	766.81	0.00	766.81	492.0	50.0	28.0	50.4	128.4	95.0	63.9	779.3	12.5
			90%	301.69	135.60	203.15	640.43	63.00	63.00	0.00	0.38	766.81	0.00	766.81	492.0	50.0	50.4	50.4	150.8	10.0	63.9	716.7	-50.1
			100%	301.69	135.60	203.15	640.43	63.00	63.00	0.00	0.38	766.81	0.00	766.81	492.0	50.0	50.4	50.4	150.8	0.0	63.9	706.7	-60.1
3	Palar	without ground water	75%	220.37	12.20	34.96	267.53	11.00	44.00	0.00	1.05	323.48	0.00	323.48	0.0	13.0	8.8	35.2	57.0	105.0	0.0	162.0	-161.5
			50%	220.37	12.20	34.96	267.53	11.00	44.00	0.00	1.05	323.48	0.00	323.48	0.0	13.0	8.8	35.2	57.0	171.0	0.0	228.0	-95.5
			90%	220.37	12.20	34.96	267.53	11.00	44.00	0.00	1.05	323.48	0.00	323.48	0.0	13.0	8.8	35.2	57.0	72.0	0.0	129.0	-194.5
			100%	220.37	12.20	34.96	267.53	11.00	44.00	0.00	1.05	323.48	0.00	323.48	0.0	13.0	8.8	35.2	57.0	18.0	0.0	75.0	-248.5
		with ground water	75%	220.37	12.20	34.96	267.53	44.00	44.00	0.00	1.05	356.58	0.00	356.58	0.0	13.0	35.2	35.2	83.4	105.0	139.7	328.1	-28.5
			50%	220.37	12.20	34.96	267.53	44.00	44.00	0.00	1.05	323.48	0.00	323.48	0.0	13.0	8.8	35.2	57.0	171.0	139.7	367.7	44.2
			90%	220.37	12.20	34.96	267.53	44.00	44.00	0.00	1.05	356.58	0.00	356.58	0.0	13.0	35.2	35.2	83.4	72.0	139.7	295.1	-61.5
			100%	220.37	12.20	34.96	267.53	44.00	44.00	0.00	1.05	356.58	0.00	356.58	0.0	13.0	35.2	35.2	83.4	18.0	139.7	241.1	-115.5
4	Chinnar	without ground water	75%	534.22	148.27	0.00	682.49	87.00	123.0	0.00	3.12	896.10	12712	13608	0.0	25.0	69.6	98.4	193.0	312.0	0.0	505.0	-13103
			50%	534.22	148.27	0.00	682.49	87.00	123.0	0.00	3.12	896.10	12712	16542	0.0	25.0	69.6	98.4	193.0	384.0	0.0	577.0	-15965
			90%	534.22	148.27	0.00	682.49	87.00	123.0	0.00	3.12	896.10	12712	13608	0.0	25.0	69.6	98.4	193.0	232.0	0.0	425.0	-13183
			100%	534.22	148.27	0.00	682.49	87.00	123.0	0.00	3.12	896.10	12712	13608	0.0	25.0	69.6	98.4	193.0	89.0	0.0	282.0	-13326
		with ground water	75%	534.22	148.27	0.00	682.49	123.0	123.0	0.00	3.12	931.61	12712	13644	0.0	25.0	98.4	98.4	221.8	312.0	177.6	711.4	-12932
			50%	534.22	148.27	0.00	682.49	123.0	123.0	0.00	3.12	931.61	12712	16577	0.0	25.0	69.6	98.4	193.0	384.0	177.6	754.6	-15823
			90%	534.22	148.27	0.00	682.49	123.0	123.0	0.00	3.12	931.61	12712	13644	0.0	25.0	98.4	98.4	221.8	232.0	177.6	631.4	-13012
			100%	534.22	148.27	0.00	682.49	123.0	123.0	0.00	3.12	931.61	12712	13644	0.0	25.0	98.4	98.4	221.8	89.0	177.6	488.4	-13155

Table 4.12.3: Cauvery Basin-Sub-basinwise Annual Water Balance for 75%, 50%, 90% and 100% Water Year Dependable Flows, Without and with Ground Water (Bhavani, Noyil, Amaravathi and Tirumanimuttar Sub-basins)

Sr. No.	Name of Sub-basin	Ground Water	% Dep	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Enviornmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Annual water balance
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
1	Bhavani	without ground water	75%	170.1	1033.5	125.9	1329.5	179.0	229.0	35.0	19.2	1791.7	1036.0	2827.7	12.0	147.2	143.2	183.2	473.6	1917.2	0.0	2402.7	-424.9
			50%	170.1	1033.5	125.9	1329.5	179.0	229.0	35.0	19.2	1791.7	1036.0	2827.7	12.0	147.2	143.2	183.2	473.6	2444.0	0.0	2929.6	101.9
			90%	170.1	1033.5	125.9	1329.5	179.0	229.0	35.0	19.2	1791.7	1036.0	2827.7	12.0	147.2	143.2	183.2	473.6	1513.0	0.0	1998.6	-829.1
			100%	170.1	1033.5	125.9	1329.5	179.0	229.0	35.0	19.2	1791.7	1036.0	2827.7	12.0	147.2	143.2	183.2	473.6	1218.0	0.0	1703.6	-1124
		with ground water	75%	170.1	1033.5	125.9	1329.5	229.0	229.0	35.0	19.2	1841.7	1036.0	2877.7	12.0	147.0	183.2	183.2	513.4	1917.2	187.7	2630.3	-247.4
			50%	170.1	1033.5	125.9	1329.5	229.0	229.0	35.0	19.2	1841.7	1036.0	2877.7	12.0	147.0	143.2	183.2	473.4	2444.0	187.7	3117.1	239.4
			90%	170.1	1033.5	125.9	1329.5	229.0	229.0	35.0	19.2	1841.7	1036.0	2877.7	12.0	147.0	183.2	183.2	513.4	1513.0	187.7	2226.1	-651.6
			100%	170.1	1033.5	125.9	1329.5	229.0	229.0	35.0	19.2	1841.7	1036.0	2877.7	12.0	147.0	183.2	183.2	513.4	1218.0	187.7	1931.1	-946.6
2	Noyil	without ground water	75%	148.5	546.9	19.7	715.1	210.0	252.0	0.0	2.3	1160.0	0.0	1160.0	446.0	53.0	168.0	201.6	422.6	225.0	0.0	1093.6	-66.4
			50%	148.5	546.9	19.7	715.1	210.0	252.0	0.0	2.3	1160.0	0.0	1160.0	446.0	53.0	168.0	201.6	422.6	234.0	0.0	1102.6	-57.4
			90%	148.5	546.9	19.7	715.1	210.0	252.0	0.0	2.3	1160.0	0.0	1160.0	446.0	53.0	168.0	201.6	422.6	213.0	0.0	1081.6	-78.4
			100%	148.5	546.9	19.7	715.1	210.0	252.0	0.0	2.3	1160.0	0.0	1160.0	446.0	53.0	168.0	201.6	422.6	201.0	0.0	1069.6	-90.4
		with ground water	75%	148.5	546.9	19.7	715.1	252.0	252.0	0.0	2.3	1221.3	0.0	1221.3	446.0	53.0	201.6	201.6	456.2	225.0	54.2	1181.4	-39.9
			50%	148.5	546.9	19.7	715.1	252.0	252.0	0.0	2.3	1221.3	0.0	1221.3	446.0	53.0	168.0	201.6	422.6	234.0	54.2	1156.8	-64.5
			90%	148.5	546.9	19.7	715.1	252.0	252.0	0.0	2.3	1221.3	0.0	1221.3	446.0	53.0	201.6	201.6	456.2	213.0	54.2	1169.4	-51.9
			100%	148.5	546.9	19.7	715.1	252.0	252.0	0.0	2.3	1221.3	0.0	1221.3	446.0	53.0	201.6	201.6	456.2	201.0	54.2	1157.4	-63.9
3	Amaravathi	without ground water	75%	672.9	1420.2	39.6	2132.6	230.0	305.0	1.0	9.0	2677.6	0.0	2677.6	475.0	129.8	184.0	244.0	557.8	898.0	0.0	1930.8	-746.9
			50%	672.9	1420.2	39.6	2132.6	230.0	305.0	1.0	9.0	2677.6	0.0	2677.6	475.0	129.8	184.0	244.0	557.8	1108.0	0.0	2140.8	-536.9
			90%	672.9	1420.2	39.6	2132.6	230.0	305.0	1.0	9.0	2677.6	0.0	2677.6	475.0	129.8	184.0	244.0	557.8	805.0	0.0	1837.8	-839.9
			100%	672.9	1420.2	39.6	2132.6	230.0	305.0	1.0	9.0	2677.6	0.0	2677.6	475.0	129.8	184.0	244.0	557.8	641.0	0.0	1673.8	-1004
		with ground water	75%	672.9	1420.2	39.6	2132.6	305.0	305.0	1.0	9.0	2752.6	0.0	2752.6	475.0	130.0	244.0	244.0	618.0	898.0	308.0	2299.0	-453.6
			50%	672.9	1420.2	39.6	2132.6	305.0	305.0	1.0	9.0	2752.6	0.0	2752.6	475.0	130.0	184.0	244.0	558.0	1108.0	308.0	2449.0	-303.6
			90%	672.9	1420.2	39.6	2132.6	305.0	305.0	1.0	9.0	2752.6	0.0	2752.6	475.0	130.0	244.0	244.0	618.0	805.0	308.0	2206.0	-546.6
			100%	672.9	1420.2	39.6	2132.6	305.0	305.0	1.0	9.0	2752.6	0.0	2752.6	475.0	130.0	244.0	244.0	618.0	641.0	308.0	2042.0	-710.6
4	Tirumanimuttar	without ground water	75%	421.7	2306.7	0.0	2728.5	412.0	530.0	0.0	6.5	3677.0	0.0	3673.5	1769	276.4	329.6	424.0	1030	649.0	0.0	3447.9	-225.5
			50%	421.7	2306.7	0.0	2728.5	412.0	530.0	0.0	6.5	3677.0	0.0	3673.5	1769	276.4	329.6	424.0	1030	1108.0	0.0	3906.9	233.4
			90%	421.7	2306.7	0.0	2728.5	412.0	530.0	0.0	6.5	3677.0	0.0	3673.5	1769	276.4	329.6	424.0	1030	624.0	0.0	3423.0	-250.5
			100%	421.7	2306.7	0.0	2728.5	412.0	530.0	0.0	6.5	3677.0	0.0	3673.5	1769	276.4	329.6	424.0	1030	565.0	0.0	3364.0	-309.5
		with ground water	75%	421.7	2304.0	0.0	2725.0	530.0	530.0	0.0	6.5	3791.5	0.0	3791.5	1769	276.0	424.0	424.0	1124	649.0	350.1	3892.1	100.6
			50%	421.7	2304.0	0.0	2725.0	530.0	530.0	0.0	6.5	3791.5	0.0	3791.5	1769	276.0	329.6	424.0	1030	1108.0	350.1	4256.7	465.2
			90%	421.7	2304.0	0.0	2725.0	530.0	530.0	0.0	6.5	3791.5	0.0	3791.5	1769	276.0	424.0	424.0	1124	624.0	350.1	3867.1	75.6
			100%	421.7	2304.0	0.0	2725.0	530.0	530.0	0.0	6.5	3791.5	0.0	3791.5	1769	276.0	424.0	424.0	1124	565.0	350.1	3808.1	16.6

Table 4.12.4: Cauvery Basin-Sub-basinwise Annual Water Balance for 75%, 50%, 90% and 100% Water Year Dependable Flows, Without and with Ground Water (Ponnanai Ar, Upper Coleroon, Lower Coleroon and Cauvery Delta Sub-basins)

Sr. No.	Name of Sub-basin	Ground Water	% Dep	Water Utilisation: Water requirements: Utilisation under irrigation projects: Proposed	Existing	Ongoing	Total	Domestic	Industrial	Hydro-power	Enviornmental	Total	Export	Gross total utilisation	Water Availability: Import	Regeneration from uses: Irrigation	Domestic	Industrial	Total	Surface water yields	Ground water yields	Gross water available	Annual water balance
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
1	Ponnanai Ar	without ground water	75%	32.56	660.76	0.00	693.32	126.0	155.0	0.00	1.91	976.51	0.00	976.51	467.0	80.0	100.8	124.0	304.8	191.0	0.0	962.8	-13.7
			50%	32.56	660.76	0.00	693.32	126.0	155.0	0.00	1.91	976.51	0.00	976.51	467.0	80.0	100.8	124.0	304.8	241.0	0.0	1012.8	36.3
			90%	32.56	660.76	0.00	693.32	126.0	155.0	0.00	1.91	976.51	0.00	976.51	467.0	80.0	100.8	124.0	304.8	160.0	0.0	931.8	-44.7
			100%	32.56	660.76	0.00	693.32	126.0	155.0	0.00	1.91	976.51	0.00	976.51	467.0	80.0	100.8	124.0	304.8	64.0	0.0	835.8	-140.7
		with ground water	75%	32.56	660.76	0.00	693.32	155.0	155.0	0.00	1.91	1005.2	0.00	1005.2	467.0	80.0	124.0	124.0	328.0	191.0	207.4	1193.4	188.2
			50%	32.56	660.76	0.00	693.32	155.0	155.0	0.00	1.91	1005.2	0.00	1005.2	467.0	80.0	100.8	124.0	304.8	241.0	207.4	1220.2	215.0
			90%	32.56	660.76	0.00	693.32	155.0	155.0	0.00	1.91	1005.2	0.00	1005.2	467.0	80.0	124.0	124.0	328.0	160.0	207.4	1162.4	157.2
			100%	32.56	660.76	0.00	693.32	155.0	155.0	0.00	1.91	1005.2	0.00	1005.2	467.0	80.0	124.0	124.0	328.0	64.0	207.4	1066.4	61.2
2	Upper Coleroon	without ground water	75%	276.65	822.00	0.00	1098.7	110.0	134.0	0.00	5.91	1348.6	0.00	1348.6	582.0	69.0	88.0	107.2	264.2	589.0	0.0	1435.2	86.6
			50%	276.65	822.00	0.00	1098.7	110.0	134.0	0.00	5.91	1348.6	0.00	1348.6	582.0	69.0	88.0	107.2	264.2	739.0	0.0	1585.2	236.6
			90%	276.65	822.00	0.00	1098.7	110.0	134.0	0.00	5.91	1348.6	0.00	1348.6	582.0	69.0	88.0	107.2	264.2	474.0	0.0	1320.2	-28.4
			100%	276.65	822.00	0.00	1098.7	110.0	134.0	0.00	5.91	1348.6	0.00	1348.6	582.0	69.0	88.0	107.2	264.2	190.0	0.0	1036.2	-312.4
		with ground water	75%	276.65	822.00	0.00	1098.7	134.0	134.0	0.00	5.91	1372.6	0.00	1372.6	582.0	69.0	107.2	107.2	283.4	589.0	252.6	1707.0	334.4
			50%	276.65	822.00	0.00	1098.7	134.0	134.0	0.00	5.91	1372.6	0.00	1372.6	582.0	69.0	107.2	107.2	283.4	739.0	252.6	1857.0	484.4
			90%	276.65	822.00	0.00	1098.7	134.0	134.0	0.00	5.91	1372.6	0.00	1348.6	582.0	69.0	107.2	107.2	283.4	474.0	252.6	1592.0	243.4
			100%	276.65	822.00	0.00	1098.7	134.0	134.0	0.00	5.91	1372.6	0.00	1372.6	582.0	69.0	107.2	107.2	283.4	190.0	252.6	1308.0	-64.6
3	Lower Coleroon	without ground water	75%	0.00	1136.0	0.00	1136.0	70.00	83.00	0.00	2.24	1291.2	0.00	1291.2	1077	90.0	56.0	66.4	212.4	224.0	0.0	1513.4	222.2
			50%	0.00	1136.0	0.00	1136.0	70.00	83.00	0.00	3.81	1292.8	0.00	1292.8	1077	90.0	56.0	66.4	212.4	381.0	0.0	1670.4	377.6
			90%	0.00	1136.0	0.00	1136.0	70.00	83.00	0.00	1.68	1290.7	0.00	1290.7	1077	90.0	56.0	66.4	212.4	168.0	0.0	1457.4	166.7
			100%	0.00	1136.0	0.00	1136.0	70.00	83.00	0.00	0.65	1289.7	0.00	1289.7	1077	90.0	56.0	66.4	212.4	65.0	0.0	1354.4	64.8
		with ground water	75%	0.00	1136.0	0.00	1136.0	83.00	83.00	0.00	2.24	1304.2	0.00	1304.2	1077	90.0	66.4	66.4	222.8	224.0	120.6	1644.4	340.2
			50%	0.00	1136.0	0.00	1136.0	83.00	83.00	0.00	3.81	1305.8	0.00	1305.8	1077	90.0	56.0	66.4	212.4	381.0	120.6	1791.0	485.2
			90%	0.00	1136.0	0.00	1136.0	83.00	83.00	0.00	1.68	1303.7	0.00	1303.7	1077	90.0	66.4	66.4	222.8	168.0	120.6	1588.4	284.7
			100%	0.00	1136.0	0.00	1136.0	83.00	83.00	0.00	0.65	1302.7	0.00	1302.7	1077	90.0	66.4	66.4	222.8	65.0	120.6	1485.4	182.8
4	Cauvery Delta	without ground water	75%	0.00	9075.0	0.00	9075.0	389.0	461.0	0.00	10.56	9935.6	0.00	9935.6	8684	724.0	311.2	368.8	1404	1050.6	0.0	11139	1203.1
			50%	0.00	9075.0	0.00	9075.0	389.0	461.0	0.00	10.56	9935.6	0.00	9935.6	8684	724.0	311.2	368.8	1404	1632.0	0.0	11720	1784.4
			90%	0.00	9075.0	0.00	9075.0	389.0	461.0	0.00	10.56	9935.6	0.00	9935.6	8684	724.0	311.2	368.8	1404	589.0	0.0	10677	741.4
			100%	0.00	9075.0	0.00	9075.0	389.0	461.0	0.00	10.56	9935.6	0.00	9935.6	8684	724.0	311.2	368.8	1404	191.0	0.0	10279	343.4
		with ground water	75%	0.00	9075.0	0.00	9075.0	461.0	461.0	0.00	10.56	9935.6	0.0	10008	8684	724.0	368.8	368.8	1462	1050.6	224.6	11421	1413.3
			50%	0.00	9075.0	0.00	9075.0	461.0	461.0	0.00	10.56	9935.6	0.0	10008	8684	724.0	311.2	368.8	1588	1632.0	224.6	12128	2120.5
			90%	0.00	9075.0	0.00	9075.0	461.0	461.0	0.00	10.56	9935.6	0.0	10008	8684	724.0	368.8	368.8	1462	589.00	224.60	10959	951.6
			100%	0.00	9075.0	0.00	9075.0	461.0	461.0	0.00	10.56	10008	0.0	10008	8684	724.0	368.8	368.8	1462	191.00	224.60	10561	553.6

Table 4.13.1: Cauvery River Basin-Monthly Water Balancc (Surplus/Deficit) for 75%, 50%, 90% and 100% Water Year Dependable Flow

Sl.No.	Name of Sub-basin	Ground water	% Dep.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1	Upeer Cauvery	Without ground water	75%	-154.57	598.37	367.15	-290.37	-391.29	-17.62	-57.12	-93.23	-117.28	-117.71	-18.79	18.00	-274.45
			50%	68.81	565.98	-302.62	-338.79	-101.61	101.27	-80.90	-107.76	-117.04	-63.26	255.11	309.11	188.30
			90%	-60.12	-40.05	-341.94	-255.04	-171.40	165.97	-45.15	-94.52	-122.16	-128.36	229.58	311.32	-551.86
			100%	-83.48	-95.77	-396.86	-276.52	-381.83	33.12	-92.91	-107.76	-83.64	-128.79	63.81	153.72	-1398.76
		With ground water	75%	-110.28	703.58	473.36	-186.36	-277.58	-11.32	-41.75	-74.86	-93.64	-95.09	-16.11	16.50	286.45
			50%	113.09	671.19	-196.41	-234.78	12.10	107.57	-20.37	-29.39	-8.04	40.39	239.85	269.27	703.95
			90%	-15.83	65.16	-235.73	-151.03	-57.69	172.27	-29.78	-76.15	-98.52	-105.74	232.25	309.83	-262.19
			100%	-39.20	9.44	-290.65	-172.51	-268.12	39.42	-77.54	-89.39	-60.00	-106.17	66.49	152.23	-1935.29
2	Kabini	Without ground water	75%	139.96	181.53	192.31	-1.37	125.87	21.54	-101.06	-202.50	-184.01	-89.70	-0.85	31.61	107.62
			50%	133.63	-245.13	151.59	269.28	203.77	-38.56	-176.32	-268.64	-244.36	-131.94	-0.41	444.27	459.87
			90%	124.43	-115.47	-83.38	-161.60	257.47	-3.14	-166.18	-262.22	-239.02	-84.99	33.43	133.96	-862.76
			100%	10.28	-172.78	-170.23	-174.77	55.33	40.77	-172.39	-261.15	-240.86	-111.89	6.62	98.65	-1910.19
		With ground water	75%	140.87	182.46	193.24	-0.47	126.80	22.45	-100.13	-201.57	-183.17	-88.77	0.05	32.54	118.62
			50%	140.73	-176.39	218.82	322.76	208.88	-21.48	-141.69	-218.06	-198.35	-108.52	4.42	445.92	835.27
			90%	131.53	-46.74	-16.15	-108.12	262.58	13.94	-131.55	-211.64	-193.00	-61.57	38.25	135.61	-487.37
			100%	17.38	-104.04	-103.01	-121.29	60.44	57.86	-137.76	-210.57	-194.85	-88.46	11.44	100.30	-1534.79
3	Shimsha	Without ground water	75%	-0.25	-35.47	-37.15	46.74	294.72	88.65	-39.34	-68.87	-55.77	-35.21	-16.19	8.86	150.81
			50%	3.26	-33.28	-34.37	66.99	367.44	117.53	-35.69	-68.76	-55.75	-35.15	-15.37	14.40	294.81
			90%	-3.01	-37.19	-39.34	30.85	237.62	65.98	-42.21	-68.96	-55.79	-35.26	-16.85	4.51	37.79
			100%	-7.62	-40.07	-42.99	4.28	142.20	28.09	-47.01	-69.10	-55.83	-35.33	-17.93	-2.75	-151.19
		With ground water	75%	6.40	16.71	21.55	91.07	299.95	124.89	28.56	21.55	15.39	2.42	-2.49	14.17	640.15
			50%	5.27	25.59	31.26	84.37	244.77	109.88	39.41	39.59	29.67	10.09	-0.14	11.21	628.26
			90%	6.73	27.11	32.77	85.83	246.28	111.35	40.92	41.11	31.03	11.61	1.32	12.72	646.06
			100%	-0.89	12.16	15.78	49.04	148.99	64.95	20.97	21.32	15.33	2.31	-4.21	2.68	341.17
4	Arkavathi	Without ground water	75%	-37.40	-35.73	-48.70	-205.15	-187.09	-90.09	-46.48	-36.57	-28.21	-25.94	-24.56	-33.27	-799.19
			50%	-43.95	-40.58	-57.64	-269.59	-245.56	-114.03	-52.95	-39.11	-29.87	-27.18	-26.38	-38.33	-697.19
			90%	-32.01	-31.73	-41.34	-152.09	-138.94	-70.38	-41.15	-34.47	-26.85	-24.91	-23.06	-29.11	-883.19
			100%	-26.88	-27.92	-34.32	-101.55	-93.08	-51.60	-36.06	-32.46	-25.55	-23.93	-21.62	-25.14	-500.11
		With ground water	75%	-35.91	-30.33	-41.07	-196.97	-181.73	-83.01	-31.44	-19.69	-17.63	-19.91	-22.29	-32.59	-712.56
			50%	-24.05	-57.45	-66.05	40.45	48.79	-31.42	-126.25	-147.76	-99.77	-69.26	-39.10	-21.81	-593.69
			90%	-38.84	-32.44	-45.07	-225.78	-207.88	-93.71	-34.33	-20.82	-18.38	-20.46	-23.11	-34.85	-795.72
			100%	-25.55	-22.69	-26.85	-93.54	-87.89	-44.69	-21.19	-15.75	-15.14	-18.07	-19.53	-24.62	-415.48

Table 4.13.2: Cauvery River Basin-Monthly Water Balance (Surplus/Deficit) for 75%, 50%, 90% and 100% Water Year Dependable Flow

Sl.No.	Name of Sub-basin	Ground water	% Dep.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1	Middle Cauvery	Without ground water	75%	-2.92	1.08	11.21	24.14	22.10	21.58	3.54	-1.63	-2.41	-3.31	-3.10	-2.86	67.42
			50%	-2.85	2.28	14.33	29.68	27.02	26.44	5.02	-1.08	-2.09	-3.17	-3.03	-2.78	89.78
			90%	-2.97	0.05	8.51	19.36	17.85	17.39	2.27	-2.11	-2.68	-3.43	-3.15	-2.94	12.98
			100%	-3.07	-1.64	4.10	11.54	10.90	10.52	0.18	-2.89	-3.13	-3.63	-3.24	-3.06	-73.57
		With ground water	75%	-1.28	39.58	46.59	52.48	24.24	29.87	21.09	23.62	20.48	12.42	2.11	-2.27	268.94
			50%	-1.21	40.78	49.72	58.02	29.17	34.73	22.58	24.17	20.80	12.56	2.17	-2.18	330.95
			90%	-1.33	38.54	43.89	47.70	20.00	25.68	19.82	23.14	20.20	12.30	2.05	-2.34	214.50
			100%	-1.43	36.85	39.48	39.88	13.04	18.81	17.73	22.37	19.75	12.11	1.97	-2.47	127.95
2	Suvarnavathi	Without ground water	75%	-1.08	-17.01	-16.92	-5.90	6.52	3.83	-9.89	-14.51	-12.85	-8.19	-2.88	-0.55	-80.41
			50%	1.25	-12.39	-14.42	8.47	20.77	18.26	-9.11	-14.42	-12.55	-8.02	-2.16	1.90	-23.41
			90%	-2.22	-19.28	-18.15	-12.96	-0.48	-3.26	-10.27	-14.55	-13.00	-8.27	-3.23	-1.75	-108.41
			100%	-2.63	-20.09	-18.59	-15.48	-2.98	-5.79	-10.41	-14.57	-13.05	-8.30	-3.36	-2.18	-118.41
		With ground water	75%	-0.89	-5.41	-6.31	2.67	6.84	6.05	-4.64	-6.52	-5.71	-4.31	-2.20	-0.70	-22.11
			50%	-0.41	-2.69	-5.70	15.20	19.19	18.64	-5.76	-8.33	-7.12	-6.05	-3.32	-0.15	12.48
			90%	-2.02	-7.68	-7.54	-4.39	-0.16	-1.04	-5.02	-6.56	-5.86	-4.39	-2.55	-1.90	-50.11
			100%	-2.44	-8.49	-7.98	-6.91	-2.66	-3.57	-5.16	-6.58	-5.91	-4.42	-2.68	-2.33	-60.11
3	Palar	Without ground water	75%	6.00	-30.75	-21.45	-10.00	1.84	-13.70	-19.12	-24.76	-27.33	-16.19	-5.45	-0.59	-161.49
			50%	12.20	-17.70	-5.09	8.05	6.49	-13.55	-16.69	-22.95	-26.24	-15.20	-5.34	0.54	-95.48
			90%	2.90	-37.27	-29.63	-19.02	-0.49	-13.78	-20.33	-25.67	-27.87	-16.68	-5.50	-1.15	-194.49
			100%	-2.17	-47.94	-43.02	-33.79	-4.29	-13.91	-22.32	-27.15	-28.76	-17.48	-5.59	-2.07	-248.48
		With ground water	75%	7.03	-3.66	3.40	10.05	3.78	-7.08	-7.59	-10.67	-12.35	-7.53	-3.40	-0.36	-28.49
			50%	21.39	9.92	20.31	28.64	8.99	-6.39	-4.62	-8.32	-10.77	-5.98	-2.75	1.32	44.22
			90%	3.93	-10.18	-4.78	1.03	1.45	-7.16	-8.80	-11.58	-12.89	-8.02	-3.45	-0.92	-61.49
			100%	-1.14	-20.85	-18.17	-13.74	-2.35	-7.29	-10.79	-13.06	-13.78	-8.82	-3.54	-1.84	-115.48
4	Chinnar	Without ground water	75%	-460.17	-156.75	-170.13	-3203.5	-4322.6	-2940.8	-656.16	-219.08	-196.32	-222.45	-168.36	-386.71	-13103.1
			50%	-554.46	-186.19	-204.52	-3927.6	-5307.5	-3604.8	-790.52	-260.82	-224.29	-252.72	-190.83	-460.45	-15964.6
			90%	-355.25	-124.16	-131.97	-2399.1	-3228.5	-2203.2	-506.72	-172.58	-165.32	-188.67	-143.32	-304.84	-13183.1
			100%	-168.06	-65.74	-63.62	-960.8	-1272.3	-884.5	-240.05	-89.92	-109.68	-128.66	-98.81	-158.19	-13326.1
		With ground water	75%	-447.75	-150.43	-166.01	-3187.5	-4309.6	-2925.3	-637.78	-210.32	-177.42	-199.32	-150.67	-370.12	-12932.2
			50%	-541.49	-179.29	-199.80	-3911.0	-5293.9	-3588.7	-771.57	-251.46	-204.90	-229.05	-172.61	-443.31	-15787.0
			90%	-342.83	-117.85	-127.85	-2383.0	-3215.5	-2187.7	-488.35	-163.82	-146.42	-165.54	-125.63	-288.25	-13012.2
			100%	-155.63	-59.42	-59.49	-944.7	-1259.3	-869.0	-221.67	-81.16	-90.78	-105.52	-81.12	-141.59	-13155.2

Table 4.13.3: Cauvery River Basin-Monthly Water Balance (Surplus/Deficit) for 75%, 50%, 90% and 100% Water Year Dependable Flow

Sl.No.	Name of Sub-basin	Ground water	% Dep.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1	Bhavani	Without ground water	75%	-84.52	-8.84	-61.01	-20.44	74.96	98.80	35.44	-80.60	-139.19	-164.53	-54.69	-22.55	-424.92
			50%	-43.69	-112.51	-89.26	25.06	159.87	77.21	34.52	-67.10	-99.91	-78.08	-27.08	40.53	101.90
			90%	-111.54	-179.61	-91.56	-33.01	44.94	43.97	45.14	-9.54	-95.23	-172.38	-48.21	-3.63	-829.10
			100%	-120.69	-148.77	-171.34	-54.01	54.29	6.10	79.71	-92.03	-142.24	-167.30	13.97	-27.18	-1124.10
		With ground water	75%	-61.94	21.80	-33.18	-8.51	75.10	98.90	39.41	-64.87	-115.71	-138.23	-45.64	-16.76	-247.39
			50%	-24.40	-85.26	-64.83	33.70	156.60	74.02	35.09	-54.78	-79.50	-55.18	-21.31	42.93	239.43
			90%	-88.96	-148.96	-63.72	-21.08	45.08	44.07	49.10	6.18	-71.75	-146.08	-39.16	2.17	-651.57
			100%	-98.11	-118.13	-143.51	-42.08	54.42	6.20	83.67	-76.31	-118.76	-141.01	23.02	-21.38	-946.57
2	Noyil	Without ground water	75%	-49.75	-30.70	-26.54	-11.19	106.39	53.38	23.26	-20.10	-22.89	-25.34	-20.90	-42.01	-66.40
			50%	-49.74	-30.66	-26.54	-10.96	111.06	55.91	24.77	-20.10	-22.89	-25.34	-20.90	-42.01	-57.40
			90%	-49.77	-30.76	-26.54	-11.50	100.16	50.01	21.25	-20.10	-22.89	-25.34	-20.90	-42.01	-78.40
			100%	-49.79	-30.82	-26.54	-11.82	93.94	46.64	19.24	-20.10	-22.89	-25.34	-20.90	-42.01	-90.40
		With ground water	75%	-42.02	-26.97	-23.84	-10.23	105.91	52.98	23.46	-18.49	-20.51	-22.71	-19.05	-38.42	-39.92
			50%	-44.77	-29.78	-26.70	-12.75	107.72	52.74	22.11	-21.35	-23.09	-25.57	-21.81	-41.28	-64.52
			90%	-42.04	-27.03	-23.84	-10.54	99.68	49.61	21.45	-18.49	-20.51	-22.71	-19.05	-38.42	-51.92
			100%	-42.06	-27.09	-23.84	-10.86	93.46	46.24	19.44	-18.49	-20.51	-22.71	-19.05	-38.42	-63.92
3	Amaravathi	Without ground water	75%	-204.99	-192.25	-154.17	-40.31	124.28	189.79	141.44	-98.93	-168.65	-207.29	-77.85	-58.30	-746.87
			50%	-174.05	-249.64	-185.27	132.30	140.74	199.89	-9.43	-26.92	-179.32	-168.54	-33.54	16.95	-536.87
			90%	-157.46	-208.33	-148.94	-34.98	41.00	147.29	11.47	-79.57	-178.88	-205.06	-49.03	22.68	-839.87
			100%	-166.36	-184.39	-144.30	-59.49	33.15	12.73	-7.95	-93.39	-176.16	-178.66	-1.63	-36.90	-1003.87
		With ground water	75%	-169.94	-145.23	-113.44	-19.87	125.29	190.15	148.70	-78.76	-137.93	-171.93	-65.73	-46.39	-453.63
			50%	-143.93	-207.71	-149.64	147.81	136.66	195.32	-7.27	-11.85	-153.20	-138.27	-26.35	23.77	-303.63
			90%	-122.41	-161.31	-108.21	-14.54	42.01	147.65	18.73	-59.40	-148.16	-169.70	-36.91	34.59	-546.63
			100%	-191.40	-187.13	-108.99	-11.49	47.46	37.06	-18.43	-57.47	-118.97	-167.82	-38.04	10.37	-710.63
4	Tirumanimuttar	Without ground water	75%	-51.62	-40.86	-65.16	-60.84	267.48	107.70	50.49	-37.17	-102.99	-147.29	-82.74	-62.52	-225.54
			50%	-50.85	-38.52	-65.16	-48.81	505.51	236.63	127.36	-37.17	-102.99	-147.29	-82.74	-62.52	233.44
			90%	-51.66	-40.99	-65.16	-61.49	254.53	100.69	46.31	-37.17	-102.99	-147.29	-82.74	-62.52	-250.50
			100%	-51.76	-41.29	-65.16	-63.04	223.93	84.11	36.43	-37.17	-102.99	-147.29	-82.74	-62.52	-309.51
		With ground water	75%	-24.71	-18.37	-31.84	-21.08	301.08	144.94	79.67	-18.26	-50.19	-71.71	-40.37	-30.56	218.64
			50%	-31.69	-24.05	-39.86	-16.81	531.10	266.11	148.53	-26.28	-57.43	-79.73	-48.13	-38.58	583.24
			90%	-34.45	-28.52	-41.87	-31.43	278.11	128.23	65.47	-28.28	-59.24	-81.73	-50.07	-40.59	75.64
			100%	-34.55	-28.82	-41.87	-32.98	247.51	111.65	55.59	-28.28	-59.24	-81.73	-50.07	-40.59	16.64

Table 4.13.4: Cauvery River Basin-Monthly Water Balance (Surplus/Deficit) for 75%, 50%, 90% and 100% Water Year Dependable Flow

Sl.No.	Name of Sub-basin	Ground water	% Dep.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1	Ponnani Ar	Without ground water	75%	-12.73	-18.84	-11.51	8.90	9.78	43.78	-1.59	-13.73	0.19	-7.17	-8.83	-1.99	-13.74
			50%	-12.12	-18.24	-10.70	14.75	19.08	61.06	5.32	-11.30	2.42	-5.72	-8.22	-0.08	36.26
			90%	-13.10	-19.21	-12.01	5.28	4.01	33.06	-5.87	-15.23	-1.19	-8.07	-9.21	-3.17	-44.71
			100%	-14.27	-20.38	-13.56	-5.95	-13.85	-0.12	-19.14	-19.89	-5.48	-10.87	-10.40	-6.83	-140.74
		With ground water	75%	3.88	6.25	4.31	22.94	40.94	69.70	32.86	13.90	7.55	5.98	2.34	6.24	216.89
			50%	2.58	4.89	3.15	26.87	48.28	85.08	37.80	14.35	8.00	5.46	1.05	6.18	243.69
			90%	1.15	3.48	1.34	17.00	32.73	56.61	26.14	9.96	3.96	2.63	-0.41	2.60	157.17
			100%	-0.02	2.31	-0.21	5.77	14.87	23.43	12.87	5.30	-0.33	-0.17	-1.60	-1.06	61.17
2	Upper Coleroon	Without ground water	75%	-2.80	-69.07	-61.16	-17.49	45.70	132.50	66.63	9.70	-3.83	-13.49	-3.86	4.80	86.64
			50%	-0.94	-59.92	-48.15	6.09	66.63	174.75	90.46	15.21	-0.46	-10.77	-2.38	7.38	236.64
			90%	-4.23	-76.14	-71.20	-35.69	29.54	99.90	48.24	5.45	-6.44	-15.60	-5.00	2.81	-28.36
			100%	-7.74	-93.44	-95.77	-80.26	-10.02	20.03	3.21	-4.96	-12.81	-20.75	-7.78	-2.07	-312.36
		With ground water	75%	2.17	-10.73	1.16	43.41	65.12	149.73	80.58	15.60	5.09	-0.61	0.86	7.04	358.44
			50%	4.03	-1.57	14.16	66.99	86.04	191.98	104.41	21.11	8.47	2.12	2.33	9.62	508.44
			90%	0.74	-17.80	-8.88	25.21	48.96	117.13	62.19	11.35	2.48	-2.72	-0.28	5.05	243.44
			100%	-4.74	-37.13	-35.48	-21.33	7.36	35.28	15.13	-1.10	-5.73	-9.90	-5.03	-1.87	-64.56
3	Lower Coleroon	Without ground water	75%	3.64	19.41	38.44	46.01	33.13	28.00	31.23	9.47	3.85	4.15	4.52	2.80	222.16
			50%	7.67	29.96	61.98	74.92	56.65	48.04	53.88	17.56	7.56	7.91	9.19	6.54	377.59
			90%	2.16	15.52	29.77	35.36	24.47	20.61	22.88	6.49	2.49	2.76	2.80	1.43	166.72
			100%	-0.46	8.68	14.49	16.61	9.22	7.61	8.19	1.24	0.08	0.33	-0.22	-1.00	64.75
		With ground water	75%	5.05	46.26	67.19	74.12	41.40	35.25	36.89	11.29	7.21	9.30	5.81	2.87	340.16
			50%	8.22	55.93	89.85	102.17	64.04	54.44	58.66	18.49	10.12	12.18	9.62	5.72	485.19
			90%	3.56	42.37	58.52	63.47	32.74	27.87	28.54	8.31	5.85	7.92	4.09	1.50	284.72
			100%	0.95	35.53	43.25	44.72	17.48	14.87	13.85	3.06	3.44	5.48	1.07	-0.93	182.75
4	Cauvery Delta	Without ground water	75%	16.48	129.89	221.85	256.38	165.12	139.55	153.12	44.39	20.67	24.69	20.46	10.45	1203.06
			50%	31.34	168.88	308.83	363.19	252.00	213.58	237.34	74.32	34.38	38.62	37.71	24.26	1784.43
			90%	4.68	98.94	152.79	171.57	96.14	80.77	86.25	20.63	9.79	13.63	6.74	-0.51	741.43
			100%	-5.42	72.45	93.70	99.00	34.12	30.47	29.02	0.30	0.47	4.17	-4.96	-9.90	343.43
		With ground water	75%	18.31	179.10	274.59	307.95	179.71	152.28	162.85	46.96	26.19	33.48	22.07	9.77	1413.26
			50%	30.90	254.39	400.76	453.12	274.61	232.94	251.13	75.10	40.90	50.69	36.86	19.14	2120.53
			90%	6.51	148.15	205.53	223.14	110.73	93.50	95.98	23.20	15.31	22.42	8.35	-1.19	951.63
			100%	-3.59	121.66	146.44	150.57	48.71	43.20	38.75	2.87	5.99	12.96	-3.35	-10.58	553.63

Table 4.14.1: Upper Cauvery Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Upper Cauvery Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Oct	-391	-8	Sep	-339	-7	Aug	-342	-7	Aug	-397	-8	Oct	703.58	14	Sep	-233	-4	Aug	-234	-4	Aug	-289	-5
Sep	-290	-6	Aug	-303	-6	Sep	-255	-5	Oct	-382	-8	Sep	473.36	10	Aug	-195	-4	Sep	-150	-3	Oct	-267	-5
Jun	-155	-3	Feb	-117	-2	Oct	-171	-3	Sep	-277	-6	Jun	16.50	0	Feb	-92.1	-2	Mar	-104	-2	Sep	-171	-3
Mar	-118	-2	Jan	-108	-2	Mar	-128	-3	Mar	-129	-3	Mar	-11.32	0	Jan	-87.9	-2	Feb	-97.2	-2	Mar	-105	-2
Feb	-117	-2	Oct	-102	-2	Feb	-122	-2	Jan	-108	-2	Feb	-16.11	0	Dec	-64	-1	Jan	-74.7	-1	Jan	-87.9	-2
Jan	-93.2	-2	Dec	-80.9	-2	Jan	-94.5	-2	Jul	-95.8	-2	Jan	-41.75	-1	Mar	-39.1	-1	Oct	-56.2	-1	Dec	-76	-1
Dec	-57.1	-1	Mar	-63.3	-1	Jun	-60.1	-1	Dec	-92.9	-2	Dec	-74.86	-2	Oct	13.59	0	Dec	-28.3	-1	Feb	-58.7	-1
Apr	-18.8	-0.4	Jun	68.81	1	Dec	-45.2	-1	Feb	-83.6	-2	Apr	-93.64	-1.9	Nov	109	2	Jun	-14.4	-0.3	Jun	-37.8	-1
Nov	-17.6	-0.4	Nov	101.3	2	Jul	-40.1	-1	Jun	-83.5	-2	Nov	-95.09	-1.9	Jun	114.5	2	Jul	66.65	1	Jul	10.93	0.2
May	18	0.4	Apr	255.1	5	Nov	166	3	Nov	33.12	1	May	-110.28	-2.2	Apr	259.2	5	Nov	173.7	3	Nov	40.86	1
Aug	367.2	7	May	309.1	6	Apr	229.6	5	Apr	63.81	1	Aug	-186.36	-4	May	309.1	6	Apr	233.7	4	Apr	67.94	1
Jul	598.4	12	Jul	566	11	May	311.3	6	May	153.7	3	Jul	-277.58	-6	Jul	672.7	13	May	311.3	6	May	153.7	3
Annual	-274	-6	Annual	188.3	4	Annual	-552	-11	Annual	-1399	-28	Annual	286.45	6	Annual	1132	21	Annual	-245	-5	Annual	-1918	-36

Table 4.14.2: Kabini Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Kabini Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Jan	-253	-5	Jan	-269	-5.5	Jan	-262	-5	Jan	-261	-5	Jan	-201.57	-4	Jan	-217	-4	Jan	-211	-4	Jan	-210	-4
Feb	-230	-5	Jul	-245	-5	Feb	-239	-5	Feb	-241	-5	Feb	-183.17	-4	Feb	-198	-4	Feb	-192	-4	Feb	-194	
Dec	-136	-3	Feb	-244	-5	Dec	-166	-3	Sep	-175	-4	Dec	-100.13	-2	Jul	-175	-4	Dec	-131	-3	Dec	-137	
Mar	-113	-2	Dec	-176	-3.6	Sep	-162	-3	Jul	-173	-4	Mar	-88.767	-2	Dec	-141	-3	Sep	-107	-2	Sep	-120	
Sep	-54.9	-1	Mar	-132	-2.7	Jul	-115	-2	Dec	-172	-4	Sep	-0.4705	-0	Mar	-108	-2	Mar	-60.6	-1	Jul	-103	
Apr	-5.67	-0	Nov	-38.6	-0.8	Mar	-85	-2	Aug	-170	-3	Apr	0.0525	0	Nov	-20.6	-0.4	Jul	-45.8	-1	Aug	-102	
Nov	4.459	0.1	Apr	-0.41	-0.01	Aug	-83.4	-2	Mar	-112	-2	Nov	22.445	0.5	Apr	5.32	0.1	Aug	-15.2	-0	Mar	-87.5	
May	29.96	0.6	Jun	133.6	2.73	Nov	-3.14	-0	Apr	6.617	0.1	May	32.543	0.7	Jun	141.6	3	Nov	14.85	0.3	Apr	12.34	
Jul	112.8	2.3	Aug	151.6	3.09	Apr	33.43	0.7	Jun	10.28	0.2	Oct	126.8	2.6	Oct	209.8	4	Apr	39.15	0.8	Jun	18.29	
Oct	120.8	2.5	Oct	203.8	4.16	Jun	124.4	2.5	Nov	40.77	0.8	Jun	140.87	2.8	Aug	219.8	4	Jun	132.4	2.7	Nov	58.76	
Aug	125.1	2.6	Sep	269.3	5.49	May	134	2.7	Oct	55.33	1.1	Jul	182.46	3.7	Sep	323.7	7	May	136.5	2.8	Oct	61.37	
Jun	132.9	2.7	May	444.3	9.06	Oct	257.5	5.3	May	98.65	2	Aug	193.24	3.9	May	446.9	9	Oct	263.5	5.4	May	101.2	
Annual	-268	-5	Annual	459.9	9.38	Annual	-863	-18	Annual	-1910	-39	Annual	118.62	2.4	Annual	846.3	17	Annual	-476	-10	Annual	-1524	

Table 4.14.3: Shimsha Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Shimsha Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Jan	-68.9	-2	Jan	-68.8	-2	Jan	-69	-2	Jan	-69.1	-2	Apr	-1.03	0.0	Apr	-0.21	0.0	Apr	1.318	0.0	Apr	-2.74	-0.1
Feb	-55.8	-1	Feb	-55.7	-1	Feb	-55.8	-1	Feb	-55.8	-1	Mar	3.936	0.1	Mar	3.992	0.1	Jun	6.734	0.2	Jun	0.575	0.0
Dec	-39.3	-1	Dec	-35.7	-1	Dec	-42.2	-1	Dec	-47	-1	Jun	7.866	0.2	Jun	11.34	0.3	Mar	11.61	0.3	Mar	3.82	0.1
Aug	-37.2	-1	Mar	-35.2	-1	Aug	-39.3	-1	Aug	-43	-1	May	15.69	0.4	Feb	16.78	0.4	May	12.72	0.3	May	4.193	0.1
Jul	-35.5	-1	Aug	-34.4	-1	Jul	-37.2	-1	Jul	-40.1	-1	Feb	16.75	0.4	Jul	20.39	0.5	Jul	27.11	0.7	Jul	13.67	0.4
Mar	-35.2	-1	Jul	-33.3	-1	Mar	-35.3	-1	Mar	-35.3	-1	Jul	18.22	0.5	May	21.17	0.5	Feb	31.03	0.8	Feb	16.69	0.4
Apr	-16.2	-0.4	Apr	-15.4	-0.4	Apr	-16.8	-0.4	Apr	-17.9	-0.5	Aug	23.06	0.6	Jan	23.18	0.6	Aug	32.77	0.8	Aug	17.29	0.4
Jun	-0.25	0.0	Jun	3.262	0.1	Jun	-3.01	-0.1	Jun	-7.62	-0.2	Jan	23.07	0.6	Aug	25.82	0.7	Dec	40.92	1.1	Dec	22.48	0.6
May	8.863	0.2	May	14.4	0.4	May	4.511	0.1	May	-2.75	-0.1	Dec	30.07	0.8	Dec	33.69	0.9	Jan	41.11	1.1	Jan	22.83	0.6
Sep	46.74	1	Sep	66.99	2	Sep	30.85	1	Sep	4.277	0.1	Sep	92.53	2.4	Sep	112.6	2.9	Sep	85.83	2.2	Sep	50.5	1.3
Nov	88.65	2	Nov	117.5	3	Nov	65.98	2	Nov	28.09	1	Nov	126.4	3.3	Nov	154.9	4.0	Nov	111.3	2.9	Nov	66.41	1.7
Oct	294.7	8	Oct	367.4	10	Oct	237.6	6	Oct	142.2	4	Oct	301.5	7.8	Oct	373.4	9.7	Oct	246.3	6.4	Oct	150.5	3.9
Annual	150.8	4	Annual	294.8	8	Annual	37.79	1	Annual	-151	-4	Annual	658	17.0	Annual	800.5	20.7	Annual	646.1	16.7	Annual	359	9.3

Table 4.14.4: Arkavathi Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Arkavathi Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Sep	-205	-10.9	Sep	-270	-14.3	Sep	-152	-8.1	Sep	-102	-5.4	Jan	-149	-7.6	Jan	-148	-7.5	Jan	-150	-7.6	Jan	-151	-8
Oct	-187	-9.9	Oct	-246	-13.0	Oct	-139	-7.4	Oct	-93.1	-4.9	Dec	-130	-6.6	Dec	-126	-6.4	Dec	-133	-6.8	Dec	-136	-7
Nov	-90.1	-4.8	Nov	-114	-6.1	Nov	-70.4	-3.7	Nov	-51.6	-2.7	Feb	-101	-5.1	Feb	-99.8	-5.1	Feb	-101	-5.2	Feb	-102	-5
Aug	-48.7	-2.6	Aug	-57.6	-3.1	Aug	-41.3	-2.2	Dec	-36.1	-1.9	Aug	-70.9	-3.6	Mar	-69.3	-3.5	Aug	-75	-3.8	Aug	-78.8	-4
Dec	-46.5	-2.5	Dec	-52.9	-2.8	Dec	-41.2	-2.2	Aug	-34.3	-1.8	Mar	-69.9	-3.6	Aug	-66	-3.4	Mar	-70.5	-3.6	Mar	-71	-4
Jun	-37.4	-2.0	Jun	-43.9	-2.3	Jan	-34.5	-1.8	Jan	-32.5	-1.7	Jul	-60.1	-3.1	Jul	-57.5	-2.9	Jul	-62.3	-3.2	Nov	-65.7	-3
Jan	-36.6	-1.9	Jul	-40.6	-2.2	Jun	-32	-1.7	Jul	-27.9	-1.5	Nov	-44.5	-2.3	Apr	-39.1	-2.0	Nov	-55.4	-2.8	Jul	-64.4	-3
Jul	-35.7	-1.9	Jan	-39.1	-2.1	Jul	-31.7	-1.7	Jun	-26.9	-1.4	Apr	-40.1	-2.0	Nov	-31.4	-1.6	Apr	-40.9	-2.1	Sep	-51.7	-3
May	-33.3	-1.8	May	-38.3	-2.0	May	-29.1	-1.5	Feb	-25.6	-1.4	Jun	-27.6	-1.4	Jun	-24	-1.2	Jun	-30.6	-1.6	Apr	-41.7	-2
Feb	-28.2	-1.5	Feb	-29.9	-1.6	Feb	-26.8	-1.4	May	-25.1	-1.3	May	-24.6	-1.3	May	-21.8	-1.1	May	-26.9	-1.4	Oct	-34.8	-2
Mar	-25.9	-1.4	Mar	-27.2	-1.4	Mar	-24.9	-1.3	Mar	-23.9	-1.3	Sep	5.113	0.3	Sep	40.45	2.1	Sep	-24	-1.2	Jun	-33.4	-2
Apr	-24.6	-1.3	Apr	-26.4	-1.4	Apr	-23.1	-1.2	Apr	-21.6	-1.1	Oct	16.73	0.9	Oct	48.79	2.5	Oct	-9.68	-0.5	May	-29	-1
Annual	-799	-42.4	Annual	-697	-37.0	Annual	-883	-46.9	Annual	-500	-26.5	Annual	-696	-35.4	Annual	-594	-30.2	Annual	-780	-39.7	Annual	-860	-44

Table 4.14.5: Middle Cauvery Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Middle Cauvery Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Mar	-3.31	-0.2	Mar	-3.17	-0.1	Mar	-3.43	-0.2	Mar	-3.63	-0.2	May	-1.83	-0.1	May	-1.74	-0.1	May	-1.90	-0.1	May	-2.02	-0.1
Apr	-3.10	-0.1	Apr	-3.03	-0.1	Apr	-3.15	-0.1	Apr	-3.24	-0.1	Jun	-0.85	0.0	Jun	-0.79	0.0	Jun	-0.91	0.0	Jun	-1.00	0.0
Jun	-2.92	-0.1	Jun	-2.85	-0.1	Jun	-2.97	-0.1	Feb	-3.13	-0.1	Apr	2.54	0.1	Apr	2.60	0.1	Apr	2.48	0.1	Apr	2.39	0.1
May	-2.86	-0.1	May	-2.78	-0.1	May	-2.94	-0.1	Jun	-3.07	-0.1	Mar	12.86	0.6	Mar	13.00	0.6	Mar	12.74	0.6	Mar	12.55	0.6
Feb	-2.41	-0.1	Feb	-2.09	-0.1	Feb	-2.68	-0.1	May	-3.06	-0.1	Feb	20.88	0.9	Feb	21.20	1.0	Dec	20.22	0.9	Oct	13.49	0.6
Jan	-1.63	-0.1	Jan	-1.08	0.0	Jan	-2.11	-0.1	Jan	-2.89	-0.1	Dec	21.54	1.0	Dec	23.02	1.0	Oct	20.32	0.9	Dec	18.17	0.8
Jul	1.08	0.0	Jul	2.28	0.1	Jul	0.05	0.0	Jul	-1.64	-0.1	Jan	24.06	1.1	Jan	24.61	1.1	Feb	20.59	0.9	Nov	19.24	0.9
Dec	3.54	0.2	Dec	5.02	0.2	Dec	2.27	0.1	Dec	0.18	0.0	Oct	24.69	1.1	Oct	29.61	1.3	Jan	23.57	1.1	Feb	20.15	0.9
Aug	11.21	0.5	Aug	14.33	0.7	Aug	8.51	0.4	Aug	4.10	0.2	Nov	30.29	1.4	Nov	35.15	1.6	Nov	25.98	1.2	Jan	22.81	1.0
Nov	21.58	1.0	Nov	26.44	1.2	Nov	17.39	0.8	Nov	10.52	0.5	Jul	40.02	1.8	Jul	41.22	1.9	Jul	38.96	1.8	Jul	37.29	1.7
Oct	22.10	1.0	Oct	27.02	1.2	Oct	17.85	0.8	Oct	10.90	0.5	Aug	47.03	2.1	Aug	50.16	2.3	Aug	44.26	2.0	Aug	39.92	1.8
Sep	24.14	1.1	Sep	29.68	1.4	Sep	19.36	0.9	Sep	11.54	0.5	Sep	52.90	2.4	Sep	58.45	2.6	Sep	47.99	2.2	Sep	40.31	1.8
Annual	67.4	3.1	Annual	89.8	4.1	Annual	13.0	0.6	Annual	-73.6	-3.3	Annual	274	12.3	Annual	336	15.1	Annual	219	9.9	Annual	133	6.0

Table 4.14.6: Savarnavathi Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Savarnavathi Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Jul	-17.01	-2	Jan	-14.42	-2	Jul	-19.28	-3	Jul	-20.09	-3	Jan	-6.05	-0.8	Jan	-5.96	-0.8	Jul	-7.21	-0.9	Jul	-8.02	-1.0
Aug	-16.92	-2	Aug	-14.42	-2	Aug	-18.15	-2	Aug	-18.59	-3	Aug	-5.83	-0.8	Feb	-4.98	-0.6	Aug	-7.06	-0.9	Aug	-7.50	-1.0
Jan	-14.51	-2	Feb	-12.55	-2	Jan	-14.55	-2	Sep	-15.48	-2	Feb	-5.28	-0.7	Mar	-3.67	-0.5	Jan	-6.09	-0.8	Sep	-6.45	-0.8
Feb	-12.85	-2	Jul	-12.39	-2	Feb	-13.00	-2	Jan	-14.57	-2	Jul	-4.94	-0.6	Dec	-3.38	-0.4	Feb	-5.43	-0.7	Jan	-6.11	-0.8
Dec	-9.89	-1	Dec	-9.11	-1	Sep	-12.96	-2	Feb	-13.05	-2	Dec	-4.16	-0.5	Aug	-3.33	-0.4	Dec	-4.54	-0.6	Feb	-5.48	-0.7
Mar	-8.19	-1	Mar	-8.02	-1	Dec	-10.27	-1	Dec	-10.41	-1	Mar	-3.84	-0.5	Apr	-1.02	-0.1	Sep	-3.93	-0.5	Dec	-4.68	-0.6
Sep	-5.90	-1	Apr	-2.16	-0	Mar	-8.27	-1	Mar	-8.30	-1	Apr	-1.74	-0.2	Jul	-0.32	-0	Mar	-3.92	-0.5	Mar	-3.95	-0.5
Apr	-2.88	-0	Jun	1.25	0.2	Nov	-3.26	-0	Nov	-5.79	-1	Jun	-0.43	-0.1	Jun	1.89	0.2	Apr	-2.09	-0.3	Nov	-3.11	-0.4
Jun	-1.08	-0	May	1.90	0.3	Apr	-3.23	-0	Apr	-3.36	-0	May	-0.22	0.0	May	2.22	0.3	Jun	-1.57	-0.2	Apr	-2.22	-0.3
May	-0.55	-0	Sep	8.47	1.1	Jun	-2.22	-0	Oct	-2.98	-0	Sep	3.13	0.4	Sep	17.50	2.3	May	-1.42	-0.2	Oct	-2.18	-0.3
Nov	3.83	0.5	Nov	18.26	2.5	May	-1.75	-0	Jun	-2.63	-0	Nov	6.51	0.8	Nov	20.94	2.7	Nov	-0.58	-0.1	Jun	-1.98	-0.3
Oct	6.52	0.9	Oct	20.77	2.8	Oct	-0.48	-0	May	-2.18	-0	Oct	7.32	1.0	Oct	21.57	2.8	Oct	0.32	0.0	May	-1.85	-0.2
Annual	-80	-11	Annual	-23	-3	Annual	-108	-15	Annual	-118	-16	Annual	-17	-2.1	Annual	40	5.3	Annual	-45	-5.8	Annual	-55	-7.1

Table 4.14.7: Palar Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year

Dependable Flow, Without and With Ground Water

Palar Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Jul	-30.75	-9.5	Feb	-26.24	-8.1	Jul	-37.27	-12	Jul	-47.94	-14.8	Feb	-11.86	-3.3	Feb	-10.77	-3.0	Feb	-12.40	-3.5	Jul	-20.31	-5.7
Feb	-27.33	-8.5	Jan	-22.95	-7.1	Aug	-29.63	-9.2	Aug	-43.02	-13.3	Jan	-10.13	-2.8	Jan	-8.32	-2.3	Jan	-11.04	-3.1	Aug	-17.63	-4.9
Jan	-24.76	-7.7	Jul	-17.70	-5.5	Feb	-27.87	-8.6	Sep	-33.79	-10.5	Dec	-7.05	-2.0	Nov	-6.39	-1.8	Jul	-9.64	-2.7	Feb	-13.29	-3.7
Aug	-21.45	-6.6	Dec	-16.69	-5.2	Jan	-25.67	-7.9	Feb	-28.76	-8.9	Mar	-6.96	-2.0	Mar	-5.98	-1.7	Dec	-8.26	-2.3	Sep	-13.20	-3.7
Dec	-19.12	-5.9	Mar	-15.20	-4.7	Dec	-20.33	-6.3	Jan	-27.15	-8.4	Nov	-6.55	-1.8	Dec	-4.62	-1.3	Mar	-7.45	-2.1	Jan	-12.52	-3.5
Mar	-16.19	-5.0	Nov	-13.55	-4.2	Sep	-19.02	-5.9	Dec	-22.32	-6.9	Jul	-3.12	-0.9	Apr	-2.75	-0.8	Nov	-6.63	-1.9	Dec	-10.25	-2.9
Nov	-13.70	-4.2	Apr	-5.34	-1.7	Mar	-16.68	-5.2	Mar	-17.48	-5.4	Apr	-2.86	-0.8	May	1.32	0.4	Aug	-4.24	-1.2	Mar	-8.25	-2.3
Sep	-10.00	-3.1	Aug	-5.09	-1.6	Nov	-13.78	-4.3	Nov	-13.91	-4.3	May	0.19	0.1	Oct	8.99	2.5	Apr	-2.91	-0.8	Nov	-6.76	-1.9
Apr	-5.45	-1.7	May	0.54	0.2	Apr	-5.50	-1.7	Apr	-5.59	-1.7	Aug	3.94	1.1	Jul	9.92	2.8	May	-0.37	-0.1	Apr	-3.00	-0.8
May	-0.59	-0.2	Oct	6.49	2.0	May	-1.15	-0.4	Oct	-4.29	-1.3	Oct	4.34	1.2	Aug	20.31	5.7	Sep	1.57	0.4	Oct	-1.79	-0.5
Oct	1.84	0.6	Sep	8.05	2.5	Oct	-0.49	-0.2	Jun	-2.17	-0.7	Jun	7.57	2.1	Jun	21.39	6.0	Oct	2.01	0.6	May	-1.29	-0.4
Jun	6.00	1.9	Jun	12.20	3.8	Jun	2.90	0.9	May	-2.07	-0.6	Sep	10.59	3.0	Sep	28.64	8.0	Jun	4.47	1.3	Jun	-0.60	-0.2
Annual	-161	-50	Annual	-95	-30	Annual	-194	-60	Annual	-248	-76.9	Annual	-22	-6.1	Annual	44	12.4	Annual	-55	-15.3	Annual	-109	-30.5

Table 4.14.8: Chinnar Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year

Dependable Flow, Without and With Ground Water

Chinnar Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Oct	-4322.6	-31.8	Oct	-5307.5	-39	Oct	-3228.5	-24	Oct	-1272	-9.3	Oct	-4309.1	-32	Oct	-5293.9	-39	Oct	-3214.9	-24	Oct	-1258.7	-9.2
Sep	-3203.5	-23.5	Sep	-3927.6		Sep	-2399.1		Sep	-960.76		Sep	-3186.9	-23	Sep	-3911.0	-29	Sep	-2382.5	-17	Sep	-944.2	-6.9
Nov	-2940.8	-21.6	Nov	-3604.8		Nov	-2203.2		Nov	-884.49		Nov	-2924.7	-21	Nov	-3588.7	-26	Nov	-2187.1	-16	Nov	-868.4	-6.4
Dec	-656.16	-4.8	Dec	-790.52		Dec	-506.72		Dec	-240.05		Dec	-637.21	-5	Dec	-771.57	-5.7	Dec	-487.77	-3.6	Dec	-221.09	-1.6
Jun	-460.17	-3.4	Jun	-554.46		Jun	-355.25		Jun	-168.06		Jun	-447.21	-3	Jun	-541.49	-4	Jun	-342.28	-2.5	Jun	-155.09	-1.1
May	-386.71	-2.8	May	-460.45		May	-304.84		May	-158.19		May	-369.57	-3	May	-443.31	-3.2	May	-287.70	-2.1	May	-141.05	-1
Mar	-222.45	-1.6	Jan	-260.82		Mar	-188.67		Mar	-128.66		Jan	-209.73	-2	Jan	-251.46	-1.8	Mar	-165.00	-1.2	Mar	-104.99	-0.8
Jan	-219.08	-1.6	Mar	-252.72		Jan	-172.58		Feb	-109.68		Mar	-198.78	-1	Mar	-229.05	-1.7	Jan	-163.23	-1.2	Feb	-90.29	-0.7
Feb	-196.32	-1.4	Feb	-224.29		Feb	-165.32		Apr	-98.81		Feb	-176.93	-1	Feb	-204.9	-1.5	Feb	-145.93	-1.1	Apr	-80.59	-0.6
Aug	-170.13	-1.3	Aug	-204.52		Apr	-143.32		Jan	-89.92		Aug	-165.41	-1	Aug	-199.8	-1.5	Aug	-127.25	-0.9	Jan	-80.57	-0.6
Apr	-168.36	-1.2	Apr	-190.83		Aug	-131.97		Jul	-65.74		Apr	-150.14	-1	Jul	-179.29	-1.3	Apr	-125.10	-0.9	Aug	-58.90	-0.4
Jul	-156.75	-1.2	Jul	-186.19		Jul	-124.16		Aug	-63.62		Jul	-149.85	-1	Apr	-172.61	-1.3	Jul	-117.26	-0.9	Jul	-58.84	-0.4
Annual	-13103	-96.3	Annual	-15965		Annual	-13183		Annual	-13326		Annual	-12925	-95	Annual	-15787	-116	Annual	-13005	-95	Annual	-13148	-96

Table 4.14.9: Bhavani Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Bhavani Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Mar	-164.53	-5.8	Jul	-112.5	-4.0	Jul	-179.6	-6.4	Aug	-171.34	-6.1	Mar	-137.4	-4.8	Jul	-81.01	-2.8	Jul	-148	-5.1	Aug	-142.7	-5.0
Feb	-139.19	-4.9	Feb	-99.91	-3.5	Mar	-172.4	-6.1	Mar	-167.30	-5.9	Feb	-114.9	-4.0	Feb	-75.66	-2.6	Mar	-145	-5.0	Mar	-140.2	-4.9
Jun	-84.52	-3.0	Aug	-89.26	-3.2	Jun	-111.5	-3.9	Jul	-148.77	-5.3	Jan	-64.03	-2.2	Aug	-60.58	-2.1	Jun	-88.1	-3.1	Feb	-118.0	-4.1
Jan	-80.60	-2.8	Mar	-78.08	-2.8	Feb	-95.23	-3.4	Feb	-142.24	-5.0	Jun	-61.12	-2.1	Mar	-50.93	-1.8	Feb	-71.0	-2.5	Jul	-117.3	-4.1
Aug	-61.01	-2.2	Jan	-67.10	-2.4	Aug	-91.56	-3.2	Jun	-120.69	-4.3	Apr	-45	-1.6	Jan	-50.53	-1.8	Aug	-62.9	-2.2	Jun	-97.29	-3.4
Apr	-54.69	-1.9	Jun	-43.69	-1.5	Apr	-48.21	-1.7	Jan	-92.03	-3.3	Aug	-32.33	-1.1	Jun	-20.29	-0.7	Apr	-38.3	-1.3	Jan	-75.46	-2.6
May	-22.55	-0.8	Apr	-27.08	-1.0	Sep	-33.0	-1.2	Sep	-54.0	-1.9	May	-15.91	-0.6	Apr	-17.20	-0.6	Sep	-20.3	-0.7	Sep	-41.25	-1.4
Sep	-20.4	-0.7	Sep	25.1	0.9	Jan	-9.54	-0.3	May	-27.18	-1.0	Sep	-7.69	-0.3	Sep	37.81	1.3	May	3.02	0.1	May	-20.53	-0.7
Jul	-8.84	-0.3	Dec	34.52	1.2	May	-3.63	-0.1	Nov	6.1	0.2	Jul	22.65	0.8	Dec	39.34	1.4	Jan	7.03	0.2	Nov	7.03	0.2
Dec	35.44	1.3	May	40.53	1.4	Nov	44.0	1.6	Apr	13.97	0.5	Dec	40.26	1.4	May	47.18	1.6	Nov	44.89	1.6	Apr	23.85	0.8
Oct	75.0	2.7	Nov	77.2	2.7	Oct	44.9	1.6	Oct	54.3	1.9	Oct	75.95	2.6	Nov	78.13	2.7	Oct	45.93	1.6	Oct	55.27	1.9
Nov	98.8	3.5	Oct	159.9	5.7	Dec	45.14	1.6	Dec	79.71	2.8	Nov	99.72	3.5	Oct	160.8	5.6	Dec	49.95	1.7	Dec	84.52	2.9
Annual	-424.9	-15	Annual	101.9	3.6	Annual	-829.1	-29.3	Annual	-1124.1	-39.7	Annual	-237.39	-8.2	Annual	289.43	10.1	Annual	-641.6	-22.3	Annual	-936.6	-32.5

Table 4.14.10: Noyil Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Noyil Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Jun	-49.75	-4.3	Jun	-49.74	-4.3	Jun	-49.77	-4.3	Jun	-49.79	-4.3	Jun	-41.33	-3.4	Jun	-41.31	-3.4	Jun	-41.3	-3.4	Jun	-41.37	-3.4
May	-42.01	-3.6	May	-42.01	-3.6	May	-42.01	-3.6	May	-42.01	-3.6	May	-37.71	-3.1	May	-37.71	-3.1	May	-37.7	-3.1	May	-37.71	-3.1
Jul	-30.70	-2.6	Jul	-30.66	-2.6	Jul	-30.76	-2.7	Jul	-30.82	-2.7	Jul	-26.26	-2.2	Jul	-26.21	-2.1	Jul	-26.3	-2.2	Jul	-26.38	-2.2
Aug	-26.54	-2.3	Aug	-26.54	-2.3	Aug	-26.54	-2.3	Aug	-26.54	-2.3	Aug	-23.13	-1.9	Aug	-23.13	-1.9	Aug	-23.1	-1.9	Aug	-23.13	-1.9
Mar	-25.34	-2.2	Mar	-25.34	-2.2	Mar	-25.34	-2.2	Mar	-25.34	-2.2	Mar	-22.00	-1.8	Mar	-22.00	-1.8	Mar	-22.0	-1.8	Mar	-22.00	-1.8
Feb	-22.89	-2.0	Feb	-22.89	-2.0	Feb	-22.89	-2.0	Feb	-22.89	-2.0	Feb	-19.87	-1.6	Feb	-19.87	-1.6	Feb	-19.9	-1.6	Feb	-19.87	-1.6
Apr	-20.90	-1.8	Apr	-20.90	-1.8	Apr	-20.90	-1.8	Apr	-20.90	-1.8	Apr	-18.36	-1.5	Apr	-18.36	-1.5	Apr	-18.4	-1.5	Apr	-18.36	-1.5
Jan	-20.10	-1.7	Jan	-20.10	-1.7	Jan	-20.10	-1.7	Jan	-20.10	-1.7	Jan	-17.78	-1.5	Jan	-17.78	-1.5	Jan	-17.8	-1.5	Jan	-17.78	-1.5
Sep	-11.19	-1.0	Sep	-10.96	-0.9	Sep	-11.50	-1.0	Sep	-11.82	-1.0	Sep	-9.54	-0.8	Sep	-9.30	-0.8	Sep	-9.8	-0.8	Sep	-10.17	-0.8
Dec	23.26	2.0	Dec	24.77	2.1	Dec	21.25	1.8	Dec	19.24	1.7	Dec	24.17	2.0	Dec	25.68	2.1	Dec	22.2	1.8	Dec	20.15	1.7
Nov	53.38	4.6	Nov	55.91	4.8	Nov	50.01	4.3	Nov	46.64	4.0	Nov	53.67	4.4	Nov	56.20	4.6	Nov	50.3	4.1	Nov	46.93	3.8
Oct	106.39	9.2	Oct	111.1	9.6	Oct	100.2	8.6	Oct	93.94	8.1	Oct	106.6	8.7	Oct	111.3	9.1	Oct	100.4	8.2	Oct	94.17	7.7
Annual	-66.40	-5.7	Annual	-57.40	-4.9	Annual	-78.40	-6.8	Annual	-90.40	-7.8	Annual	-31.52	-2.6	Annual	-22.52	-1.8	Annual	-43.5	-3.6	Annual	-55.5	-4.5

Table 4.14.11: Amaravathi Sub-basin-Monthiy Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Amaravathi Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Mar	-207.3	-7.7	Jul	-249.6	-9.3	Jul	-208.3	-7.8	Jul	-184.4	-6.9	Mar	-170.7	-6.2	Jul	-201.3	-7.3	Mar	-168.4	-6.1	Jun	-190.2	-6.9
Jun	-205.0	-7.7	Aug	-185.3	-6.9	Mar	-205.1	-7.7	Mar	-178.7	-6.7	Jun	-168.7	-6.1	Feb	-147.4	-5.4	Jul	-160.0	-5.8	Jul	-185.9	-6.8
Jul	-192.3	-7.2	Feb	-179.3	-6.7	Feb	-178.9	-6.7	Feb	-176.2	-6.6	Jul	-144.0	-5.2	Aug	-143.3	-5.2	Feb	-147.0	-5.3	Mar	-166.5	-6.0
Feb	-168.6	-6.3	Jun	-174.0	-6.5	Jun	-157.5	-5.9	Jun	-166.4	-6.2	Feb	-136.8	-5.0	Jun	-137.8	-5.0	Jun	-121.2	-4.4	Feb	-117.8	-4.3
Aug	-154.2	-5.8	Mar	-168.5	-6.3	Aug	-148.9	-5.6	Aug	-144.3	-5.4	Aug	-112.2	-4.1	Mar	-131.9	-4.8	Aug	-106.9	-3.9	Aug	-107.7	-3.9
Jan	-98.93	-3.7	Apr	-33.5	-1.3	Jan	-79.57	-3.0	Jan	-93.39	-3.5	Jan	-77.5	-2.8	Apr	-20.2	-0.7	Jan	-58.13	-2.1	Jan	-56.20	-2.0
Apr	-77.85	-2.9	Jan	-26.92	-1.0	Apr	-49.03	-1.8	Sep	-59.49	-2.2	Apr	-64.5	-2.3	Jan	-5.5	-0.2	Apr	-35.68	-1.3	Apr	-36.81	-1.3
May	-58.30	-2.2	Dec	-9.43	-0.4	Sep	-34.98	-1.3	May	-36.90	-1.4	May	-45.1	-1.6	Dec	-0.90	0.0	Sep	-13.31	-0.5	Dec	-17.16	-0.6
Sep	-40.31	-1.5	May	16.95	0.6	Dec	11.47	0.4	Dec	-7.95	-0.3	Sep	-18.6	-0.7	May	30.14	1.1	Dec	20.00	0.7	Sep	-10.26	-0.4
Oct	124.3	4.6	Sep	132.3	4.9	May	22.68	0.8	Apr	-1.63	-0.1	Oct	126.6	4.6	Oct	143.0	5.2	May	35.87	1.3	May	11.65	0.4
Dec	141.4	5.3	Oct	140.7	5.3	Oct	41.00	1.5	Nov	12.73	0.5	Dec	150.0	5.4	Sep	154.0	5.6	Oct	43.29	1.6	Nov	38.29	1.4
Nov	189.8	7.1	Nov	199.9	7.5	Nov	147.3	5.5	Oct	33.15	1.2	Nov	191.4	7.0	Nov	201.5	7.3	Nov	148.9	5.4	Oct	48.74	1.8
Annual	-746.9	-27.9	Annual	-536.9	-20.0	Annual	-839.9	-31.4	Annual	-1003.9	-37.5	Annual	-438.6	-15.9	Annual	-228.6	-8.3	Annual	-531.63	-19.3	Annual	-695.63	-25.3

Table 4.14.12: Tirumanimuttar Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Tirumanimuttar Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Mar	-147.3	-4.0	Mar	-147.3	-4.0	Mar	-147.3	-4.0	Mar	-147.3	-4.0	Mar	-79.73	-2.1	Mar	-79.73	-2.1	Mar	-79.73	-2.1	Mar	-79.73	-2.1
Feb	-103.0	-2.8	Feb	-103.0	-2.8	Feb	-103.0	-2.8	Feb	-103.0	-2.8	Feb	-57.43	-1.5	Feb	-57.43	-1.5	Feb	-57.43	-1.5	Feb	-57.43	-1.5
Apr	-82.74	-2.3	Apr	-82.74	-2.3	Apr	-82.74	-2.3	Apr	-82.74	-2.3	Apr	-48.13	-1.3	Apr	-48.13	-1.3	Apr	-48.13	-1.3	Apr	-48.13	-1.3
Aug	-65.16	-1.8	Aug	-65.16	-1.8	Aug	-65.16	-1.8	Aug	-65.16	-1.8	Aug	-39.86	-1.1	Aug	-39.86	-1.1	Aug	-39.86	-1.1	Aug	-39.86	-1.1
May	-62.52	-1.7	May	-62.52	-1.7	May	-62.52	-1.7	Sep	-63.04	-1.7	May	-38.58	-1.0	May	-38.58	-1.0	May	-38.58	-1.0	May	-38.58	-1.0
Sep	-60.84	-1.7	Jun	-50.85	-1.4	Sep	-61.49	-1.7	May	-62.52	-1.7	Jun	-32.47	-0.9	Jun	-31.69	-0.8	Jun	-32.51	-0.9	Jun	-32.61	-0.9
Jun	-51.62	-1.4	Sep	-48.81	-1.3	Jun	-51.66	-1.4	Jun	-51.76	-1.4	Sep	-28.84	-0.8	Jan	-26.28	-0.7	Sep	-29.49	-0.8	Sep	-31.04	-0.8
Jul	-40.86	-1.1	Jul	-38.52	-1.0	Jul	-40.99	-1.1	Jul	-41.29	-1.1	Jul	-26.39	-0.7	Jul	-24.05	-0.6	Jul	-26.52	-0.7	Jul	-26.82	-0.7
Jan	-37.17	-1.0	Jan	-37.17	-1.0	Jan	-37.17	-1.0	Jan	-37.17	-1.0	Jan	-26.28	-0.7	Sep	-16.81	-0.4	Jan	-26.28	-0.7	Jan	-26.28	-0.7
Dec	50.49	1.4	Dec	127.4	3.5	Dec	46.31	1.3	Dec	36.43	1.0	Dec	71.65	1.9	Dec	148.5	3.9	Dec	67.47	1.8	Dec	57.59	1.5
Nov	107.7	2.9	Nov	236.6	6.4	Nov	100.7	2.7	Nov	84.11	2.3	Nov	137.2	3.6	Nov	266.1	7.0	Nov	130.2	3.4	Nov	113.6	3.0
Oct	267.5	7.3	Oct	505.5	13.8	Oct	254.5	6.9	Oct	223.9	6.1	Oct	293.1	7.7	Oct	531.1	14	Oct	280.1	7.4	Oct	249.5	6.6
Annual	-225.54	-6.1	Annual	233.44	6.4	Annual	-250.50	-6.8	Annual	-309.51	-8.4	Annual	124.24	3.3	Annual	583.24	15	Annual	99.24	2.6	Annual	40.24	1.1

Table 4.14.13: Ponnanai Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Ponnanai Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Jul	-18.84	-1.9	Jul	-18.24	-1.9	Jul	-19.21	-2.0	Jul	-20.38	-2.1	Apr	0	0.04	Apr	1.05	0.1	Apr	0.05	0.0	Apr	-1.14	-0.1
Jan	-13.73	-1.4	Jun	-12.12	-1.2	Jan	-15.23	-1.6	Jan	-19.89	-2.0	Jun	1.97	0.20	Jun	2.58	0.3	Jun	1.60	0.2	May	-0.57	-0.1
Jun	-12.73	-1.3	Jan	-11.30	-1.2	Jun	-13.10	-1.3	Dec	-19.14	-2.0	Aug	2.34	0.23	Aug	3.15	0.3	Aug	1.84	0.2	Feb	0.10	0.0
Aug	-11.51	-1.2	Aug	-10.70	-1.1	Aug	-12.01	-1.2	Jun	-14.27	-1.5	Mar	4.01	0.40	Jul	4.89	0.5	May	3.09	0.3	Aug	0.29	0.0
Apr	-8.83	-0.9	Apr	-8.22	-0.8	Apr	-9.21	-0.9	Oct	-13.85	-1.4	May	4.27	0.43	Mar	5.46	0.5	Mar	3.11	0.3	Mar	0.31	0.0
Mar	-7.17	-0.7	Mar	-5.72	-0.6	Mar	-8.07	-0.8	Aug	-13.56	-1.4	Jul	4.28	0.43	May	6.18	0.6	Jul	3.91	0.4	Jun	0.43	0.0
May	-1.99	-0.2	May	-0.08	0.0	Dec	-5.87	-0.6	Mar	-10.87	-1.1	Feb	5.77	0.57	Feb	8.00	0.8	Feb	4.39	0.4	Jul	2.74	0.3
Dec	-1.59	-0.2	Feb	2.42	0.2	May	-3.17	-0.3	Apr	-10.40	-1.1	Jan	11.93	1.19	Jan	14.35	1.4	Jan	10.43	1.0	Jan	5.77	0.6
Feb	0.19	0.0	Dec	5.32	0.5	Feb	-1.19	-0.1	May	-6.83	-0.7	Sep	21.03	2.09	Sep	26.87	2.7	Sep	17.41	1.7	Sep	6.18	0.6
Sep	8.90	0.9	Sep	14.75	1.5	Oct	4.01	0.4	Sep	-5.95	-0.6	Dec	30.89	3.07	Dec	37.80	3.8	Dec	26.61	2.6	Dec	13.34	1.3
Oct	9.78	1.0	Oct	19.08	2.0	Sep	5.28	0.5	Feb	-5.48	-0.6	Oct	38.97	3.88	Oct	48.28	4.8	Oct	33.20	3.3	Oct	15.34	1.5
Nov	43.78	4.5	Nov	61.06	6.2	Nov	33.06	3.4	Nov	-0.12	0.0	Nov	67.79	6.75	Nov	85.08	8.5	Nov	57.07	5.7	Nov	23.89	2.4
Annual	-13.74	-1.4	Annual	36.26	3.7	Annual	-44.71	-4.6	Annual	-140.74	-14.4	Annual	193.69	19.27	Annual	243.69	24.2	Annual	162.7	16.2	Annual	66.69	6.6

Table 4.14.14: Upper Coleroon Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Upper Coleroon Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
Jul	-69.07	-5.1	Jul	-59.92	-4.4	Jul	-76.14	-5.6	Aug	-95.77	-7.1	Jul	-12.36	-0.9	Jul	-3.20	-0.2	Jul	-19.43	-1.4	Jul	-36.73	-2.7
Aug	-61.16	-4.5	Aug	-48.15	-3.6	Aug	-71.20	-5.3	Jul	-93.44	-6.9	Mar	-2.24	-0.2	Mar	0.49	0.0	Aug	-10.51	-0.8	Aug	-35.08	-2.6
Sep	-17.49	-1.3	Mar	-10.77	-0.8	Sep	-35.69	-2.6	Sep	-80.26	-5.9	Apr	-0.72	-0.1	Apr	0.76	0.1	Mar	-4.35	-0.3	Sep	-20.93	-1.5
Mar	-13.49	-1.0	Apr	-2.38	-0.2	Mar	-15.60	-1.2	Mar	-20.75	-1.5	Aug	-0.47	0.0	Jun	2.45	0.2	Apr	-1.86	-0.1	Mar	-9.50	-0.7
Apr	-3.86	-0.3	Jun	-0.94	-0.1	Feb	-6.44	-0.5	Feb	-12.81	-0.9	Jun	0.59	0.0	Feb	7.00	0.5	Jun	-0.84	-0.1	Feb	-5.36	-0.4
Feb	-3.83	-0.3	Feb	-0.46	0.0	Apr	-5.00	-0.4	Oct	-10.02	-0.7	Feb	3.62	0.3	May	7.99	0.6	Feb	1.01	0.1	Apr	-4.64	-0.3
Jun	-2.80	-0.2	Sep	6.09	0.5	Jun	-4.23	-0.3	Apr	-7.78	-0.6	May	5.41	0.4	Aug	12.53	0.9	May	3.42	0.2	Jun	-4.35	-0.3
May	4.80	0.4	May	7.38	0.5	May	2.81	0.2	Jun	-7.74	-0.6	Jan	13.97	1.0	Jan	19.48	1.4	Jan	9.72	0.7	May	-1.46	-0.1
Jan	9.70	0.7	Jan	15.21	1.1	Jan	5.45	0.4	Jan	-4.96	-0.4	Sep	41.84	3.0	Sep	65.42	4.8	Sep	23.64	1.7	Jan	-0.69	-0.1
Oct	45.70	3.4	Oct	66.63	4.9	Oct	29.54	2.2	May	-2.07	-0.2	Oct	63.48	4.6	Oct	84.41	6.1	Oct	47.32	3.4	Oct	7.76	0.6
Dec	66.63	4.9	Dec	90.46	6.7	Dec	48.24	3.6	Dec	3.21	0.2	Dec	78.95	5.8	Dec	102.8	7.5	Dec	60.56	4.4	Dec	15.53	1.1
Nov	132.5	9.8	Nov	174.8	13.0	Nov	99.90	7.4	Nov	20.03	1.5	Nov	148.1	10.8	Nov	190.4	13.9	Nov	115.5	8.4	Nov	35.68	2.6
Annual	86.64	6.4	Annual	236.64	17.5	Annual	-28.36	-2.1	Annual	-312.36	-23.2	Annual	339.2	24.7	Annual	489.2	35.6	Annual	224.2	16.3	Annual	-59.8	-4.4

Table 4.14.15: Lower Coleroon Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Lower Coleroon Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
May	2.80	0.02	May	6.54	0.1	May	1.43	0.01	May	-1.00	-0.008	May	3.10	0.2	May	6.83	0.5	May	1.72	0.1	May	-0.71	-0.1
Jun	3.64	0.03	Feb	7.56	0.1	Jun	2.16	0.02	Jun	-0.46	-0.004	Jun	5.26	0.4	Jun	9.29	0.7	Jun	3.78	0.3	Jun	1.16	0.1
Feb	3.85	0.03	Jun	7.67	0.1	Feb	2.49	0.02	Apr	-0.22	-0.002	Apr	6.02	0.5	Apr	10.69	0.8	Apr	4.30	0.3	Apr	1.28	0.1
Mar	4.15	0.03	Mar	7.91	0.1	Mar	2.76	0.02	Feb	0.08	0.001	Feb	7.41	0.6	Feb	11.12	0.9	Feb	6.05	0.5	Jan	3.28	0.3
Apr	4.52	0.04	Apr	9.19	0.1	Apr	2.80	0.02	Mar	0.33	0.003	Mar	9.52	0.7	Mar	13.28	1.0	Mar	8.14	0.6	Feb	3.64	0.3
Jan	9.47	0.08	Jan	17.56	0.1	Jan	6.49	0.05	Jan	1.24	0.010	Jan	11.51	0.9	Jan	19.60	1.5	Jan	8.53	0.7	Mar	5.70	0.4
Jul	19.41	0.16	Jul	29.96	0.2	Jul	15.52	0.13	Nov	7.61	0.063	Nov	35.47	2.7	Nov	55.51	4.3	Nov	28.08	2.2	Dec	14.07	1.1
Nov	28.00	0.23	Nov	48.04	0.4	Nov	20.61	0.17	Dec	8.19	0.068	Dec	37.11	2.8	Jul	57.03	4.4	Dec	28.76	2.2	Nov	15.08	1.2
Dec	31.23	0.26	Dec	53.88	0.4	Dec	22.88	0.19	Jul	8.68	0.072	Oct	41.62	3.2	Dec	59.76	4.6	Oct	32.96	2.5	Oct	17.71	1.4
Oct	33.13	0.27	Oct	56.65	0.5	Oct	24.47	0.20	Oct	9.22	0.076	Jul	46.49	3.6	Oct	65.14	5.0	Jul	42.59	3.3	Jul	35.75	2.7
Aug	38.44	0.32	Aug	61.98	0.5	Aug	29.77	0.25	Aug	14.49	0.120	Aug	67.41	5.2	Aug	90.96	7.0	Aug	58.74	4.5	Aug	43.47	3.3
Sep	46.01	0.38	Sep	74.92	0.6	Sep	35.36	0.29	Sep	16.61	0.137	Sep	74.34	5.7	Sep	103.24	7.9	Sep	63.68	4.9	Sep	44.93	3.4
Annual	222.2	1.84	Annual	377.6	3.1	Annual	166.7	1.38	Annual	64.8	0.536	Annual	342.76	26.3	Annual	498.19	38.2	Annual	287.3	22	Annual	185.4	14.2

Table 4.14.16: Cauvery Delta Sub-basin-Monthly Deficits or Surpluses in Descending Order for 75%, 50%, 90% and 100% Water Year Dependable Flow, Without and With Ground Water

Cauvery Delta Sub-basin																							
Without ground water												With ground water											
75%			50%			90%			100%			75%			50%			90%			100%		
Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%
May	10.45	0.1	May	24.26	0.2	May	-0.51	0.0	May	-9.90	-0.1	May	11.44	0.1	May	25.25	0.3	May	0.03	0.0	May	-8.91	-0.1
Jun	16.48	0.2	Jun	31.34	0.3	Jun	4.68	0.0	Jun	-5.42	-0.1	Jun	21.95	0.2	Jun	36.82	0.4	Jun	7.69	0.1	Jun	0.05	0.0
Apr	20.46	0.2	Feb	34.38	0.3	Apr	6.74	0.1	Apr	-4.96	0.0	Apr	25.53	0.3	Apr	42.78	0.4	Apr	9.53	0.1	Apr	0.11	0.0
Feb	20.67	0.2	Apr	37.71	0.4	Feb	9.79	0.1	Jan	0.30	0.0	Feb	32.71	0.3	Feb	46.42	0.5	Feb	16.42	0.2	Jan	7.20	0.1
Mar	24.69	0.2	Mar	38.62	0.4	Mar	13.63	0.1	Feb	0.47	0.0	Mar	42.88	0.4	Mar	56.81	0.6	Mar	23.64	0.2	Feb	12.51	0.1
Jan	44.39	0.4	Jan	74.32	0.7	Jan	20.63	0.2	Mar	4.17	0.0	Jan	51.29	0.5	Jan	81.21	0.8	Jan	24.43	0.2	Mar	22.36	0.2
Jul	129.9	1.3	Jul	168.9	1.7	Nov	80.77	0.8	Dec	29.02	0.3	Nov	164.8	1.6	Nov	238.9	2.4	Nov	94.68	0.9	Dec	48.92	0.5
Nov	139.6	1.4	Nov	213.6	2.1	Dec	86.25	0.9	Nov	30.47	0.3	Dec	173.0	1.7	Dec	257.2	2.6	Dec	97.20	1.0	Nov	55.75	0.6
Dec	153.1	1.5	Dec	237.3	2.4	Oct	96.14	1.0	Oct	34.12	0.3	Oct	193.9	1.9	Jul	260.5	2.6	Oct	112.0	1.1	Oct	62.85	0.6
Oct	165.1	1.7	Oct	252.0	2.5	Jul	98.94	1.0	Jul	72.45	0.7	Jul	221.5	2.2	Oct	280.7	2.8	Jul	149.4	1.5	Jul	164.1	1.6
Aug	221.9	2.2	Aug	308.8	3.1	Aug	152.8	1.5	Aug	93.70	0.9	Aug	319.9	3.2	Aug	406.9	4.1	Aug	206.8	2.1	Aug	191.8	1.9
Sep	256.4	2.6	Sep	363.2	3.7	Sep	171.6	1.7	Sep	99.00	1.0	Sep	352.2	3.5	Sep	459.0	4.6	Sep	224.3	2.2	Sep	194.9	1.9
Annual	1203.1	12.1	Annual	1784.4	18.0	Annual	741.4	7.5	Annual	343.4	3.5	Annual	1611.2	16.1	Annual	2193	21.9	Annual	966.0	9.7	Annual	751.5	7.5

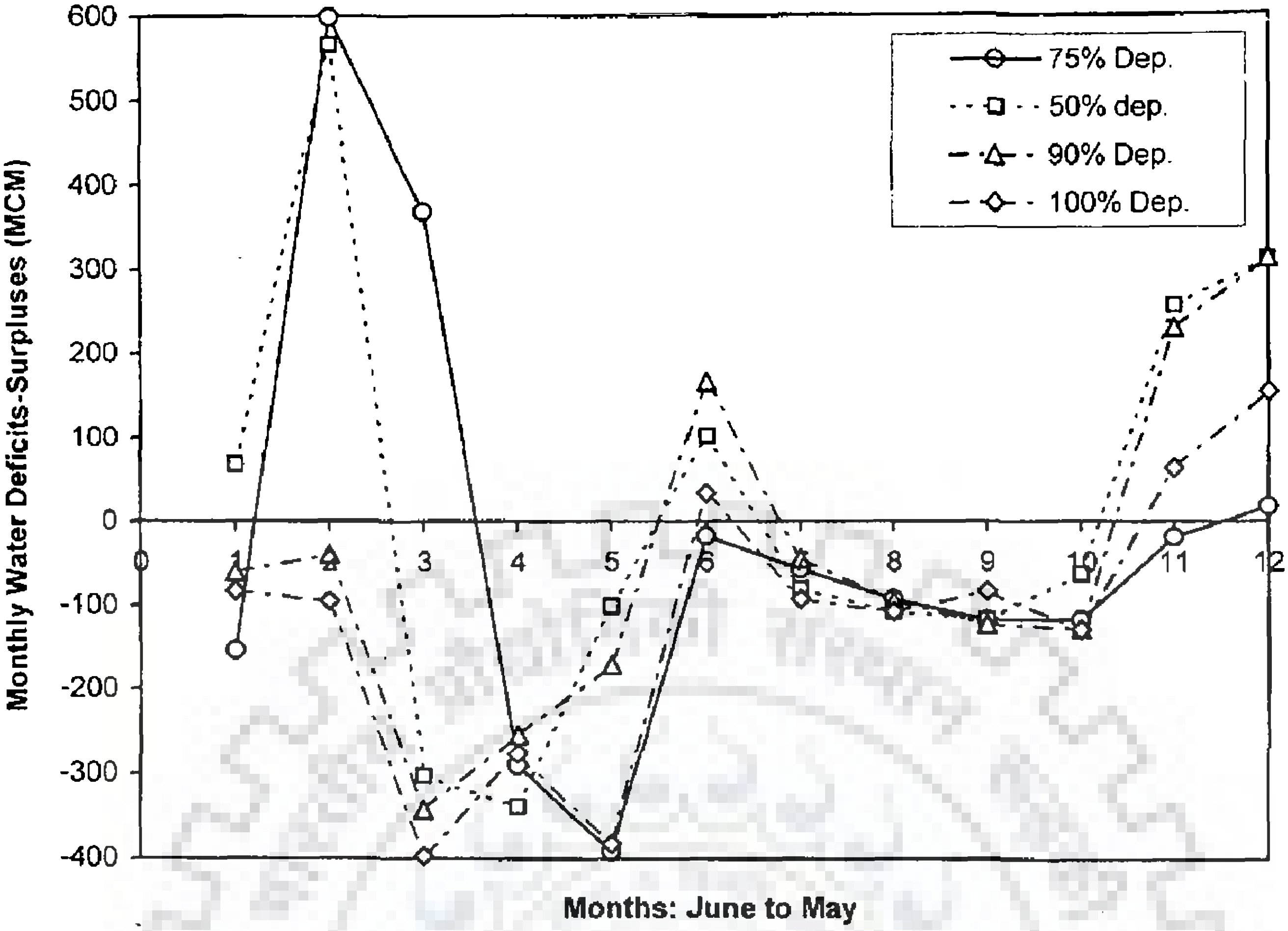

Figure 4.1(a): Upper Cauvery Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

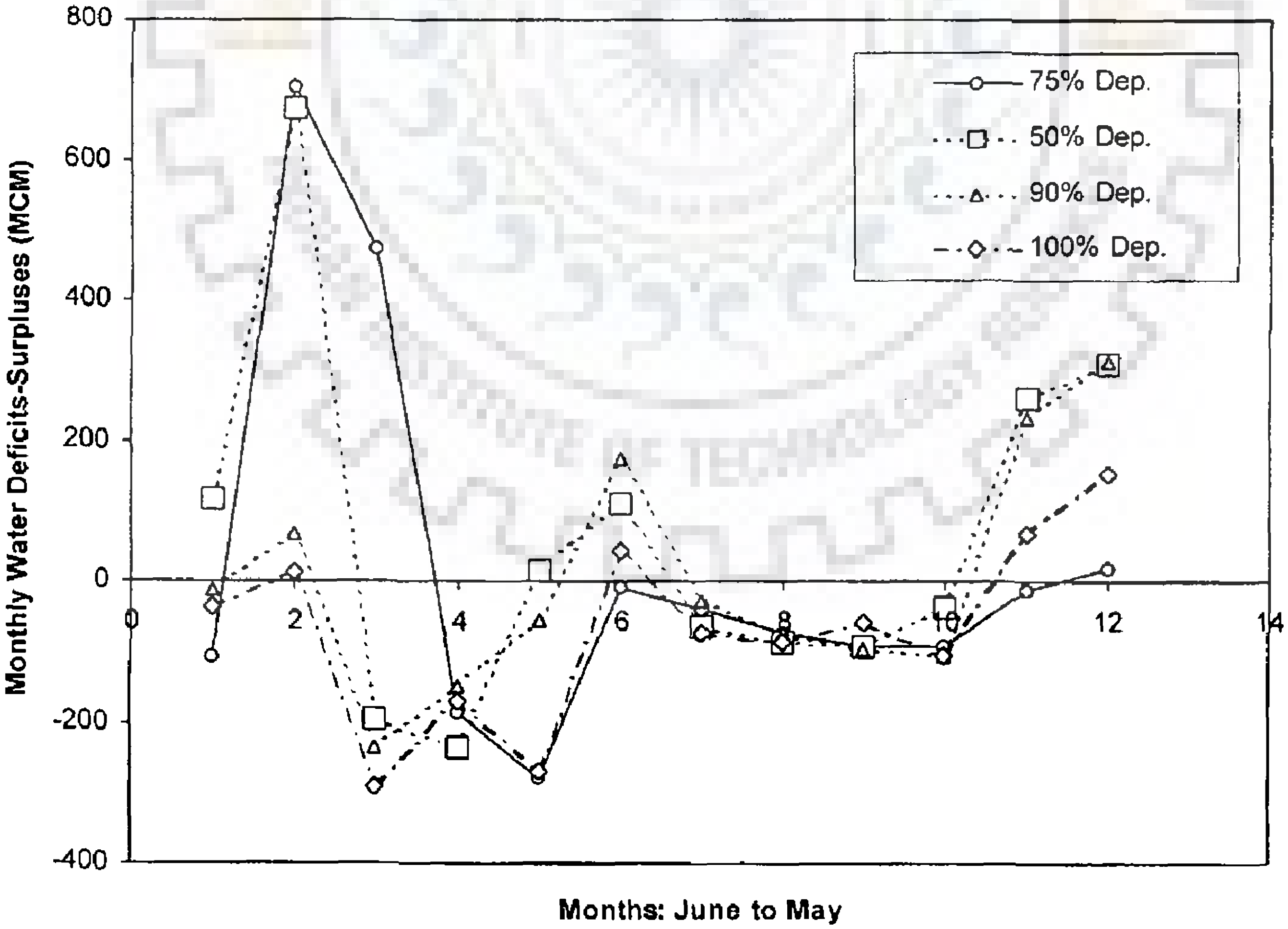

Figure 4.1(b): Upper Cauvery Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

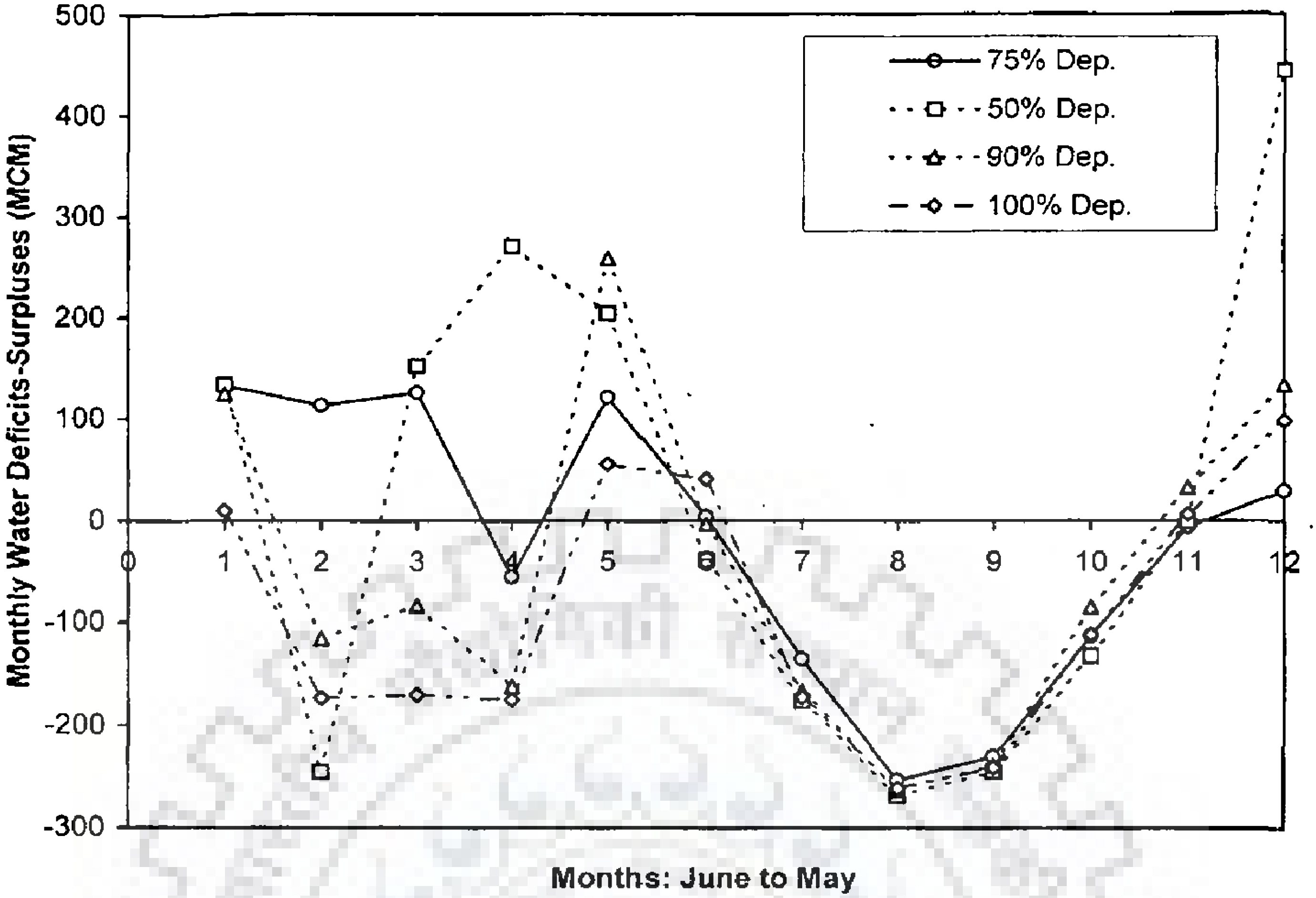

Figure 4.2(a): Kabini Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

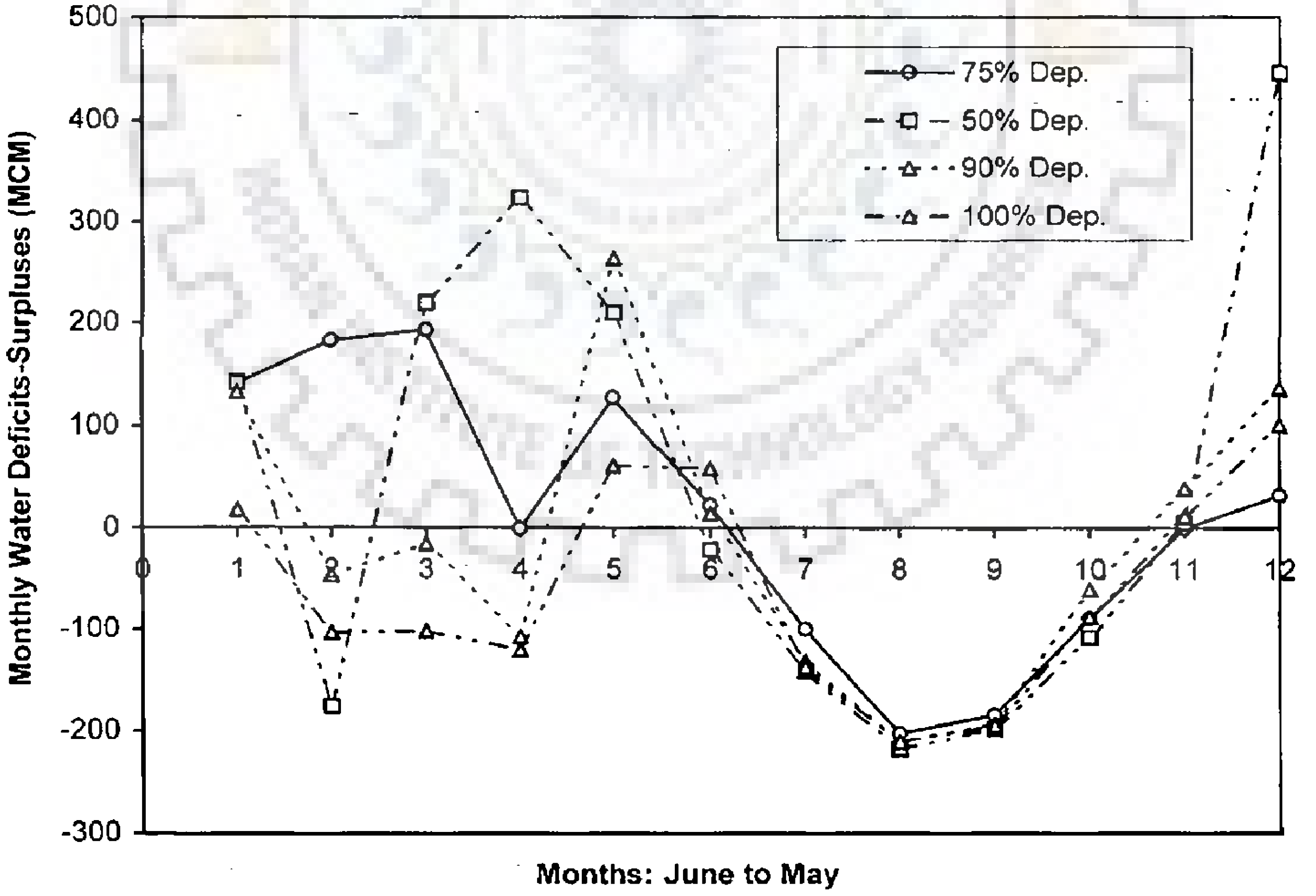

Figure 4.2(b): Kabini Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

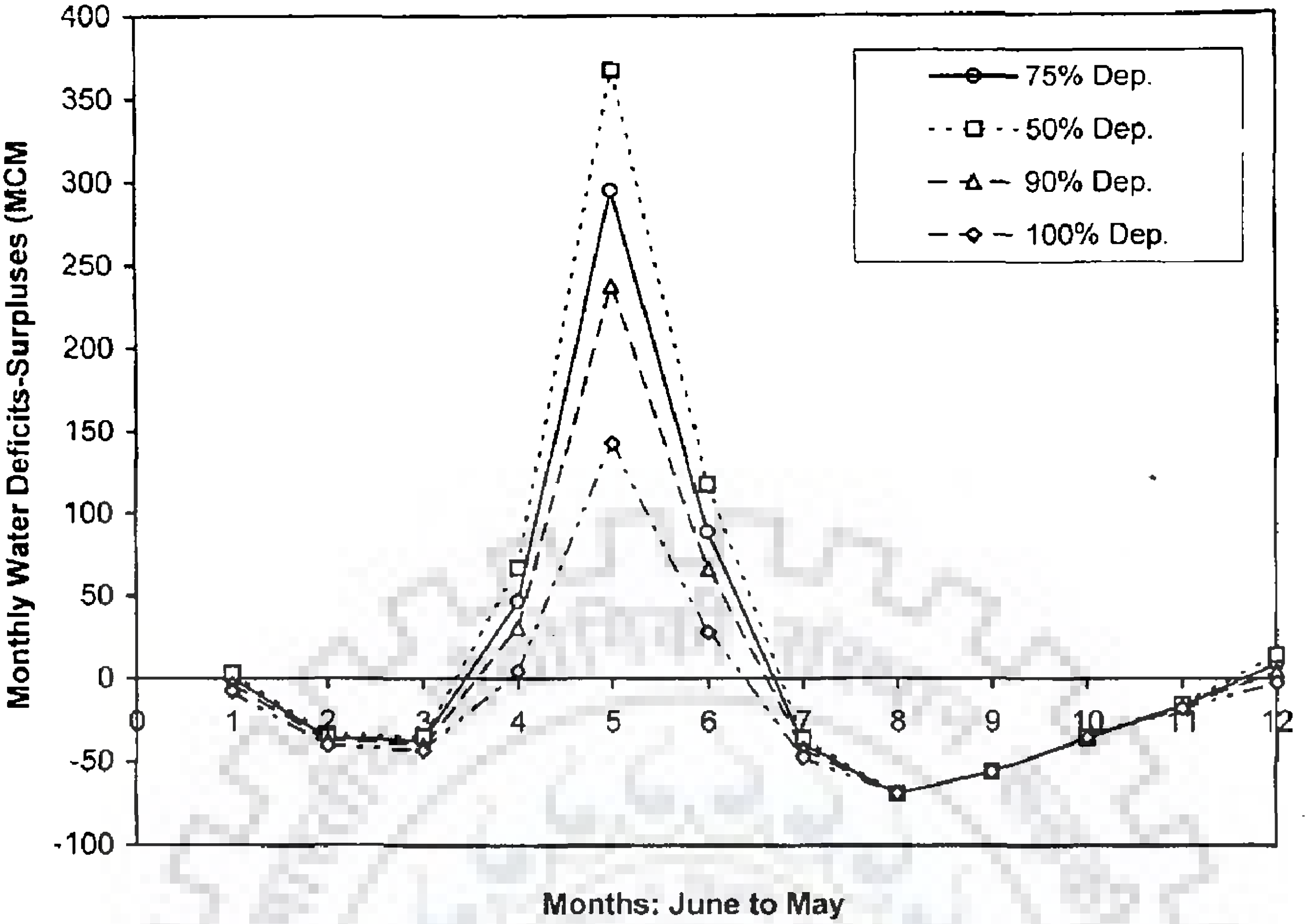

Figure 4.3(a): Shimsha Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

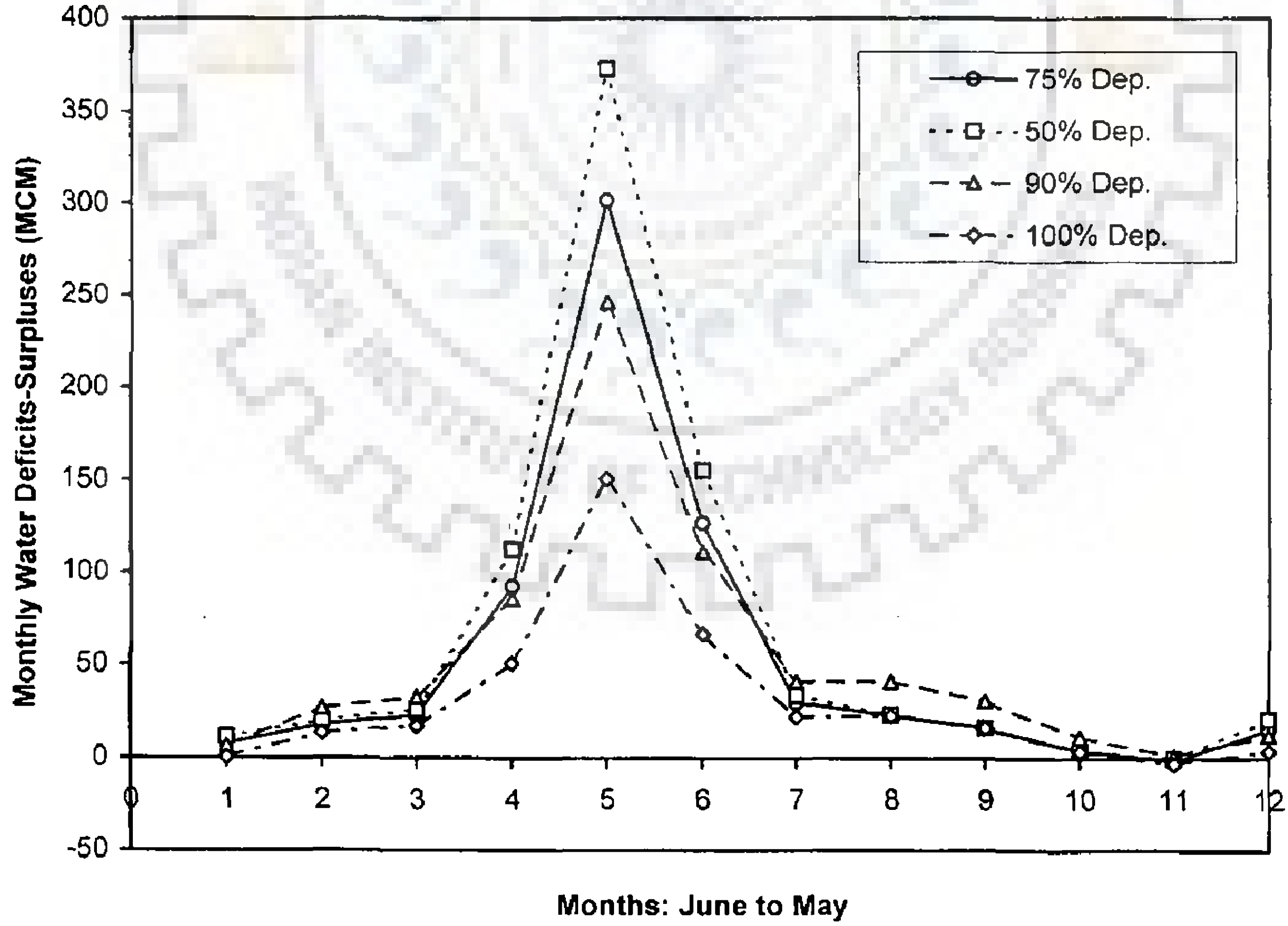

Figure 4.3(b): Shimsha Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

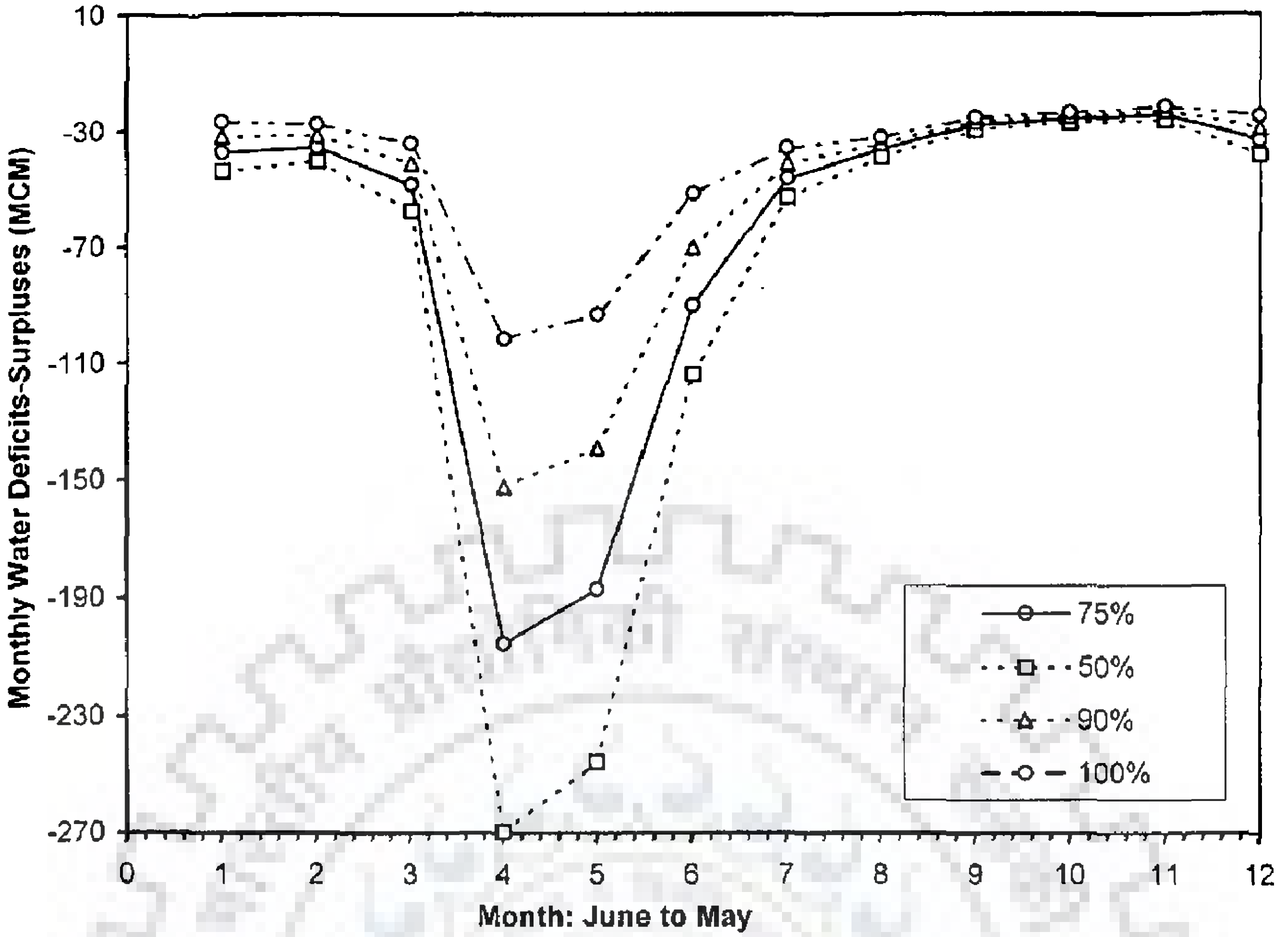

Figure 4.4(a): Arkavathi Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

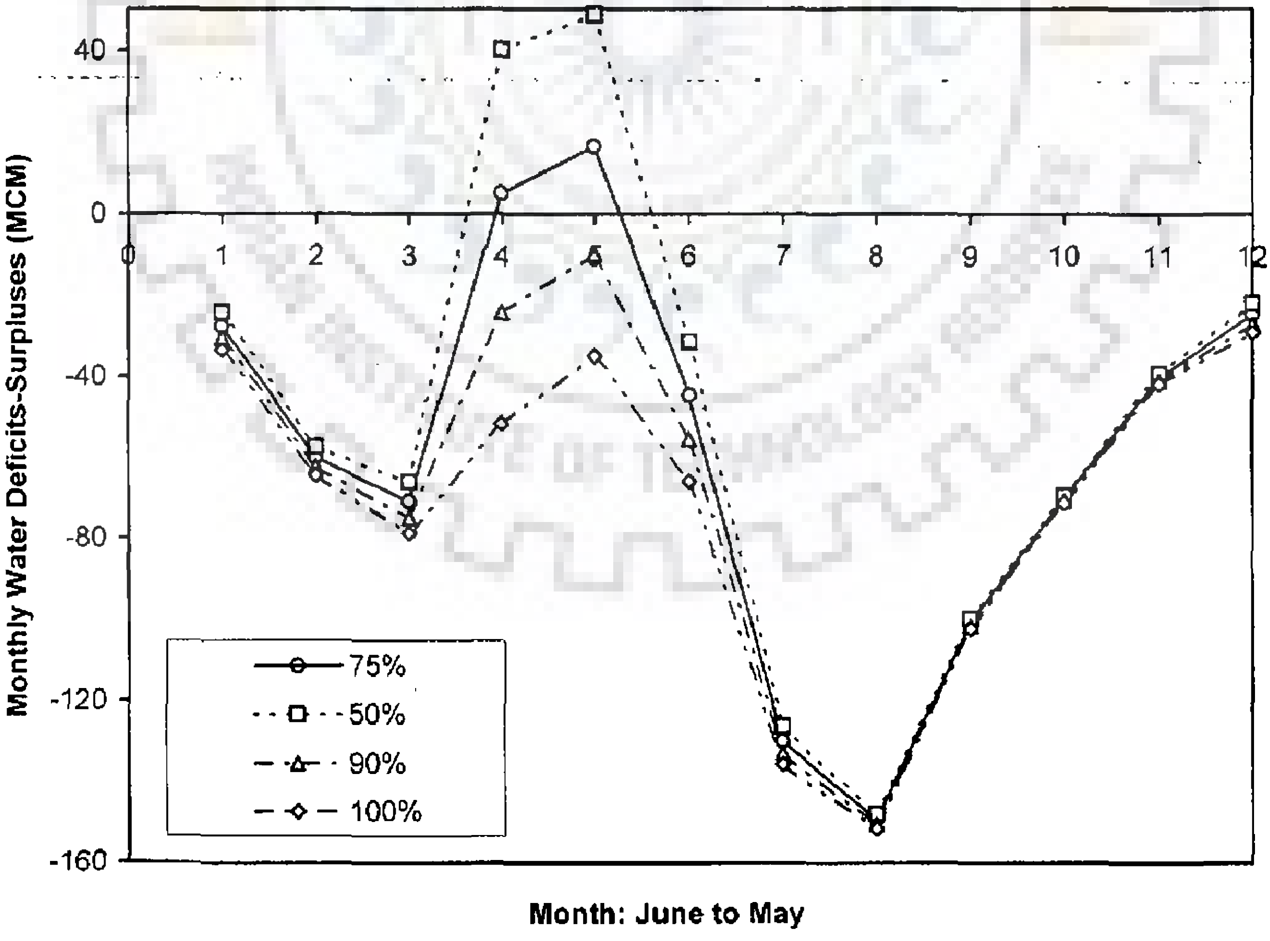

Figure 4.4(b): Arkavathi Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

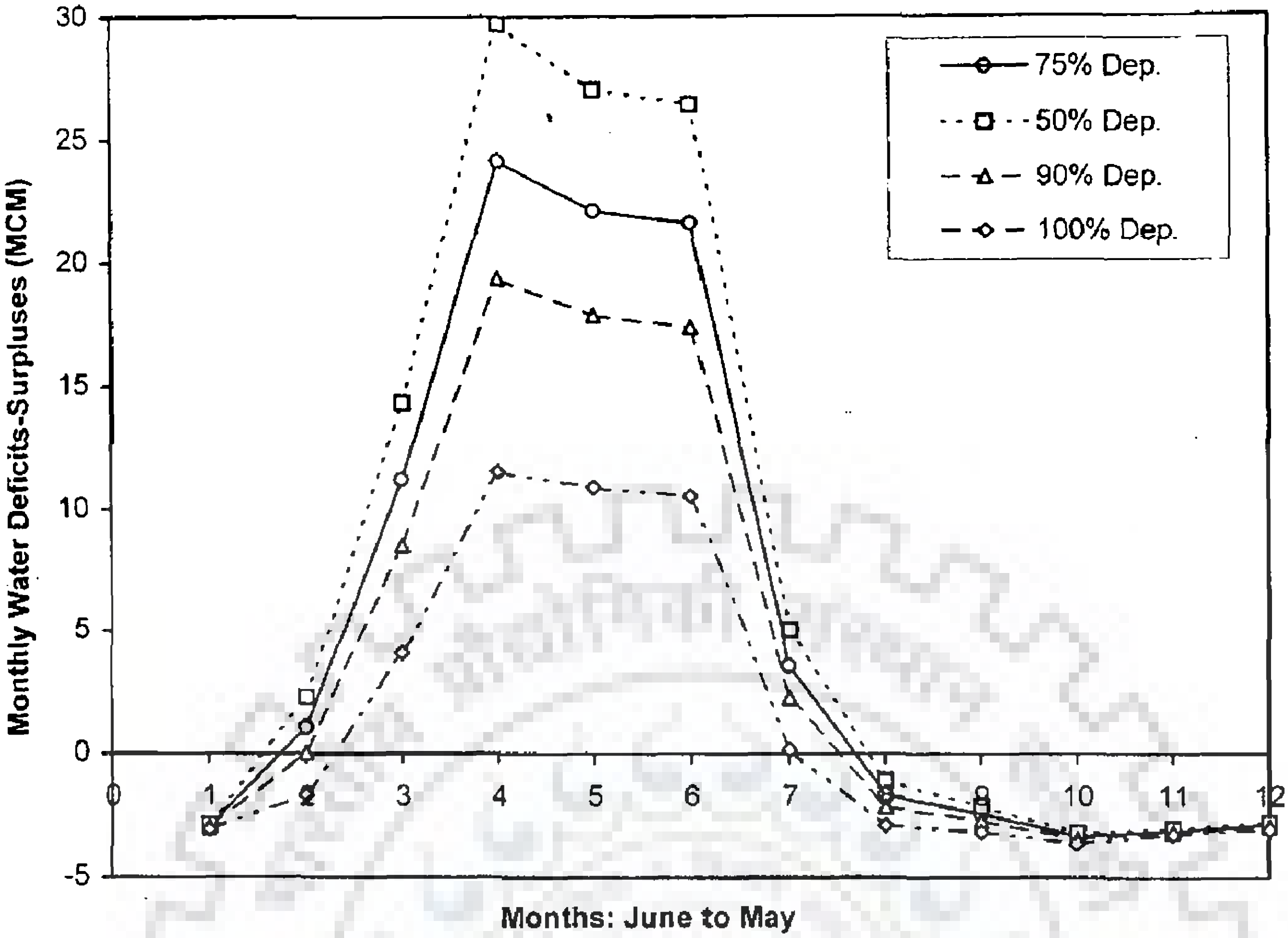

Figure 4.5(a): Middle Cauvery Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

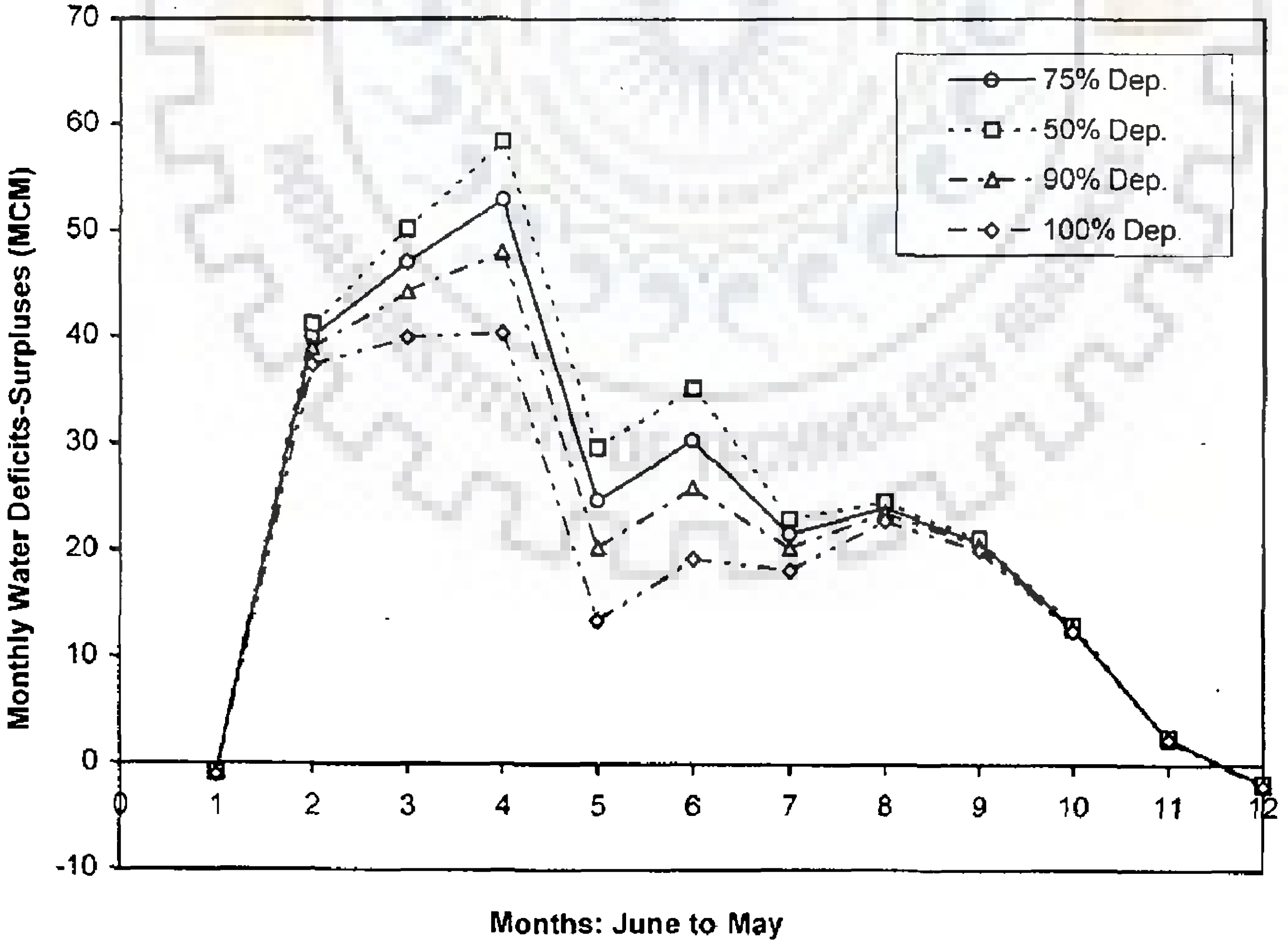

Figure 4.5(b): Middle Cauvery Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

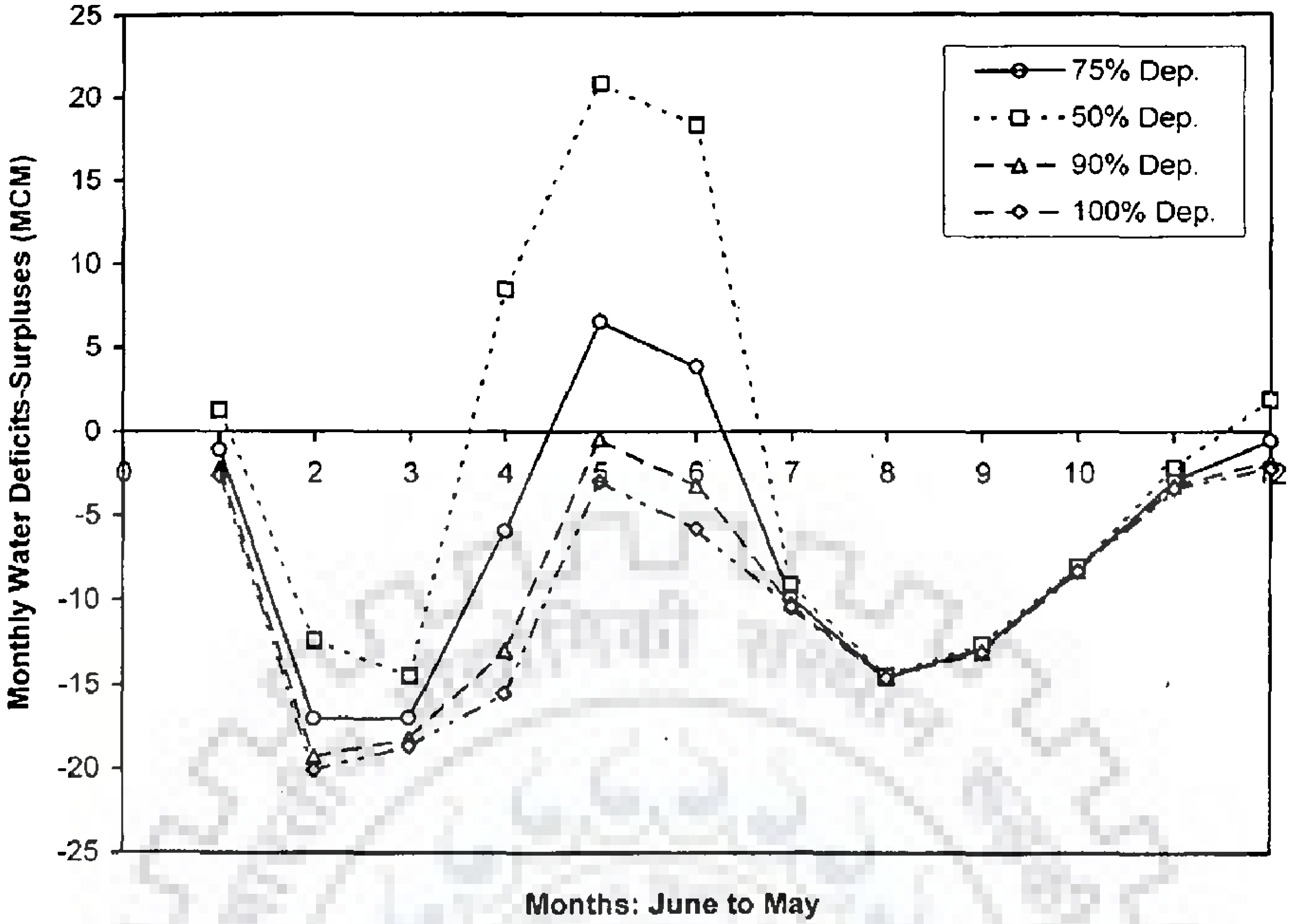

Figure 4.6(a): Suvarnavathi Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

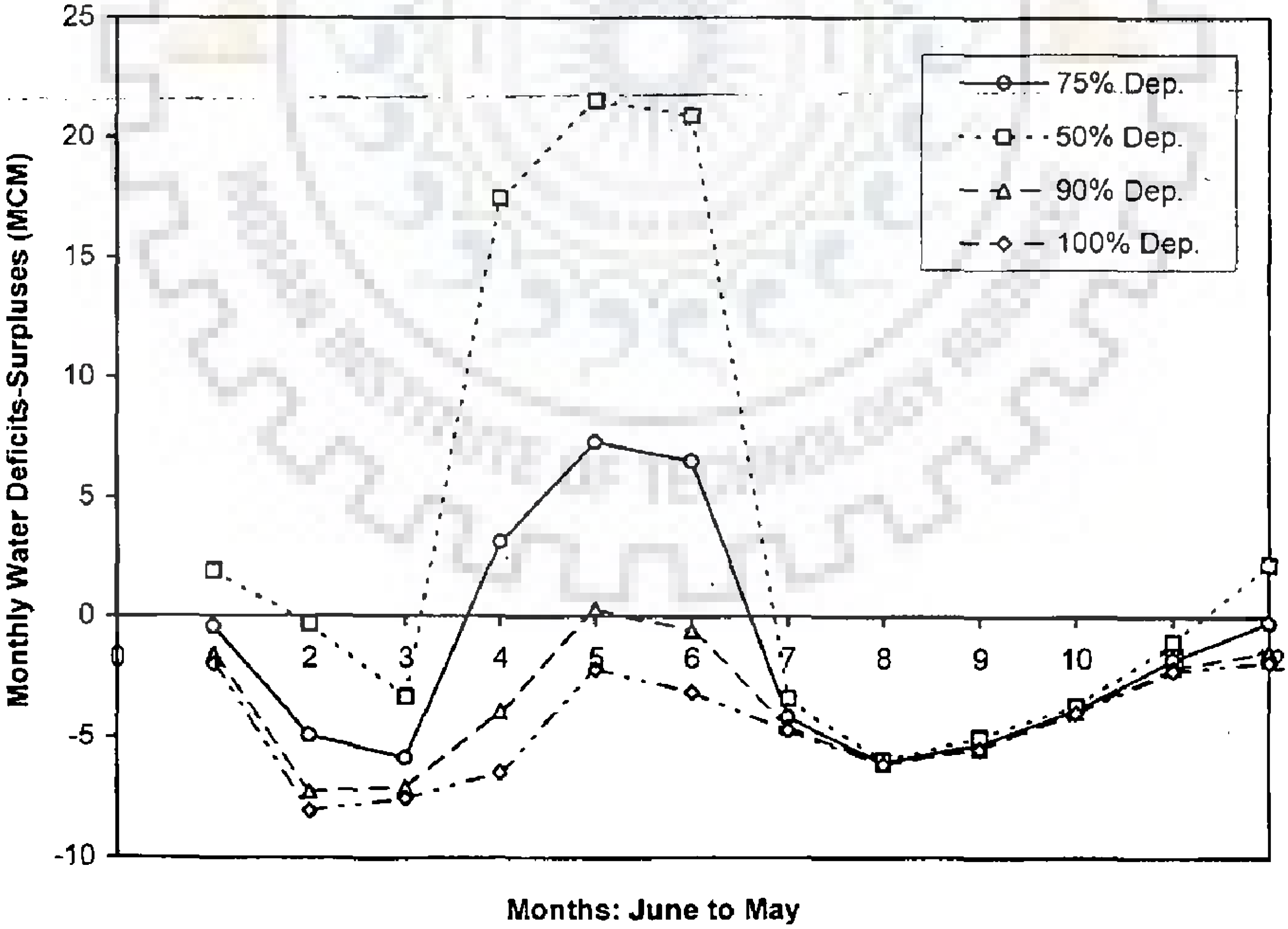

Figure 4.6(b): Suvarnavathi Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

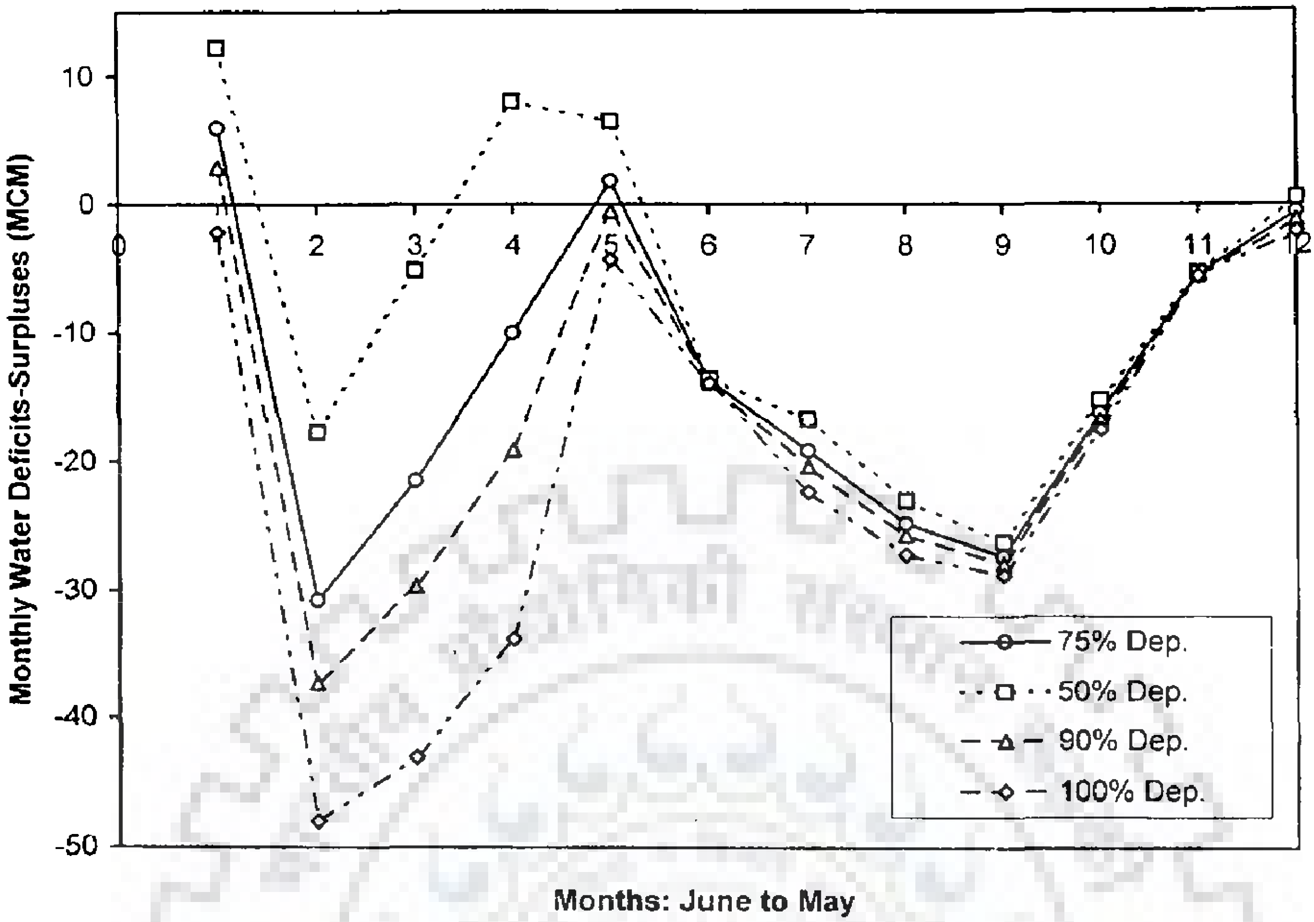

Figure 4.7(a): Palar Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

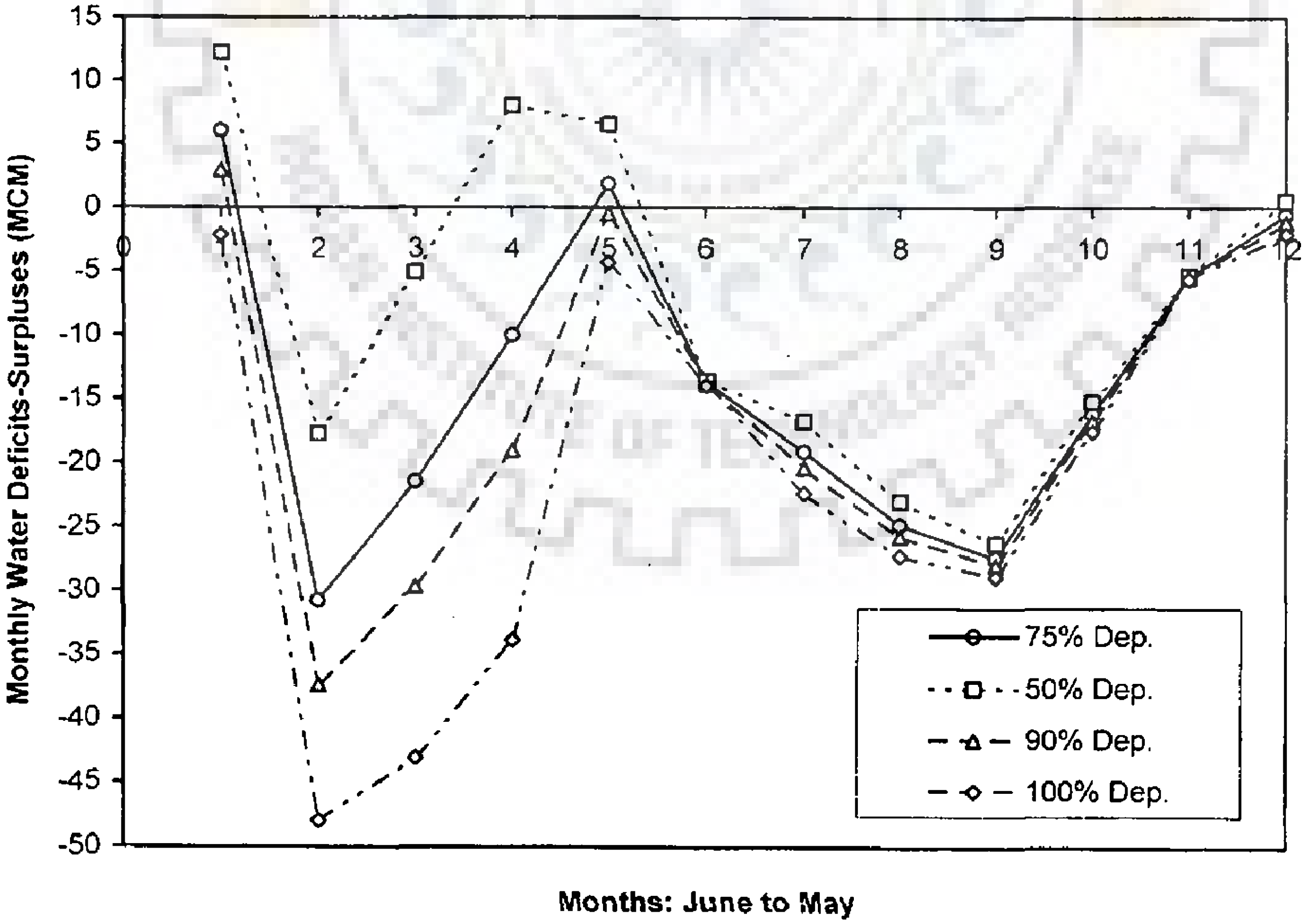

Figure 4.7(b): Palar Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

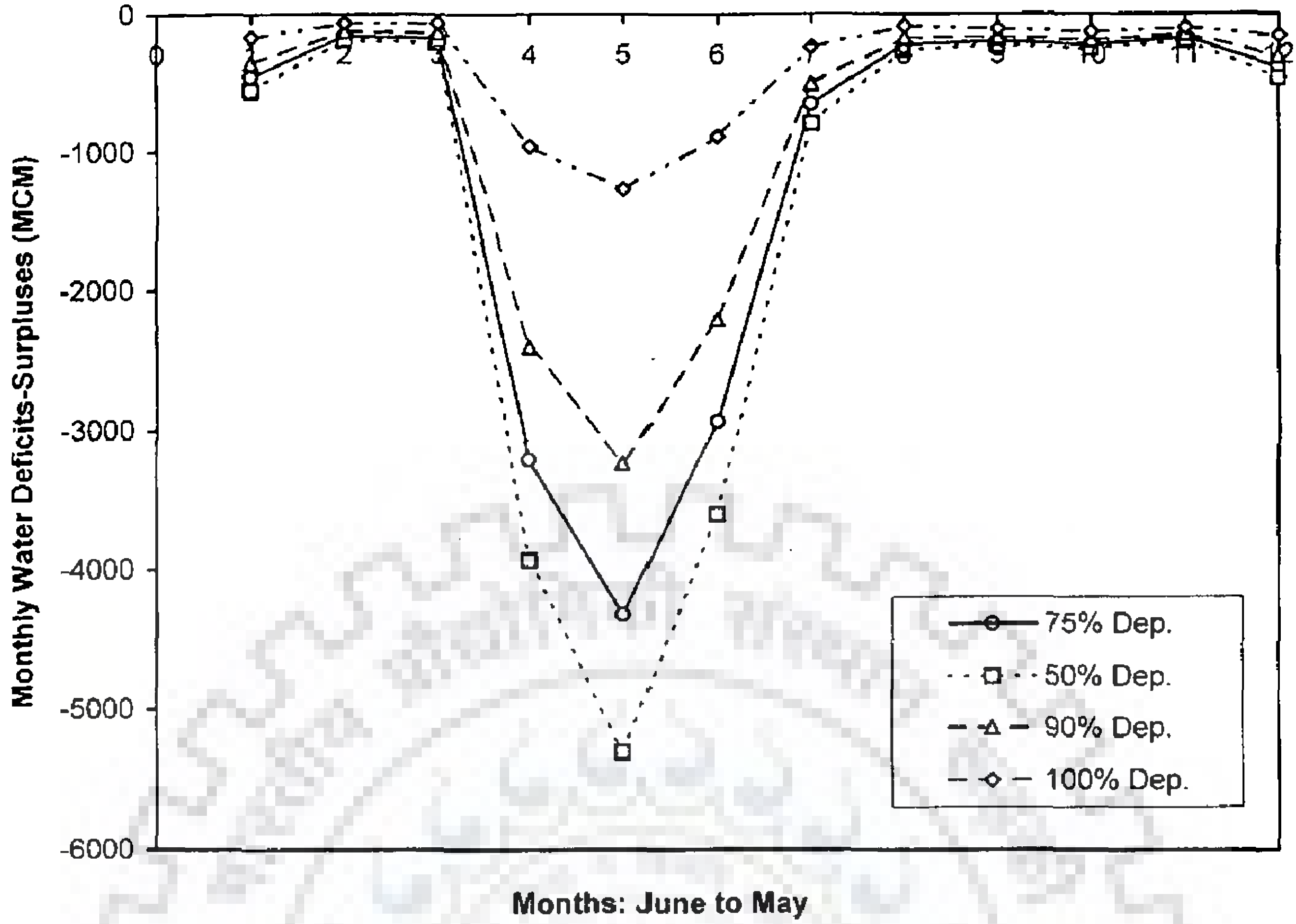

Figure 4.8(a): Chinnar Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

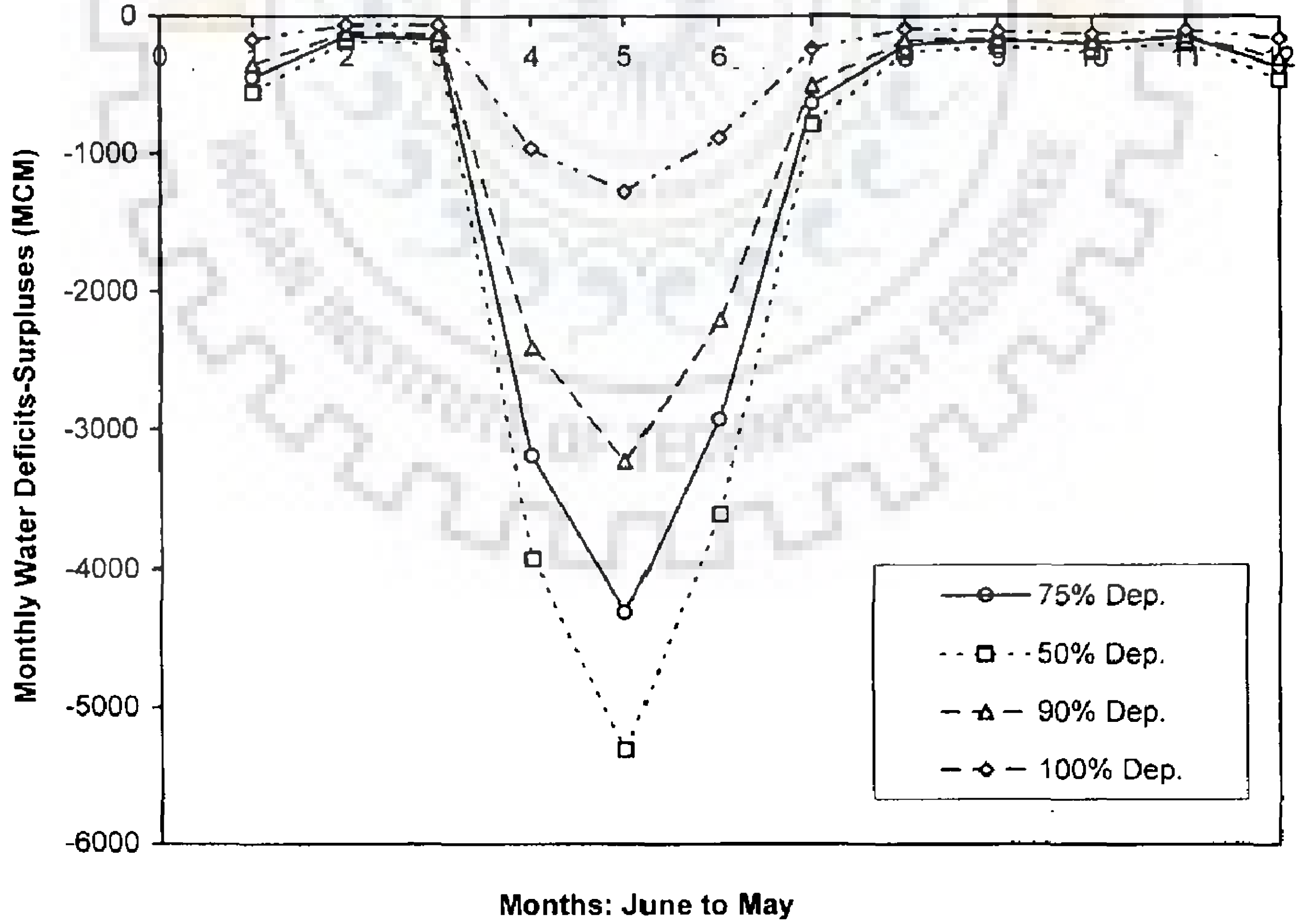

Figure 4.8(b): Chinnar Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

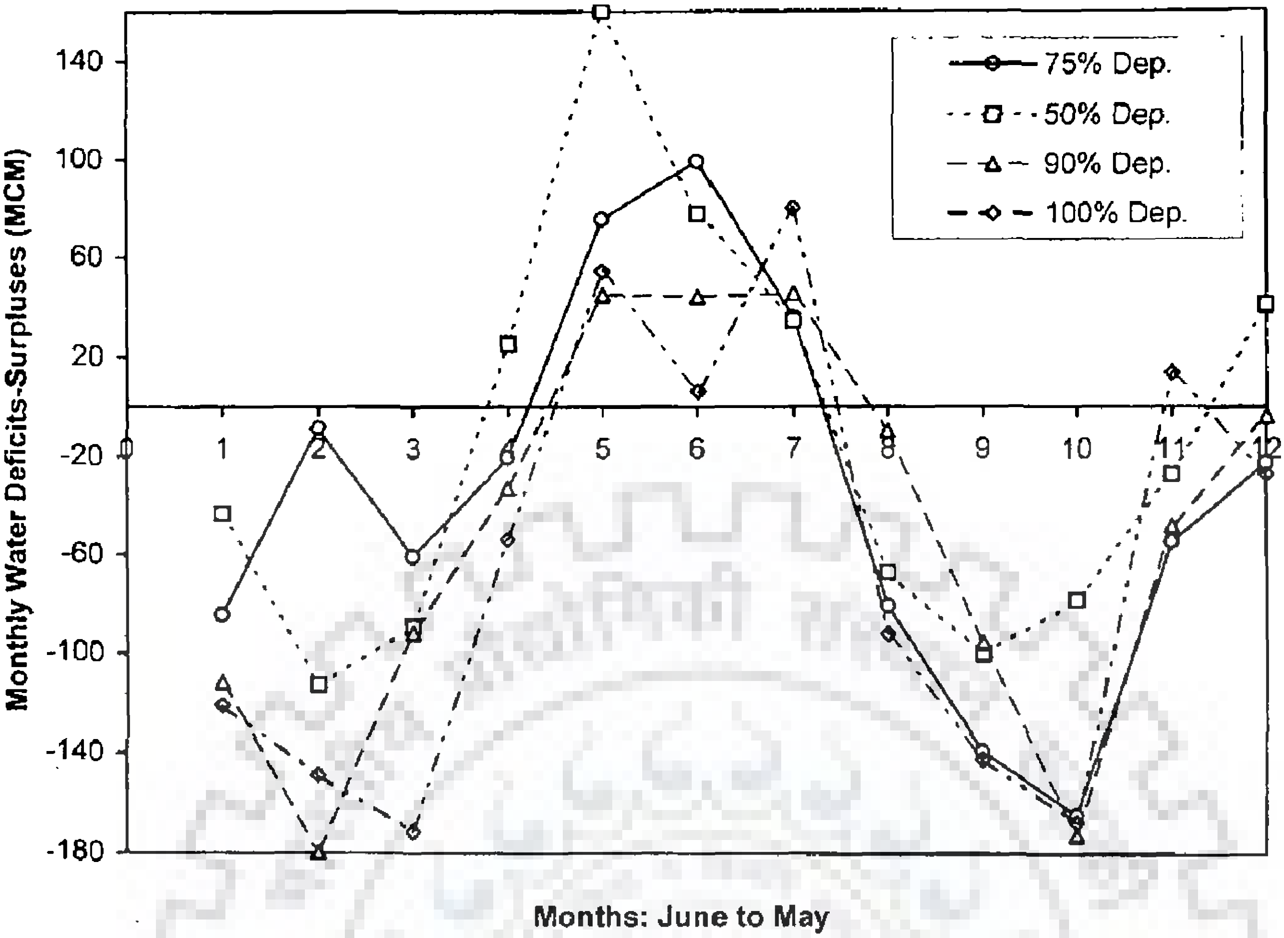

Figure 4.9(a): Bhavani Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

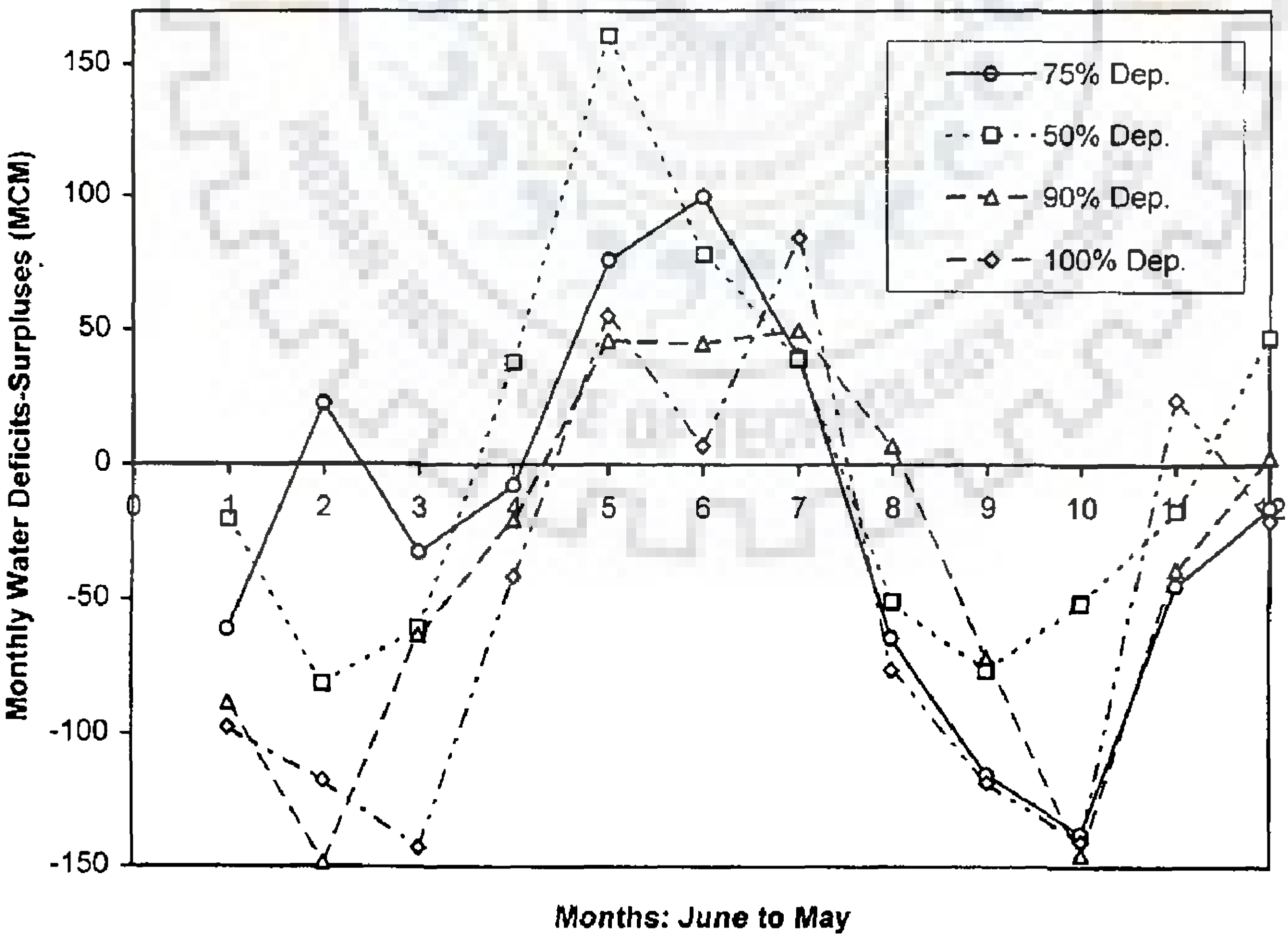

Figure 4.9(b): Bhavani Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

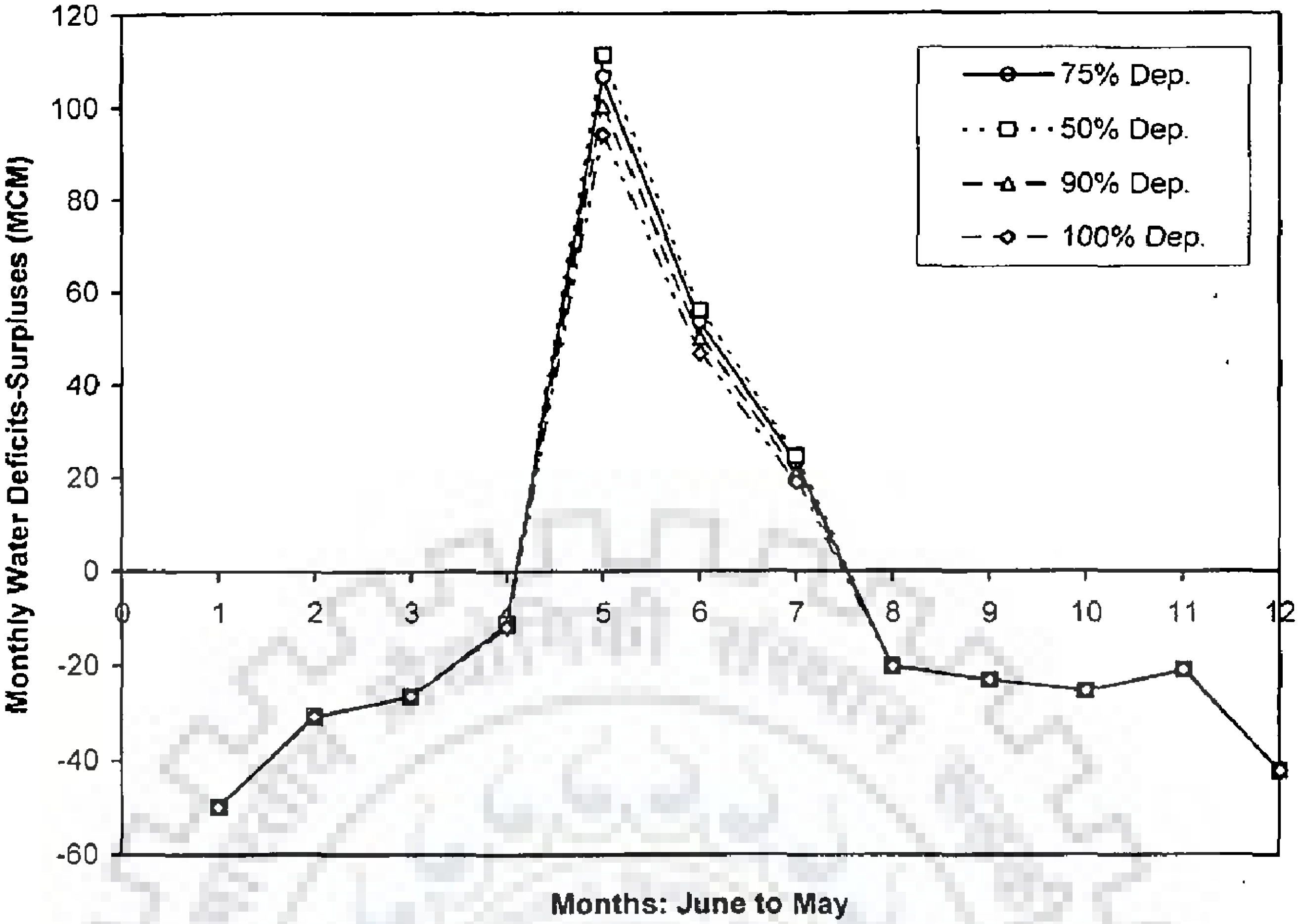

Figure 4.10(a): Noyil Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

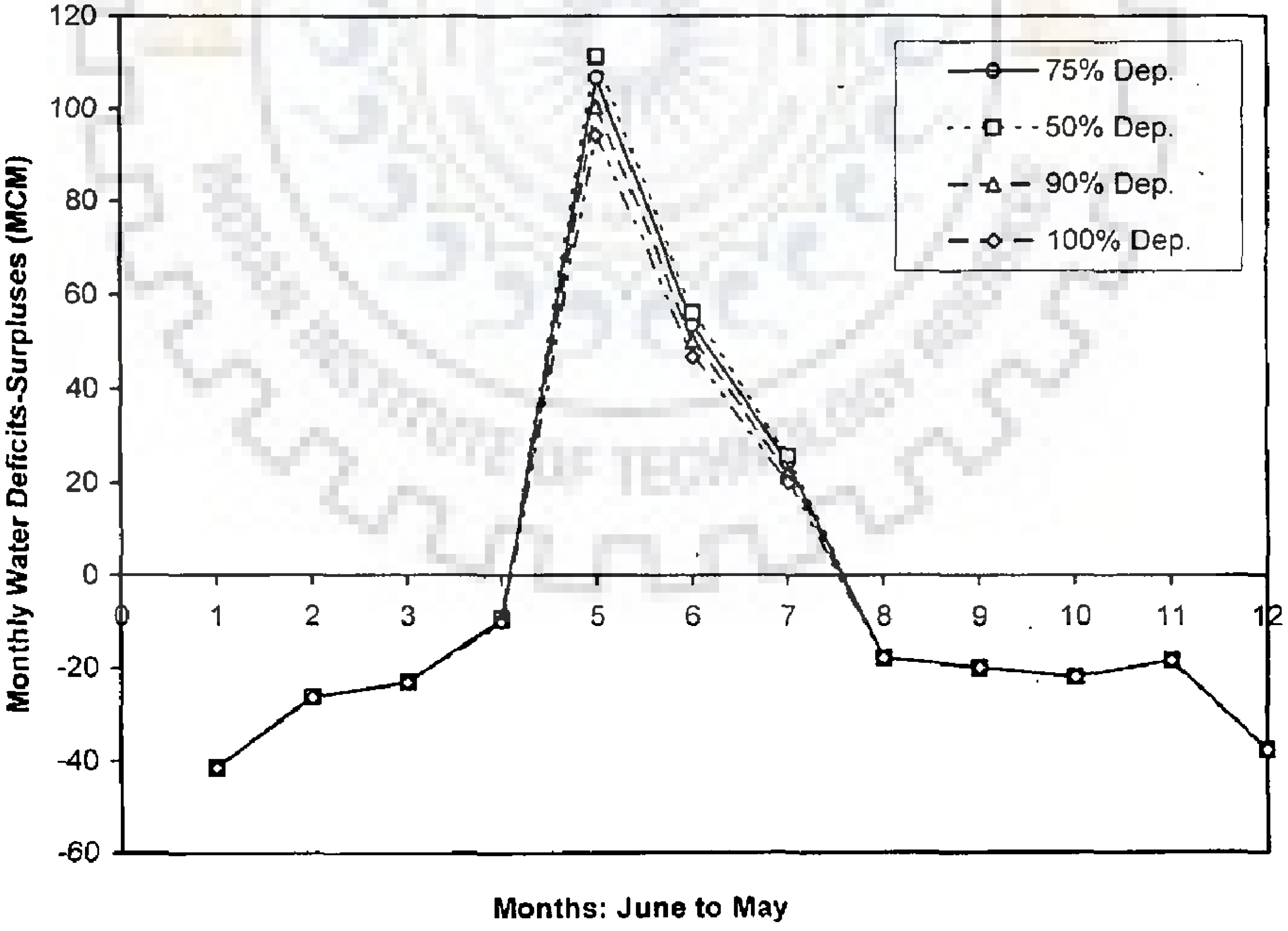

Figure 4.10(b): Noyil Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

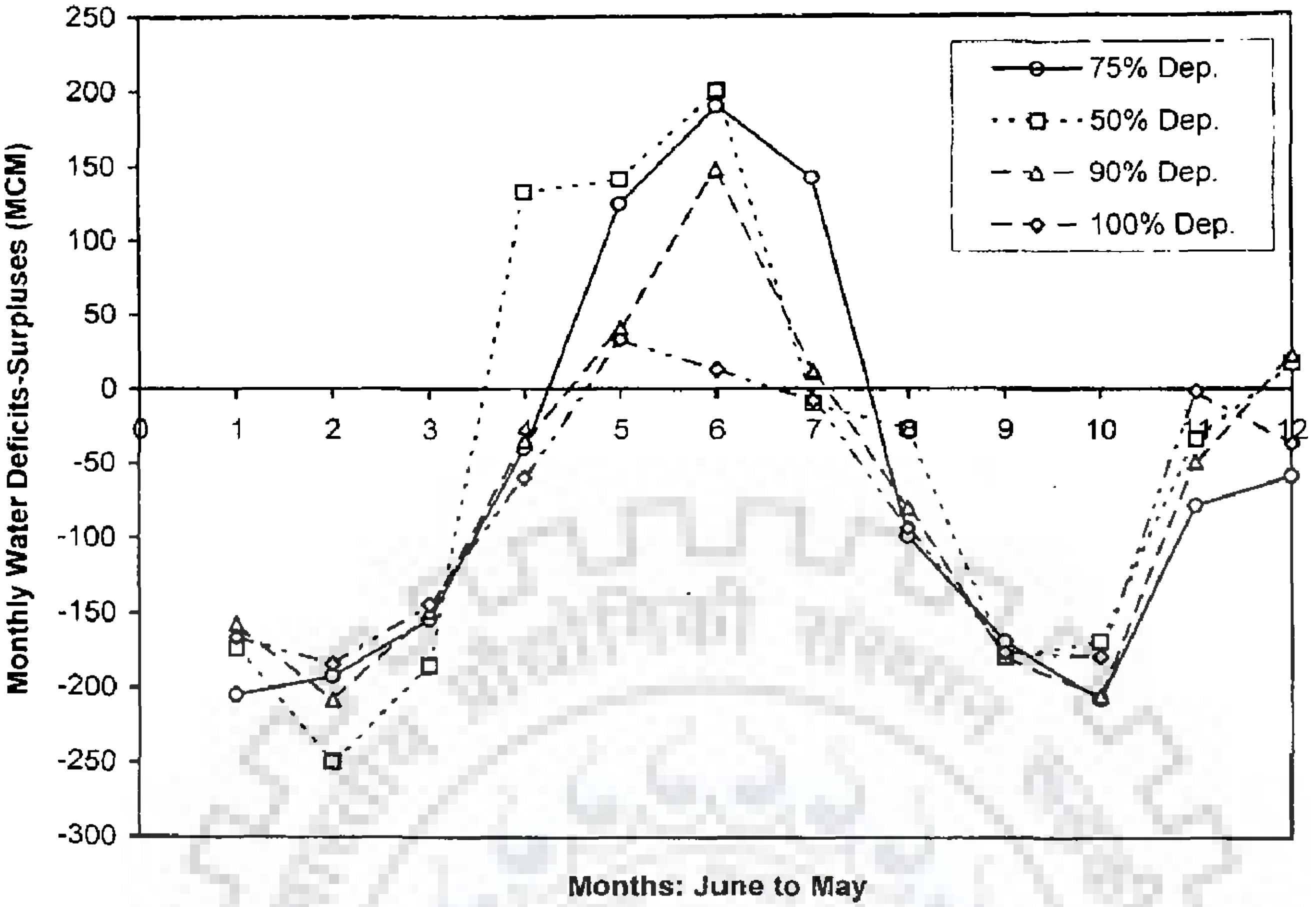

Figure 4.11(a): Amaravathi Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

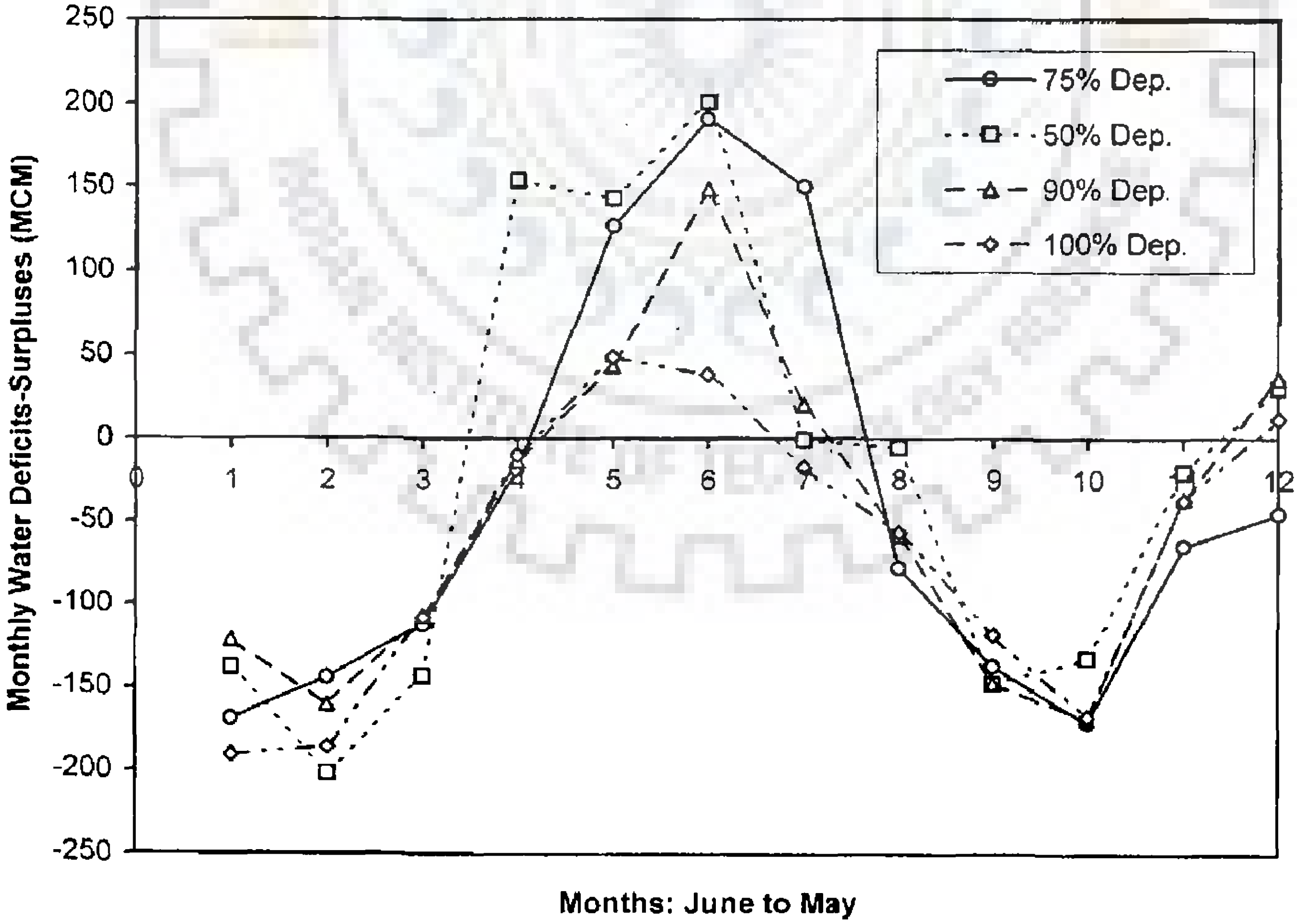

Figure 4.11(b): Amaravathi Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

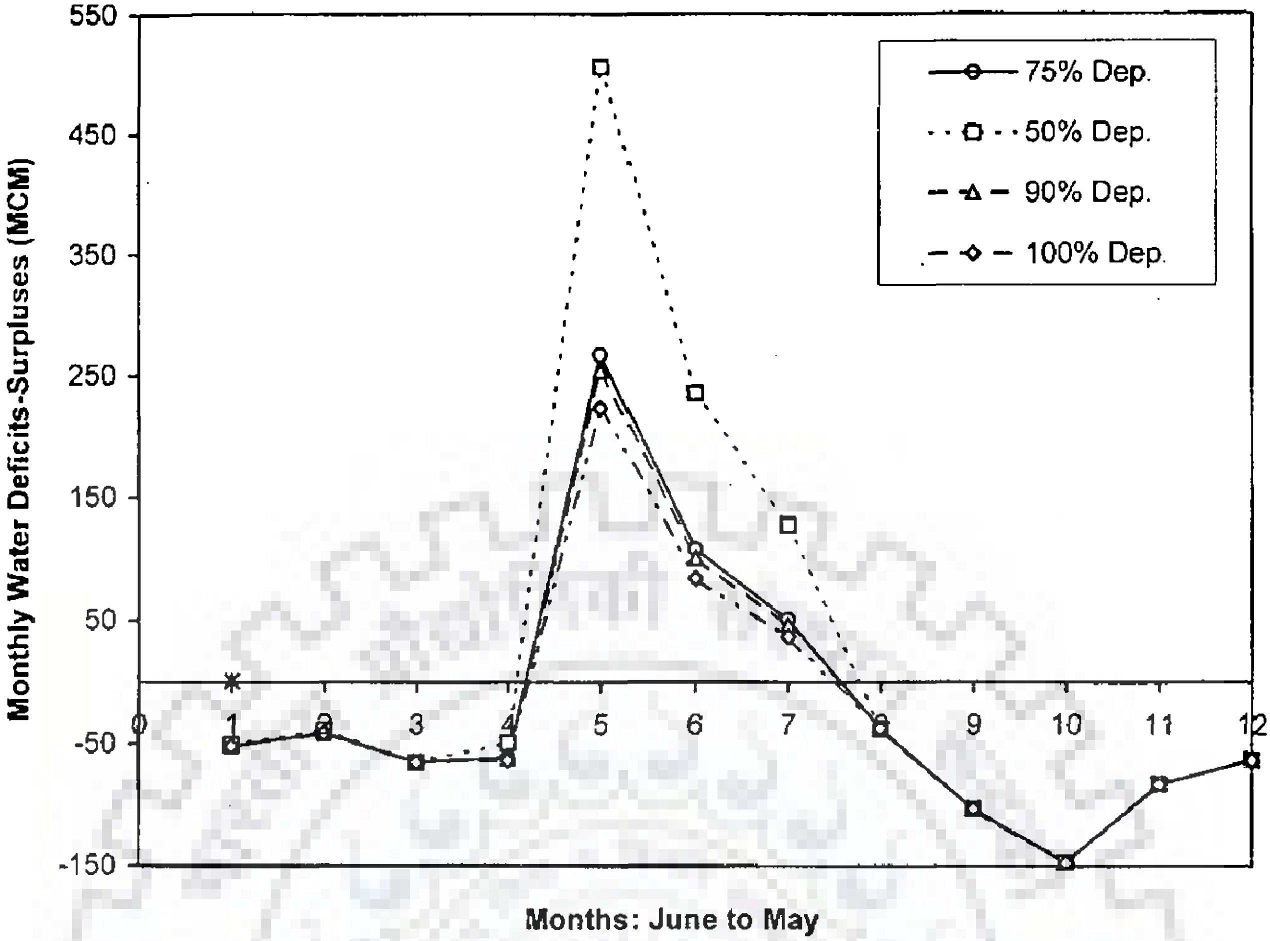

Figure 4.12(a): Tirumanimuttar Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

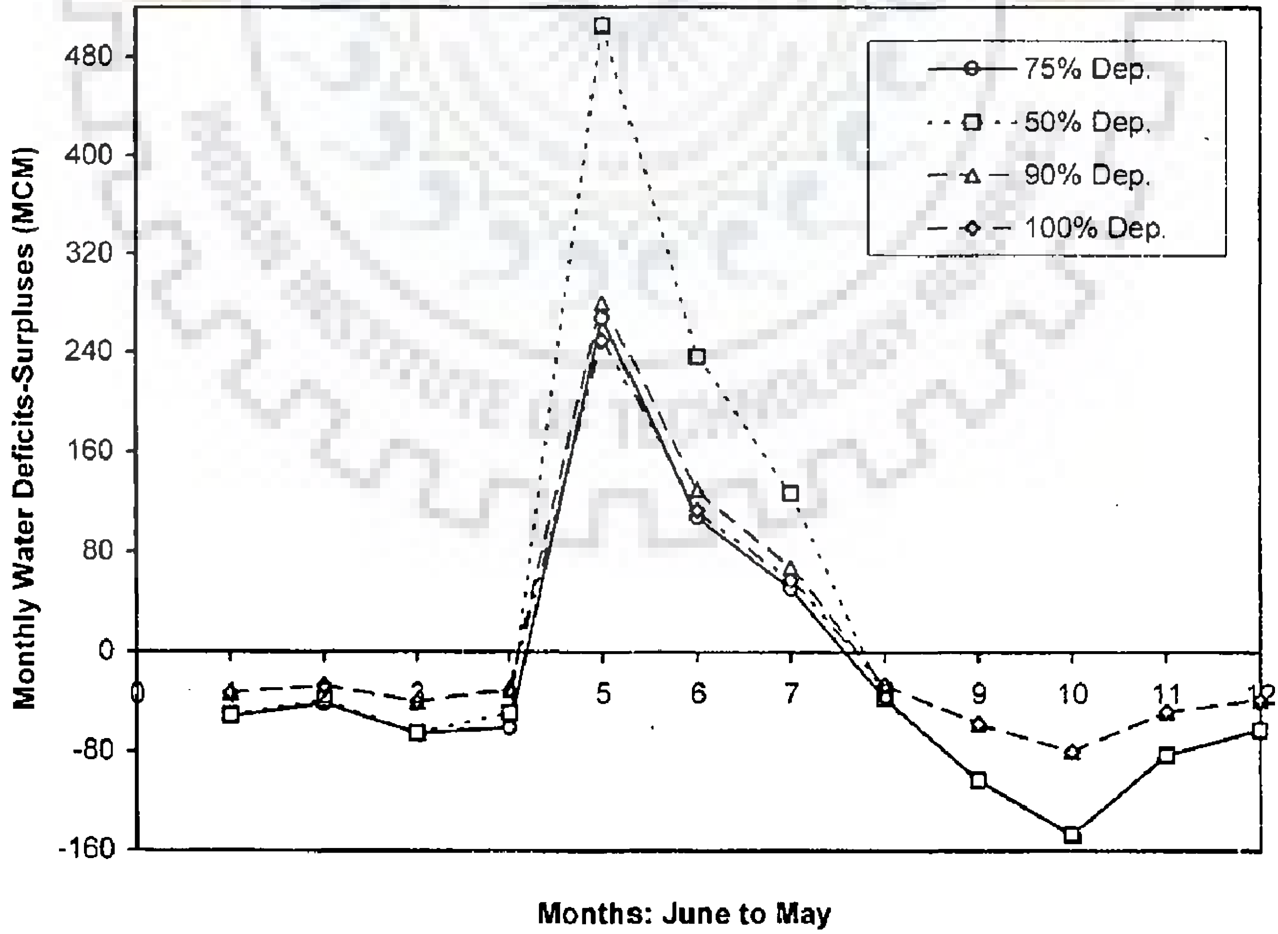

Figure 4.12(b): Tirumanimuttar Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

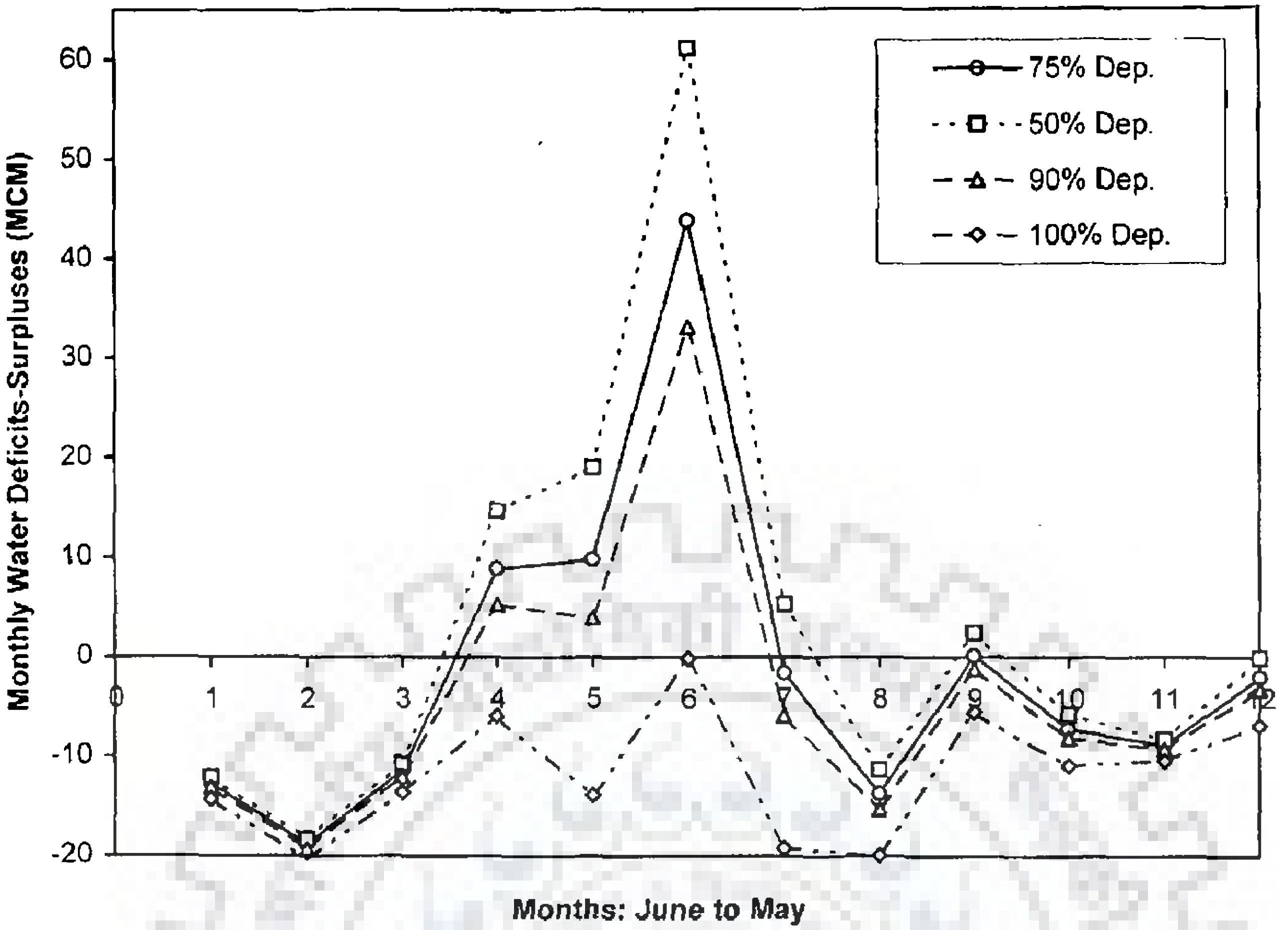

Figure 4.13(a): Ponnanai Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

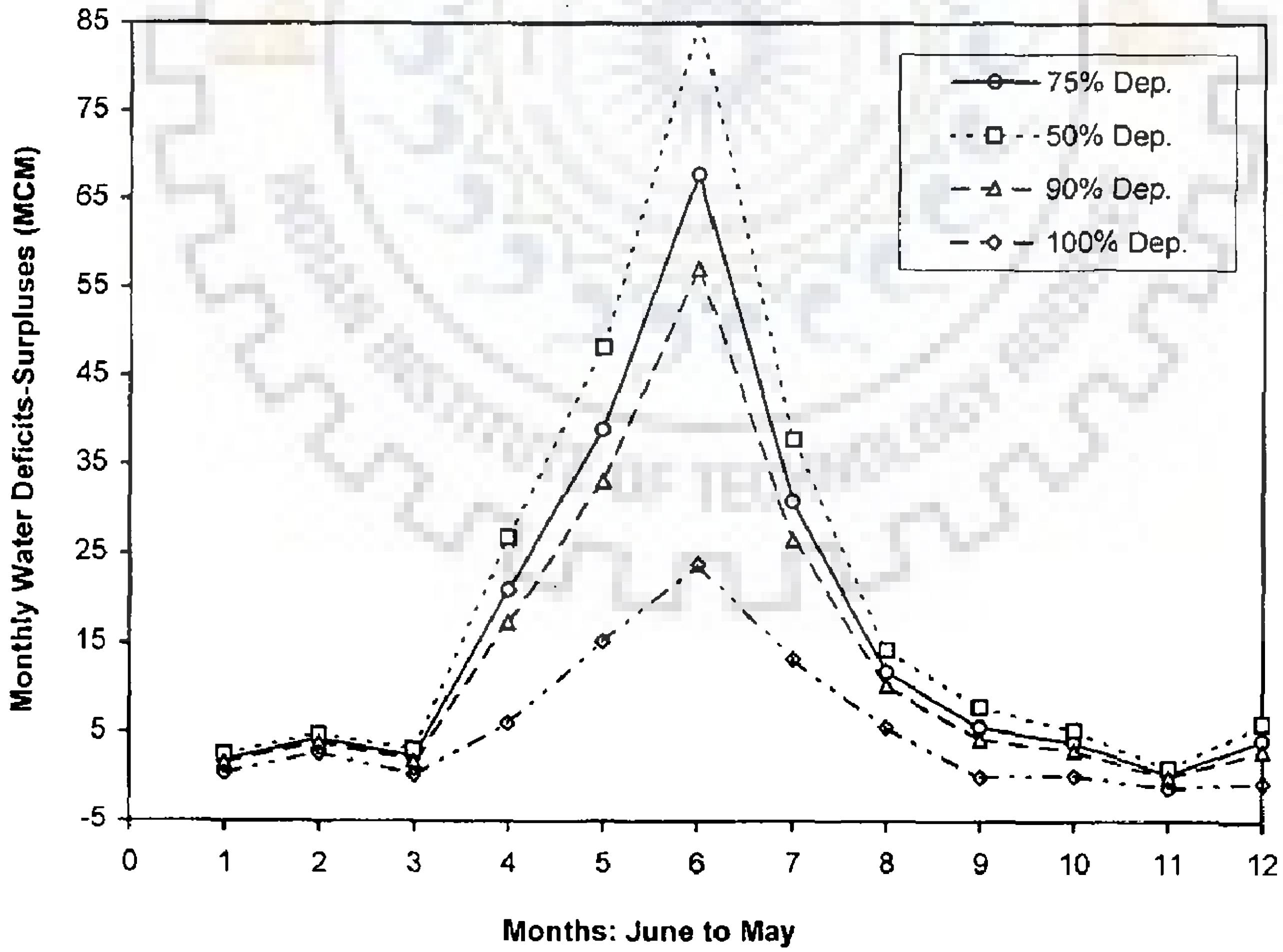

Figure 4.13(b): Ponnanai Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

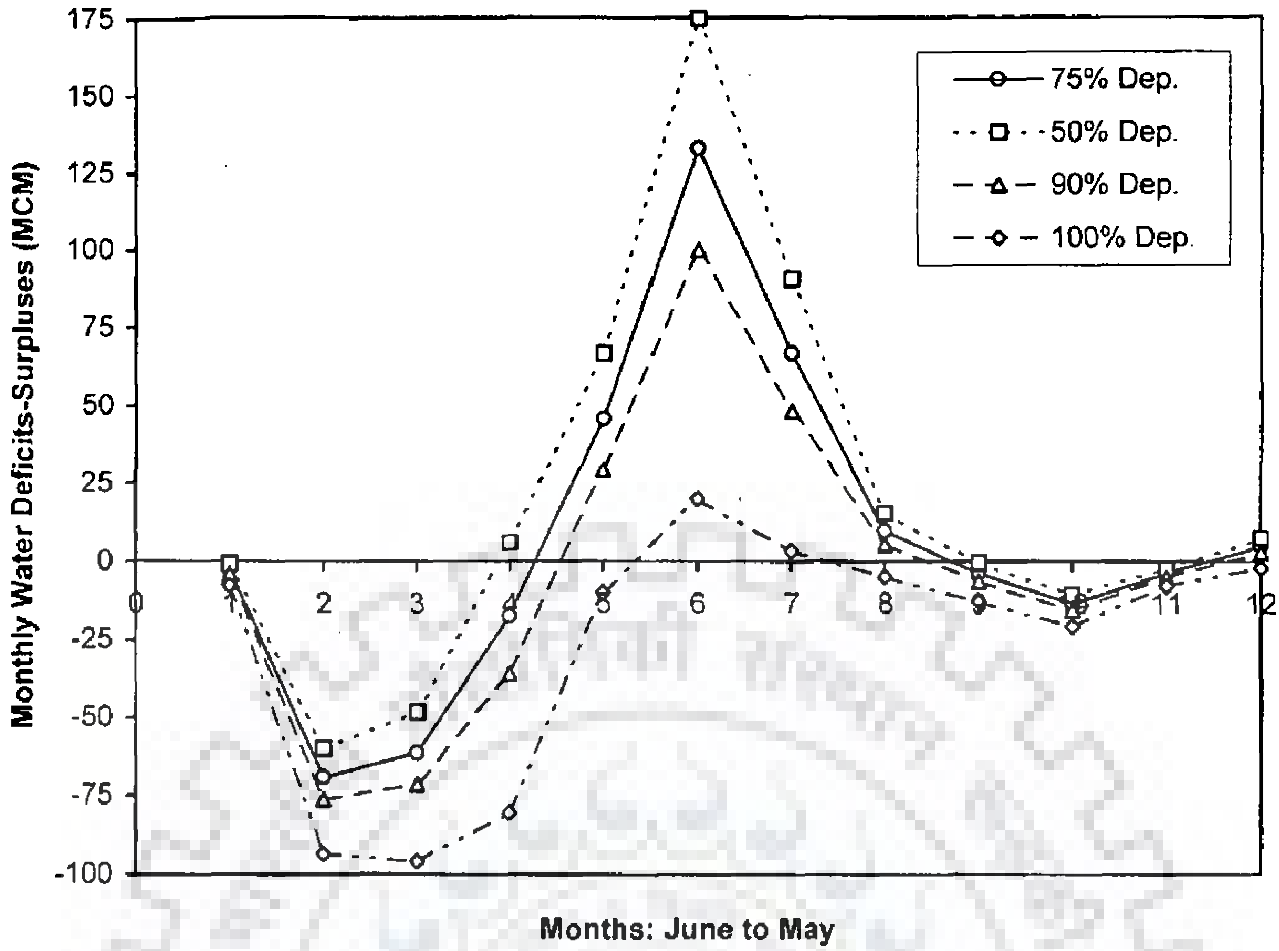

Figure 4.14(a): Upper Coleroon Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

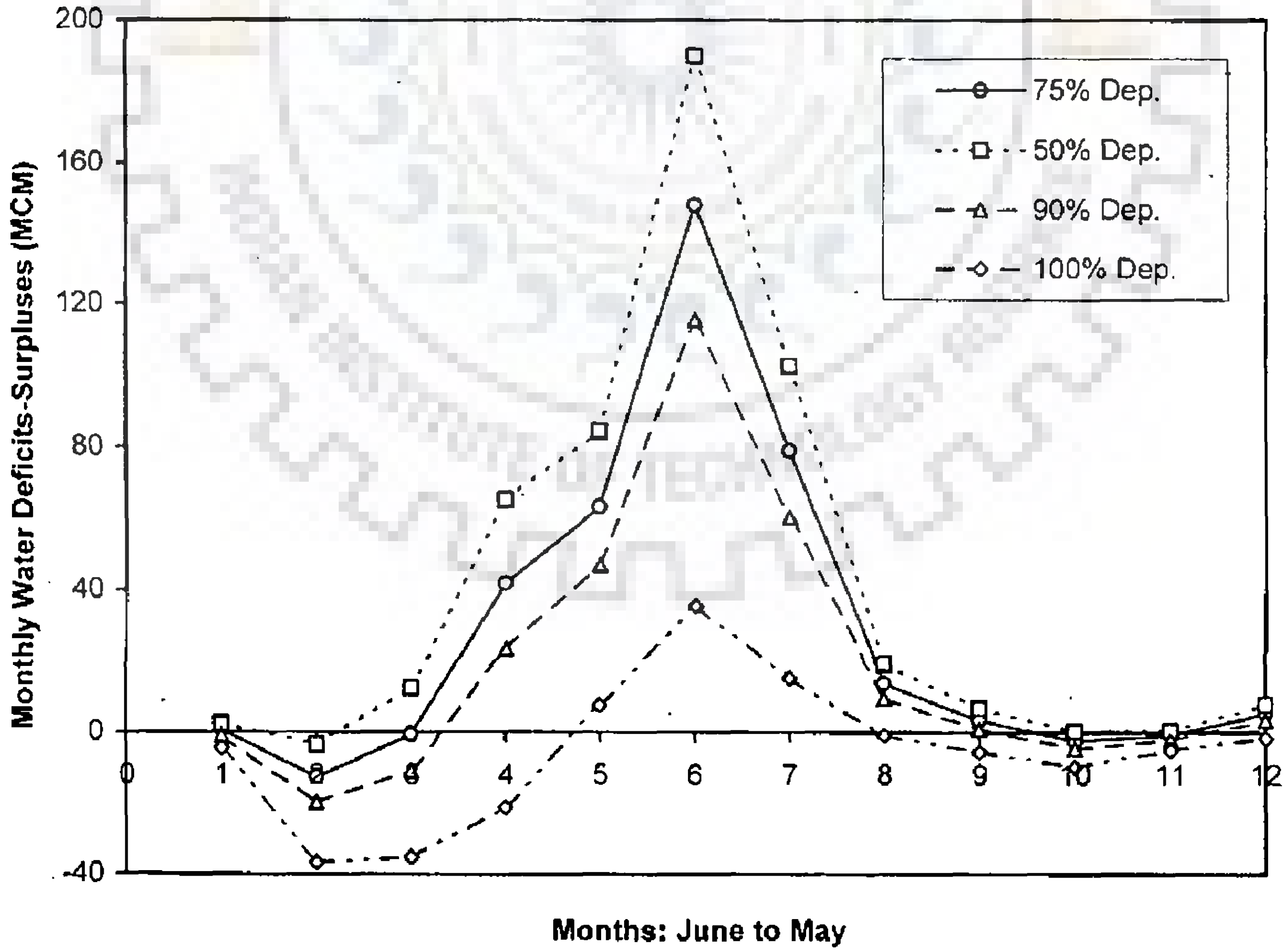

Figure 4.14(b): Upper Coleroon Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

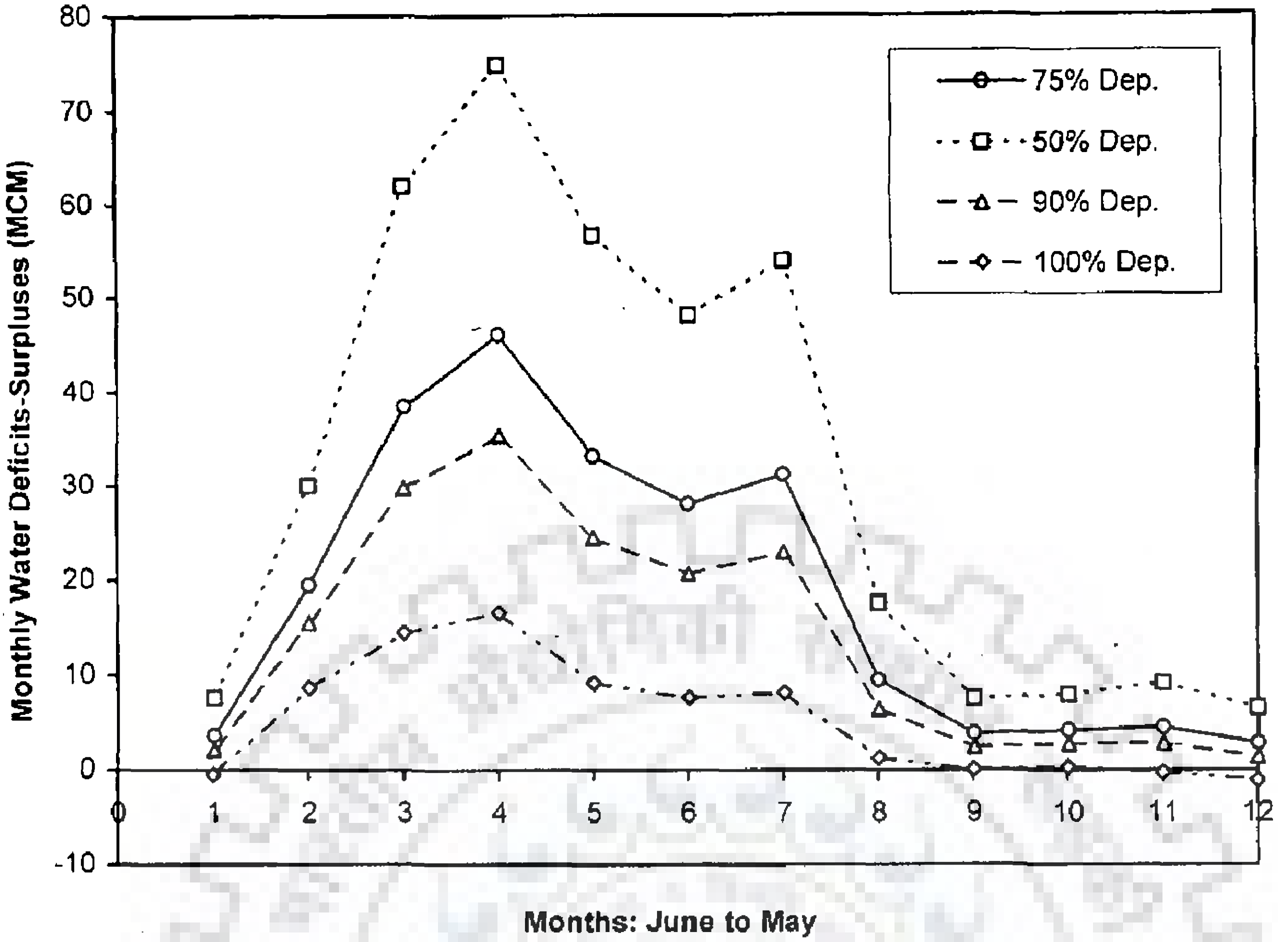

Figure 4.15(a): Lower Coleroon Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

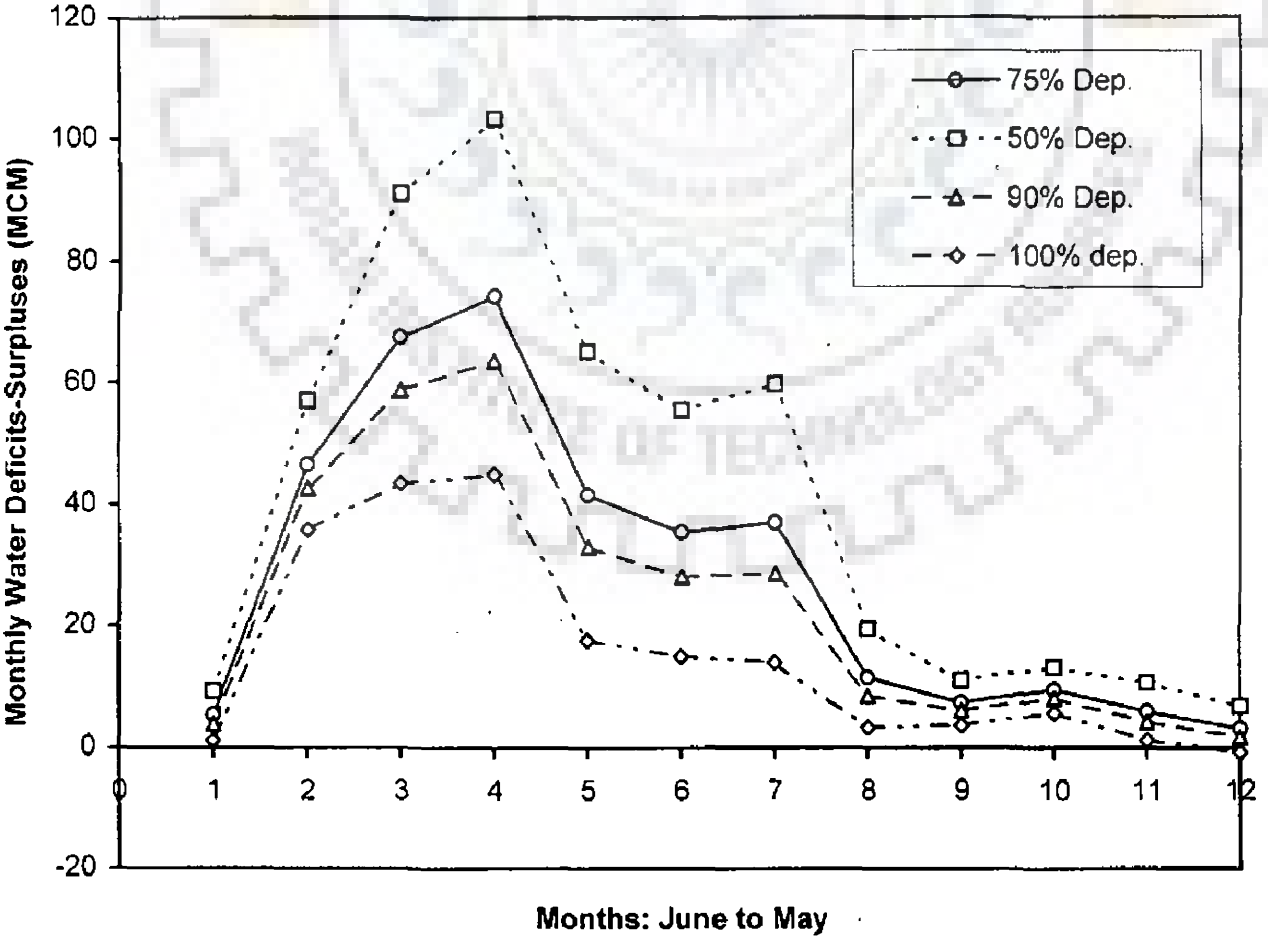

Figure 4.15(b): Lower Coleroon Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

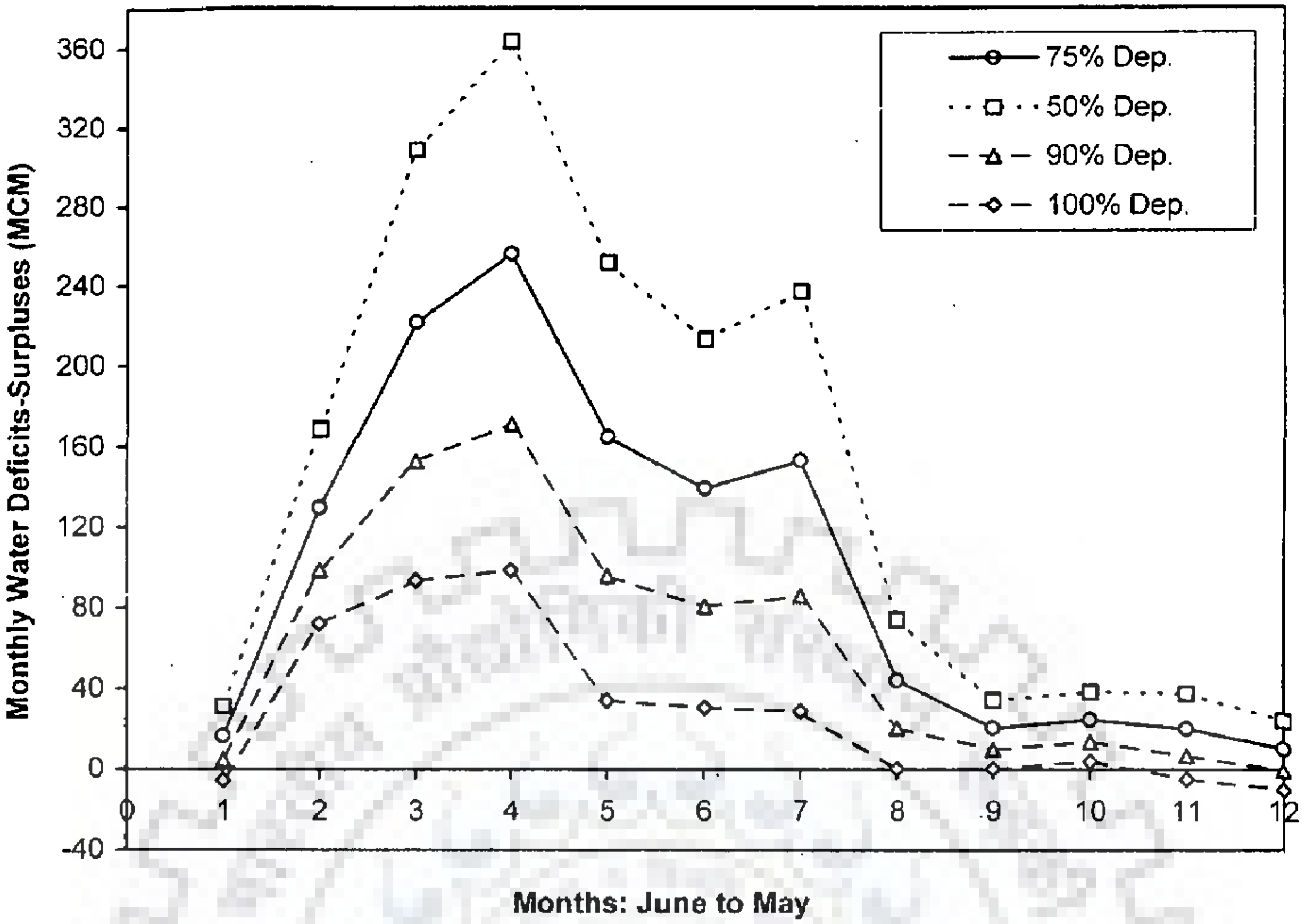

Figure 4.16(a): Cauvery Delta Sub-basin: Monthly Water Deficits- Surpluses Without Ground Water

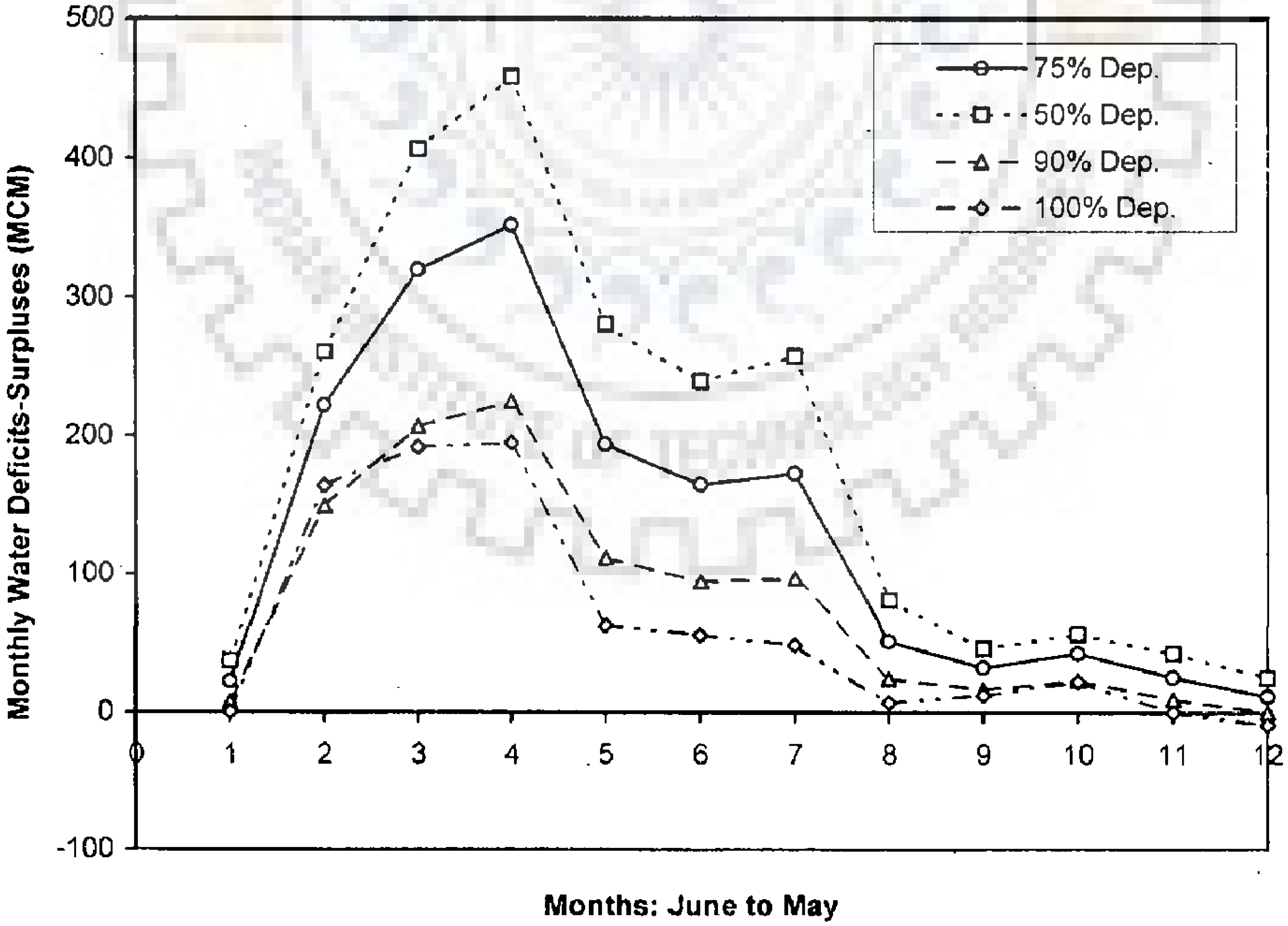

Figure 4.16(b): Cauvery Delta Sub-basin: Monthly Water Deficits-Surpluses With Ground Water

Chapter - 5

LINEAR PROGRAMMING MODEL

5.1 INTRODUCTION

Operation research or system engineering provides methodologies for studying and analyzing various aspects of a complex river basin system, by using mathematical models or computer models. The linear programming and its offshoots are probably the most widely used methods of operation research. It also assists in decision-making process by selecting the best alternative policies subject to all pertinent constraints by simulation and optimization techniques.

A mathematical model is a set of equations that describes and represents the real system. Out of several mathematical programming techniques, linear programming (LP) has been widely used in the optimization of water resources systems for very obvious reasons of large number of variables are involved in a complex water resources problems.

Linear programming is a powerful mathematical technique in decision making to determine the monthly or seasonal releases from canal/reservoir, to allocate irrigated area so that the annual utilization of the available water resources among various uses can be maximized. The task of the linear programming model is to analyze the whole range of development alternatives in a river basin. To perform this task, a linear programming model for multipurpose, multi reservoir and multi-irrigated area proposed to be investigated in this study has to be as realistic as possible.

Some of the assumptions, which have been made for ease of formulation are:

1. The objective function and the constraints are in linear form,

2. It is deterministic in nature, i.e., hydrologic inputs are taken as known values and are certain to occur, and

3. The model is to be run for one representative year only at a time.

Major design variables/parameters considered are:

1. Capacity of the reservoir,

2. The area sown for each crop,

3. The annual amount of upstream water for irrigation and water supply (municipal and industrial uses),

4. The annual amount of downstream water for irrigation and water supply (municipal and industrial uses), and

5. Capacity of the associated canal system.

A LP model is formulated below:

5.2 OBJECTIVE FUNCTION

A sample site is shown in Figure 5.1. The variables/ parameters of a reservoir are shown in Figure 5.2.

For linear programming model the following 4 single objective functions are considered individually:

1. To maximize the total annual diversions for irrigation and water supply (annual water utilization) from reservoirs (major projects) and remaining areas in each sub-basin not covered by reservoirs.

2. To maximize the area to be irrigated at each reservoir,

3. To maximize the agricultural food production at each reservoir, and

4. To maximize the total annual net benefits from crops at each reservoir.

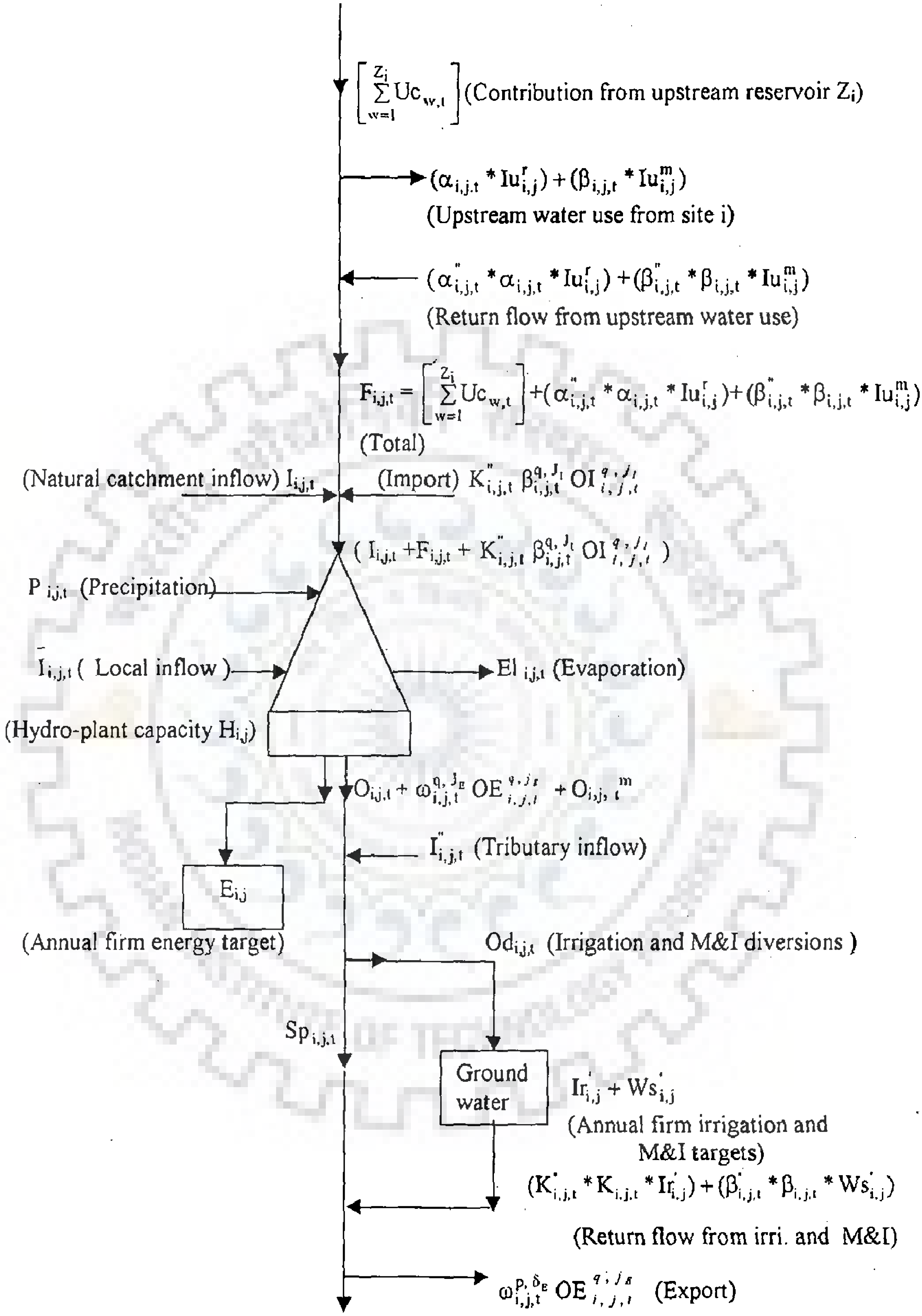

Figure 5.1: Sample Site with One Multipurpose Reservoir.

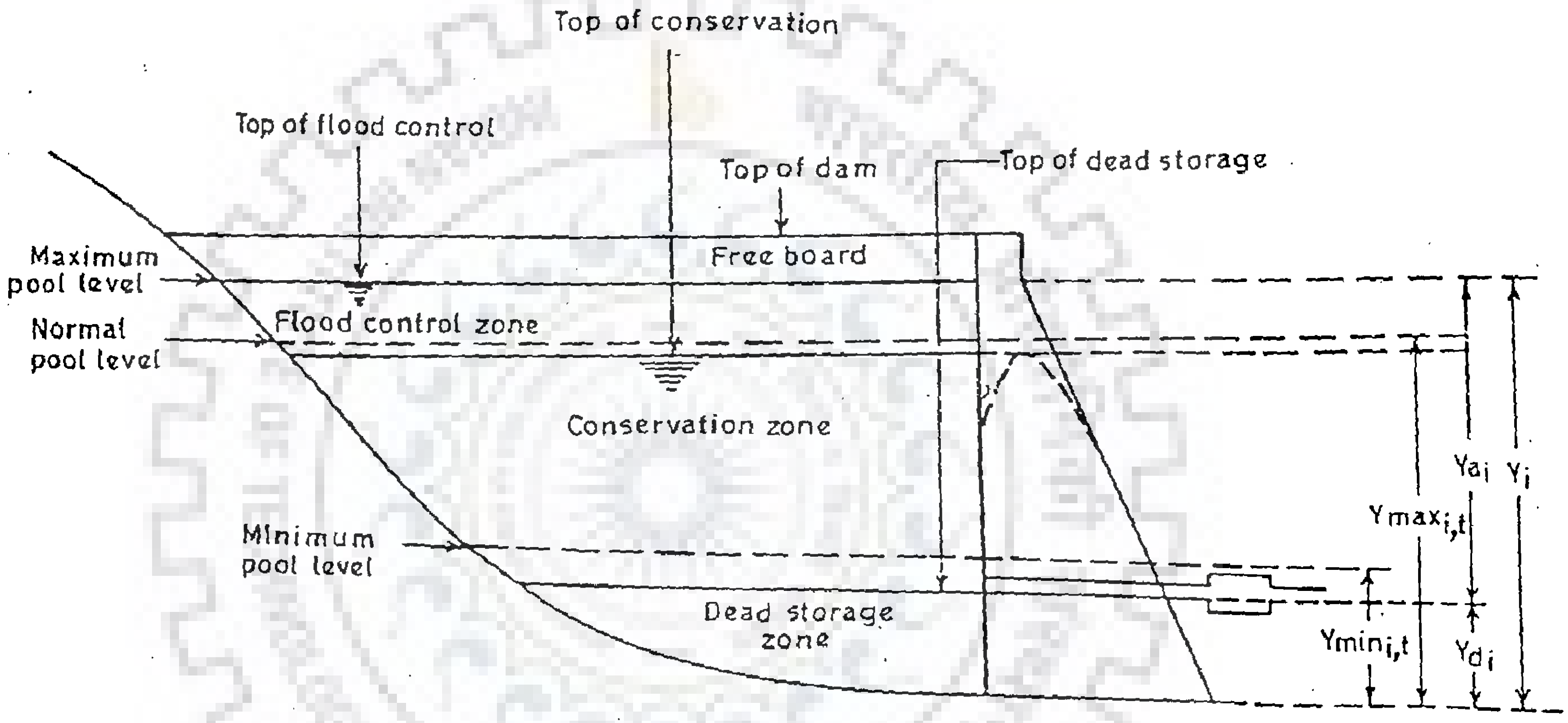

Figure 5.2: Various Reservoir Storage and Variables Related to a Reservoir Site

These objective functions are mathematically written as follows:

(1) To maximize the total annual diversions for irrigation and water supply/ or irrigation (annual water utilization) from reservoirs (major projects) and remaining areas in each sub-basin not covered by reservoirs, i.e.,

1(a)- For lumped irrigation and water supply for entire system:

$$\text{Max } Z = \sum_{j=1}^{NB} \sum_{i=1}^{N_j} (Ir'_{i,j} + Ws'_{i,j}) \qquad \text{(For lumped irrigation model)} \quad (5.2.1\text{-I})$$

where

i	Reservoir i
j	Sub-basin j
N_j	Number of sites, in sub-basin j
NB	Number of sub-basins
$Ir'_{i,j}$	Total annual reservoir diversions (annual water utilization) for irrigation from site i, in sub-basin j
$Ws'_{i,j}$	Annual water supply diversion from sites i, sub-basin j

1(b)-For each reservoir (major project):

$$\text{Max } Z = \sum_{t=1}^{12} \sum_{k=1}^{NCI^{i,j}} W^k_{i,j,t} * A^k_{i,j} \qquad \text{For all i and j (For crop consideration model)}$$

(5.2.1-II)

where

$w^k_{i,j,t}$	Total water diversion requirements in depth for crop k, at site i, in sub-basin j, in time t
i	Reservoir i
j	Sub-basin j
k	Crop k
t	Time t
N_j	Number of sites, in sub-basin j
$NCI^{i,j}$	Total number of irrigated crops at site i, in sub-basin j
$A^k_{i,j}$	Irrigated-cropped area of crop k, at site i, in sub-basin j

(2) To maximize the area to be irrigated at each reservoir, i. e.,

$$\text{Max } Z = \sum_{k=1}^{NCI^{i,j}} A_{i,j}^{k} \qquad \text{For all i and j} \qquad (5.2.2)$$

where

i	Reservoir i
j	Sub-basin j
k	Crop k
$NCI^{i,j}$	Total number of irrigated crops at site i, in sub-basin j
$A_{i,j}^{k}$	Irrigated-cropped area of crop k, at site i, in sub-basin j

(3) To maximize the agricultural food production at each reservoir, i.e.,

$$\text{Max } Z = \sum_{k=1}^{NCI^{i,j}} A_{i,j}^{k} * y_{i,j}^{k} \qquad \text{For all i and j} \qquad (5.2.3)$$

where

i	Reservoir i
j	Sub-basin j
k	Crop k
$NCI^{i,j}$	Total number of irrigated crops at site i, in sub-basin j
$y_{i,j}^{k}$	Yield per unit area of crop k, at site i, in sub-basin j
$A_{i,j}^{k}$	Irrigated-cropped area of crop k, at site i, in sub-basin j

4. To maximize the total annual net benefits from crops at each reservoir, i.e.,

$$\text{Max } Z = \sum_{k=1}^{NCI^{i,j}} A_{i,j}^{k} * y_{i,j}^{k} * b_{i,j}^{k} \qquad \text{For all i and j} \qquad (5.2.4)$$

where

i	Reservoir i
j	Sub-basin j
k	Crop k

$NCI^{i,j}$	Total number of irrigated crops at site i, in sub-basin j
$y_{i,j}^{k}$	Yield per unit area of crop k, at site i, in sub-basin j
$A_{i,j}^{k}$	Irrigated-cropped area of crop k, at site i, in sub-basin j
$b_{i,j}^{k}$	Net benefits from crop k, at site i, in sub-basin j

5.3 THE CONSTRAINTS

The maximization of the objective function is to be achieved subject to the following constraints:

5.3.1 Reservoir Continuity Equation Constraints

Continuity constraints are those constraints that are included in the model to ensure conservation of mass in a given time. In terms of a river system this means that the water that enters a point on the stream must leave that point on the stream, if it has not been stored in a reservoir or diverted out of the stream for a water use. The basic continuity principle applies throughout the entire reach of the stream for all the times. However, it is necessary to write continuity constraints only at site where water is stored diverted or imported. The continuity relationship for a multi reservoir system at a reservoir site can be written as follows:

$$
\begin{aligned}
K'_{i,j,t} * S_{i,j,t} &= S_{i,j,t-1} + I_{i,j,t} + F_{i,j,t} + \sum (\psi_{i,j,t}^{q,j_I} * TI_{i,j}^{q,j_I}) \\
&- \sum (\omega_{i,j,t}^{q,j_E} * TE_{i,j}^{q,j_E}) + \sum_{p} \sum_{j_E} K''_{p,j,t} (\psi_{i,j,t}^{q,j_I} * OI_{i,j,p}^{q,j_I}) \\
&- \sum_{j_I} \sum_{p} (\omega_{i,j,t}^{p,j_I} * OE_{i,j}^{q,j_{I,p}}) + P_{i,j,t} + \bar{I}_{i,j,t} - O_{i,j,t}^{m} - O_{i,j,t} - O_{i,j,t}^{sa} \\
&- (\alpha_{i,j,t} * Iu_{i,j}^{rs} + \beta_{i,j,t} * Iu_{i,j}^{mhs}) + (\alpha''_{i,j,t} * \alpha_{i,j,t} * Iu_{i,j}^{r}) + (\beta''_{i,j,t} * \beta_{i,j,t} Iu_{i,j}^{m})
\end{aligned}
$$

For all i, j and t

(5.3.1.1)

$$
\begin{aligned}
&K'_{i,j,t} * S_{i,j,t} - S_{i,j,t-1} + O_{i,j,t} - F_{i,j,t} - P_{i,j,t} - \bar{I}_{i,j,t} - \sum (\psi^{q,\,j_I}_{i,\,j,\,t} * TI^{q,j_I}_{i,j}) + O^{se}_{i,j,t} \\
&+ \sum (\omega^{q,\,j_E}_{i,\,j,\,t} * TE^{q,\,j_E}_{i,\,j}) - \sum_{p} \sum_{j_E} K''_{p,j,t} (\psi^{q,\,j_I}_{i,\,j,\,t} * OI^{q,\,j_I}_{i,\,j,\,p}) + \sum_{j_I} \sum_{p} (\omega^{p,\,j_E}_{i,\,j,t} * OE^{q,\,j_I,p}_{i,\,j}) \\
&+ (\alpha_{i,j,t} * Iu^{r\,s}_{i,j} + \beta_{i,j,t} * Iu^{m\,h\,s}_{i,j}) - (\alpha''_{i,\,j,\,t} * \alpha_{i,\,j,\,t} * Iu^{r}_{i,\,j}) - (\beta''_{i,j,t} * \beta_{i,j,t} * Iu^{m}_{i,\,j}) \\
&- I_{i,j,t} + O^{m}_{i,j,t} = 0
\end{aligned}
$$

For all i, j and t (Rearranged equation)

(5.3.1.1)

where

The physical meaning of each term in the above equation is defined as below.

$S_{i,j,t}$	Final storage in the reservoir i, in sub-basin j, in time t
$S_{i,j,t-1}$	Initial storage in the reservoir i, in sub-basin j, in time t
$K'_{i,j,t}$	Reservoir evaporation coefficient for site i, in sub-basin j, in time t
$I_{i,j,t}$	Natural catchment inflow to reservoir/site i, in sub-basin j, in time t
$F_{i,j,t}$	Contribution from upstream reservoirs/sites to the reservoir/site I, in sub-basin j, in time t
$\psi^{q,j_I}_{i,j,k}$	Percentage of import to reservoir/site i, in sub-basin j, in time t, from site q, of exporting sub-basin j_I
$TI^{q,j_I}_{i,j,t}$	Import to reservoir/site i, in sub-basin j, in time t, from site q, of exporting sub-basin j_I
$\omega^{q,j_E}_{i,j,t}$	Percentage of export from site/reservoir i, in sub-basin j, in time t, to site q, of importing sub-basin j_E
$TE^{q,j_E}_{i,j,t}$	Export from site/reservoir i, in sub-basin j, in time t, to site q, of importing sub-basin j_E
$P_{i,j,t}$	Precipitation directly upon the reservoir i, in sub-basin j, in time t
$\bar{I}_{i,j,t}$	Local inflow to the reservoir/site i, from the surrounding area in sub-basin j, in time t
$O^{m}_{i,j,t}$	Mandatory releases to downstream natural channel from site i, in sub-basin j, in time t
$O_{i,j,t}$	Release from reservoir/site i, in sub-basin j, in time t
$Iu^{r,s}_{i,j}$	Total annual upstream irrigation water use targets from surface water of reservoir/site i, in sub-basin j

$O^{se}_{i,j,t}$ = Seepage losses from reservoir/site i, in sub-basin j, in time t

$Iu_{i,j}^{m,s}$	Total annual upstream domestic and industrial water use target from surface water of site i, in sub-basin j
$K_{i,j,t}$	% annual irrigation from site i, in sub-basin j, in time t
$K''_{i,j,t}$	Percent of return flow to river from irrigation from site i, in sub-basin j, in time t
$Iu_{i,j}^{r}$	Total annual upstream irrigation water use targets of reservoir/site i, in sub-basin j
$Iu_{i,j}^{m}$	Total annual upstream domestic and industrial water use target of site i, in sub-basin j

where

(a) The mandatory release should be equal to the percent of the inflow.

$$O_{i,j,t}^{m} - 0.01 * I_{i,j,t} = 0 \quad \text{For all i, j and t} \quad (5.3.1.2)$$

(b) The total annual upstream M&I water use target should equal the sum of total annual upstream M&I water use target from surface water and total annual upstream M&I water use for rural human population and live stock population.

$$Iu_{i,j}^{mh} + Iu_{i,j}^{ml} - Iu_{i,j}^{m} = 0 \quad \text{For all i and j} \quad (5.3.1.3)$$

where

$Iu_{i,j}^{m,h}$	Total annual upstream domestic water use for rural human population of site i, in sub-basin j
$Iu_{i,j}^{m,l}$	Total annual upstream domestic water use for livestock population of site i, in sub-basin j

(c) The total annual upstream irrigation water use target should equal the sum of annual upstream irrigation water use target from surface water and ground water.

$$Iu_{i,j}^{rg} + Iu_{i,j}^{rs} - Iu_{i,j}^{r} = 0 \quad \text{For all i and j} \quad (5.3.1.4)$$

where

$Iu_{i,j}^{r,g}$	Total annual upstream irrigation water utilization from ground water of reservoir/site i, in sub-basin j

$Iu^{r,s}_{i,j}$	Total annual upstream irrigation water use targets from surface water of reservoir/site i, in sub-basin j
$Iu^{r}_{i,j}$	Total annual upstream irrigation water use targets of reservoir/site i, in sub-basin j

(d) From the annual upstream ground water available the sum of annual upstream water requirement for rural human population from ground water and annual upstream water requirement for live stock population from ground water has been subtracted. The annual upstream irrigation use by ground water should not exceed this quantity.

$$Iu^{rg}_{i,j} \le Og^{us}_{i,j} - (Iu^{ml}_{i,j} + Iu^{mhg}_{i,j}), \qquad \text{For all i and j} \qquad (5.3.1.5)$$

$$\text{if R.H.S. is } - \text{ve, then } Iu^{rg}_{i,j} = 0$$

where

$Og^{us}_{i,j}$	Annual upstream ground water available for site i, in sub-basin j
$Iu^{m,h,g}_{i,j}$	Total annual upstream rural human population water use target from ground water of site i, in sub-basin j

(e) The annual upstream water requirement from ground water for rural population should be 50 percent of the annual upstream M&I water use from ground water.

$$Iu^{mhg}_{i,j} - 0.5 Iu^{mh}_{i,j} = 0 \qquad \text{For all i and j} \qquad (5.3.1.6)$$

where

$Iu^{m,h,g}_{i,j}$	Total annual upstream rural human population water use target from ground water of site i, in sub-basin j
$Iu^{m,h}_{i,j}$	Total annual upstream domestic water use for rural human population of site i, in sub-basin j

(f) The annual upstream water use for rural population from surface water should be 50 percent of the annual upstream domestic water use for rural human population.

$$Iu_{i,j}^{mhs} - 0.5Iu_{i,j}^{mh} = 0 \qquad \text{For all i and j} \qquad (5.3.1.7)$$

where

$Iu_{i,j}^{m,h,s}$	Total annual upstream domestic water use for rural human population from surface water of site i, in sub-basin j
$Iu_{i,j}^{m,h}$	Total annual upstream domestic water use for rural human population of site i, in sub-basin j

(g) The value of the total inflow to a reservoir/site is the sum of all the downstream contributions made from the upstream reservoirs linked to the reservoir under consideration which includes spills, the return flows from all the irrigation areas and M&I water supply upstream of the reservoir under consideration.

$$F_{i,j,t} = \sum_{w=1}^{Z_{i,j}} \left[Sp_{w,j,t} + (K''_{w,j,t} * K_{w,j,t} * Ir'_{w,j}) + (\beta''_{w,j,t} * \beta_{w,j,t} * Ws'_{w,j}) + \delta''_{w,j,t} * O^{m}_{w,j,t} \right]$$

$$+ (\alpha''_{i,j,t} * \alpha_{i,j,t} * Iu^{r}_{i,j}) + (\beta''_{i,j,t} * \beta_{i,j,t} * Iu^{m}_{i,j}) \qquad \text{For all i, j and t} \qquad [5.3.1.8]$$

where

$F_{i,j,t}$	Contribution from upstream reservoirs/sites to the reservoir/site I, in sub-basin j, in time t
w	Reservoir / site contributing to the flow of i^{th} downstream reservoir / site
$Z_{i,j}$	Number of upstream reservoirs contributing to the flow of downstream site i, in sub basin j
$Sp_{w,j,t}$	Secondary water release (spill) from site w, in time t
$K''_{i,j,t}$	Percent of return flow to river from irrigation from site i, in sub-basin j, in time t
$K_{w,j,t}$	Reservoir evaporation from site w, in sub-basin j, in time t
$Ir'_{w,j}$	Total annual irrigation target from site w, in sub-basin j
$\beta''_{w,j,t}$	Percent of return flow to river from water supply from site i, in sub-basin j, in time t

$\beta_{w,j,t}$	Percent of annual water supply ($Ws'_{w,j}$) from site i, in sub-basin j, in time t
$Ws'_{w,j}$	Total annual water supply target from site w, in sub-basin j
$\delta''_{w,j,t}$	Percent of downstream mandatory release returning to river from site w, in time t
$O^{m}_{i,j,t}$	Mandatory releases to downstream natural channel from site i, in sub-basin j, in time t
$\alpha''_{i,j,t}$	Percent of return flow to river from upstream water use for irrigation of site i, in sub-basin j, in time t
$\alpha_{i,j,t}$	Percent of annual upstream irrigation water use of site i, in sub-basin j, in time t
$\beta''_{i,j,t}$	Percent of return flow to river from upstream water use for domestic use of site i, in sub-basin j, in time t
$\beta_{i,j,t}$	Percent of annual upstream domestic and industrial water use of site i, in sub-basin j, in time t
$Iu^{m}_{i,j}$	Total annual upstream domestic and industrial water use target of site i, in sub-basin j

$$F_{i,j,t} - \sum_{w=1}^{Z_i}\left[Sp_{w,j,t} + (K''_{w,j,t} * K_{w,j,t} * Ir'_{w,j}) + (\beta''_{w,j,t} * \beta_{w,j,t} * Ws'_{w,j}) + \delta''_{w,j,t} * O^{m}_{w,j,t}\right]$$

$$- (\alpha''_{i,j,t} * \alpha_{i,j,t} * Iu^{r}_{i,j}) + (\beta''_{i,j,t} * \beta_{i,j,t} * Iu^{m}_{i,j}) = 0$$

For all i, j and t (Rearranged equation)

[5.3.1.8]

In the model, the storage at the end of the time period t, plus natural catchment inflow, Plus all other possible inflows (sum of all the down stream contributions made from the upstream reservoirs linked to the reservoir under consideration which include spills, the return flows from all the irrigated areas and the municipal and industrial uses upstream of the reservoir under consideration), minus all downstream releases made from the reservoir under consideration. This is some times called a continuous model.

5.3.2 Storage Limits

The contents of the reservoir at any period cannot exceed the capacity of the reservoir, but should be greater than the dead storage of the reservoir, i.e.

$$Yd_{i,j} \le Ymin_{i,j,t} \le S_{i,j,t-1} \le Ymax_{i,j,t} \le Y_{i,j} \qquad \text{For all i, j and t} \qquad (5.3.2)$$

where

$Yd_{i,j}$	Dead storage capacity of reservoir/site i, in sub-basin j
$Ymin_{i,j,t}$	Gross capacity up to the minimum pool level of reservoir/site i, in sub-basin j, in time t
$S_{i,j,t-1}$	Initial storage in the reservoir i, in sub-basin j, in time t
$Ymax_{i,j,t}$	Gross capacity up to the normal pool level of reservoir/site i, in sub-basin j, in time t
$Y_{i,j}$	Gross storage capacity of reservoir/site i, in sub-basin j

5.3.3 Reservoir Release Constraints

(a) The volume of the water released from the reservoir must be sufficient to meet the irrigation, domestic and industrial demand during that period by using surface and ground water potential, i.e., where,

$$O_{i,j,t} + I''_{i,j,t} = Od_{i,j,t} + Sp_{i,j,t} \qquad \text{For all i, j and t} \qquad (5.3.3.1)$$

where

$O_{i,j,t}$	Total release from site i, in sub-basin j, in time t
$Ir''_{i,j,t}$	Water that joins the main stream just above the irrigation diversion canal site i, in sub-basin j
$Od_{i,j,t}$	Total release at site i, in sub-basin j, in time t for irrigation and water supply
$Sp_{i,j,t}$	Secondary water release (spill) from site i, in sub-basin j, in time t

(b) The total release from reservoir in any period for irrigation and M&I water use is equal to release for irrigation and M&I water use.

$$Od_{i,j,t} = Od^{r}_{i,j,t} + Od^{m}_{i,j,t} \qquad \text{For all i, j and t} \qquad (5.3.3.2)$$

where

$Od_{i,j,t}$	Total release at site i, in sub-basin j, in time t for irrigation and water supply
$Od^{r}_{i,j,t}$	Release at site i, in sub-basin j, in time t, for irrigation
$Od^{m}_{i,j,t}$	Release at site i, in sub-basin j, in time t, for water supply

(c) Ground water required for irrigation in any period is a fraction of total annual ground water irrigation target.

$$Og^{r}_{i,j,t} = K_{i,j,t} * Ir^{g}_{i,j} \qquad \text{For all i, j and t} \qquad (5.3.3.3)$$

where

$Og^{r}_{i,j,t}$	Ground water available for irrigation, from site i, in sub-basin j, in time t
$K_{i,j,t}$	% annual irrigation from site i, in sub-basin j, in time t
$Ir^{g}_{i,j}$	Total annual ground water irrigation target from site i, in sub-basin j

(d) The release for irrigation use from surface water should be a fraction of the total annual surface water irrigation target.

$$Od^{r}_{i,j,t} = K_{i,j,t} * Ir^{S}_{i,j} \qquad \text{For all i, j and t} \qquad (5.3.3.4)$$

where

$Od^{r}_{i,j,t}$	Release at site i, in sub-basin j, in time t, for irrigation
$K_{i,j,t}$	% annual irrigation from site i, in sub-basin j, in time t
$Ir^{s}_{i,j}$	Total annual surface water irrigation target from site i, in sub-basin j

(e) Ground water required for M&I water use in any period should be equal to the sum of the M&I water supply target for urban and industrial water use from ground water.

$$Og^{m}_{i,j,t} = \xi_{i,j,t}(\varphi^{Ug}_{i,j} Ws^{U}_{i,j} + \varphi^{Ig}_{i,j} Ws^{I}_{i,j}) \qquad \text{For all i, j and t} \qquad (5.3.3.5)$$

where

$Og^{m}_{i,j,t}$	Ground water available for municipal and industrial from site i, in sub-basin j, in time t
$\xi_{i,j,t}$	% of annual water use for industrial and urban from site i, in sub-basin j, in time t
$\phi^{U^g}_{i,j}$	% of annual ground water for urban domestic water requirement from site i, in sub-basin j
$Ws^{U}_{i,j}$	Annual water requirement for urban domestic use from sites i, in sub-basin j
$\phi^{I^g}_{i,j}$	% of annual ground water for industrial requirement from sites i, in sub-basin j
$Ws^{I}_{i,j}$	Annual water requirement for industrial use from sites i, in sub-basin j

(f) The release for M&I water use in any period should be equal to the sum of the M&I water supply target for urban and industrial water use from surface water.

$$Od^{m}_{i,j,t} = \xi_{i,j,t}(\varphi^{U^s}_{i,j} Ws^{U}_{i,j} + \varphi^{I^s}_{i,j} Ws^{I}_{i,j}) \qquad \text{For all i, j and t} \qquad (5.3.3.6)$$

where

$Od^{m}_{i,j,t}$	Release at site i, in sub-basin j, in time t, for water supply
$\xi_{i,j,t}$	% of annual water use for industrial and urban from site i, in sub-basin j, in time t
$\phi^{U^s}_{i,j}$	% of annual surface water for urban domestic water requirement from site i, in sub-basin j
$Ws^{U}_{i,j}$	Annual water requirement for urban domestic use from sites i, in sub-basin j
$\phi^{I^s}_{i,j}$	% of annual surface water for industrial requirement from sites i, in sub-basin j
$Ws^{I}_{i,j}$	Annual water requirement for industrial use from sites i, in sub-basin j

(g) The annual irrigation target should equal the sum of annual irrigation targets from the surface and ground waters.

$$Ir'_{i,j} = Ir^{s}_{i,j} + Ir^{g}_{i,j} \qquad \text{For all i and j} \qquad (5.3.3.7)$$

where

$Ir'_{i,j}$	Total annual irrigation target from site i, in sub-basin j
$Ir^{s}_{i,j}$	Total annual surface water irrigation target from site i, in sub-basin j
$Ir^{g}_{i,j}$	Total annual ground water irrigation target from site i, in sub-basin j

(h) The annual M&I water use target should equal the sum of annual M&I water use targets from surface and ground water.

$$Ws'_{i,j} = Ws^{U}_{i,j} + Ws^{I}_{i,j} \qquad \text{For all i and j} \qquad (5.3.3.8)$$

where

$Ws'_{i,j}$	Annual water supply diversion from sites i, sub-basin j
$Ws^{U}_{i,j}$	Annual surface water requirement for urban domestic use from sites i, in sub-basin j
$Ws^{I}_{i,j}$	Annual surface water requirement for industrial use from sites i,in sub-basin j

5.3.4 Ground Water Availability Constraints

(a) The total annual downstream water use for irrigation and water supply from ground water should be equal to the annual ground water available in the downstream.

$$\sum_t Og^{m}_{i,j,t} + \sum_t Og^{r}_{i,j,t} = Og^{ds}_{i,j} \qquad \text{For all i and j} \qquad (5.3.4.1)$$

where

$Og^{m}_{i,j,t}$	Ground water available for municipal and industrial from site i, in sub-basin j, in time t
$Og^{r}_{i,j,t}$	Ground water available for irrigation, from site i, in sub-basin j, in time t
$Og^{ds}_{i,j}$	Annual d/s ground water available for site i, in sub-basin j.

(b) *The total annual upstream use for irrigation and water supply from ground water* should be equal to the annual ground water available in upstream.

$$Iu_{i,j}^{m,g} + Iu_{i,j}^{r,g} = Og_{i,j}^{us} \qquad \text{For all i and j} \qquad (5.3.4.2)$$

where

$Iu_{i,j}^{m,g}$	Total annual upstream M & I water use target from surface water of site i, in sub-basin j
$Iu_{i,j}^{r,g}$	Total annual upstream irrigation water use targets from ground water of site i, in sub-basin j
$Og_{i,j}^{us}$	Annual upstream ground water available for site i, in sub-basin j.

(c) The annual ground water available at the upstream and downstream of a site should equal to total annual ground water available at the site.

$$Og_{i,j}^{us} + Og_{i,j}^{ds} = Og_{i,j} \qquad \text{For all i and j} \qquad (5.3.4.3)$$

where

$Og_{i,j}^{us}$	Annual upstream ground water available for site i, in sub-basin j.
$Og_{i,j}^{ds}$	Annual d/s ground water available for site i, in sub-basin j.
$Og_{i,j}$	Annual ground water available for site i, in sub-basin j.

5.3.5 Sub-Basin Wise Annual Irrigation Constraints

Annual irrigation diversion from site i, in sub-basin j should not exceed total annual release for irrigation at site i in sub-basin j, i.e.,

$$OC_{i,j}^{r} = \sum_{t=1}^{12} Od_{i,j,t}^{r} \qquad \text{For all i and j} \qquad (5.3.5)$$

where

$OC_{i,j}^{r}$	Annual irrigation diversion from site i in sub-basin j.

5.3.6 Sub-Basin Wise Annual Water Supply Constraints

Annual water supply diversion from site i, in sub-basin j, should not exceed total annual release for water supply at site i in sub-basin j.

$$OC^{m}_{i,j} = \sum_{t=1}^{12} Od^{m}_{i,j,t} \qquad \text{For all i and j} \qquad (5.3.6)$$

where

$OC^{m}_{i,j}$	Annual water supply diversion from site i, in sub-basin j.
$Od^{m}_{i,j,t}$	Release at site i, in sub-basin j, in time t, for water supply

5.3.7 Total Annual Canal Capacity Constraints

Total annual diversion for irrigation and water supply both at site i in sub-basin j should not exceed the canal capacity. i.e.,

$$(OC^{r}_{i,j} + OC^{m}_{i,j}) - CC_{i,j} <= 0 \qquad \text{For all i and j} \qquad (5.3.7)$$

where

$OC^{r}_{i,j}$	Annual irrigation diversion from site i, in sub-basin j
$OC^{m}_{i,j}$	Annual water supply diversion from sites i, in sub-basin j
$CC_{i,j}$	Annual capacity of canal at site i, in sub-basin j

5.3.8 Land Use Constraints

The total area under crops at any time t should be less than or equal to total available area. i.e.,

$$\sum_{k=1}^{NCI^{i,j}} \lambda^{k}_{i,j,t} * A^{k}_{i,j} \leq TA_{i,j} \qquad \text{For all i and j} \qquad (5.3.8)$$

where

$\lambda^k_{i,j,t}$	Land use coefficient for crop k, for site i in, sub-basin j, in time t
$A^k_{i,j}$	Irrigation area of crop k, for site i, in sub-basin j
$TA_{i,j}$	Total culturable command area (CCA) of site i, in sub-basin j

5.3.9 Crop Water Requirement Constraints

The water requirements of various crops are made in each month and cannot exceed the monthly availability of surface water and ground water, i.e.,

$$\sum_{k=1}^{NCI^{i,j}} W^k_{i,j,t} * A^k_{i,j} \le Od^r_{i,j,t} + Og^r_{i,j,t} \qquad \text{For all i, j and t} \qquad (5.3.9)$$

where

$W^k_{i,j,t}$	Water requirement for crop k, at site i, in sub-basin j, in time t
$A^k_{i,j}$	Irrigation area of crop k, for site i, in sub-basin j
$Od^r_{i,j,t}$	Release at site i, in sub-basin j, in time t, for irrigation
$Og^r_{i,j,t}$	Ground water available for irrigation, from site i, in sub-basin j, in time t

5.3.10 Food Self-Sufficiency Constraints

The food production at each reservoir in the sub-basin/basin should be sufficient enough to meet requirements of the people living in the sub-basin/basin, taking their habits, i.e.,

(i) For cereal crops constraints

$$\sum_{k=1}^{NCI^{r}_{i,j}} A^k_{i,j} * y^k_{i,j} \ge FC_{i,j} \qquad \text{For all i and j} \qquad (5.3.10.1)$$

where

$A^{k}_{i,j}$	Irrigation area of crop k, for site i, in sub-basin j
$y^{k}_{i,j}$	Yield per quintal per hector area of crop k, from site i, in sub-basin j
$FC_{i,j}$	Cereal food requirements of the people living in the area of site i, in sub-basin j

(ii) For pulses crops constraints

$$\sum_{k=1}^{NCI^{P}_{i,j}} A^{k}_{i,j} * y^{k}_{i,j} \geq FP_{i,j} \qquad \text{For all i and j} \qquad (5.3.10.2)$$

where

$A^{k}_{i,j}$	Irrigation area of crop k, for site i, in sub-basin j
$y^{k}_{i,j}$	Yield per quintal per hector area of crop k, from site i, in sub-basin j
$FP_{i,j}$	Pulses food requirements of the people living in the area of site i, in sub-basin j

(iii) For oilseed crops constraints

$$\sum_{k=1}^{NCI^{O}_{i,j}} A^{k}_{i,j} * y^{k}_{i,j} \geq FO_{i,j} \qquad \text{For all i and j} \qquad (5.3.10.3)$$

where

$A^{k}_{i,j}$	Irrigation area of crop k, for site i, in sub-basin j
$y^{k}_{i,j}$	Yield per quintal per hector area of crop k, from site i, in sub-basin j
$FO_{i,j}$	Oilseed crops requirements of the people living in the area of site i, in sub-basin j

(iv) Upper and lower crop areas constraint

$$LL^{k}_{i,j} \leq A^{k}_{i,j} \leq UL^{k}_{i,j} \qquad \text{For all i, j and k} \qquad (5.3.10.4)$$

where

$LL^{k}_{i,j}$	Lower limit of crop area at site i, in sub basin j
$A^{k}_{i,j}$	Irrigation area of crop k, for site i, in sub-basin j
$UL^{k}_{i,j}$	Upper limit of crop area at site i, in sub basin j

5.3.11 Hydroelectric Energy Constraints

The production of hydroelectric energy is a relatively well defined technical process. There are only three decision variables which affect-

(i) The flow through the turbine of the power plant,

(ii) The head associated with flow, and

(iii) The capacity of power plant.

The relationships of these variables to electric energy production are the origins of the energy constraints, and are defined below:

(i) The flow through the turbines should meet energy generation demand, i.e.,

$$E_{i,j,t} = Cf * (O_{i,j,t} + OE^{q,j_E}_{i,j,t} + O^{m}_{i,j,t}) * He_{i,j,t} * e_{i,j} * h_{i,j,t}$$

For all i, j and t (5.3.11.1)

where

$E_{i,j,t}$	Total energy generated from hydropower plant at site i, in sub-basin j, in time t
C_f	Conversion factor from m cm/month to mw-h
$O_{i,j,t}$	Total release from site i, in sub-basin j, in time t
$OE^{q,j_E}_{i,j,p}$	Export from site i, in sub-basin j, to irrigation area p, upstream of site q, in importing sub-basin j_E
$O^{m}_{i,j,t}$	Mandatory releases to downstream natural channel from site i, in sub-basin j, in time t
$He_{i,j,t}$	Average storage head at dam, for site i, in sub-basin j, in time t
$e_{i,j}$	Turbine and generator efficiency of hydropower plant at site i, in sub-basin j
$h_{i,j,t}$	Number of hours in the period t at dam for site i, in sub-basin j ,in time t

(ii) Total energy is defined by

$$E_{i,j,t} = \delta_{i,j,t} * E_{i,j} + \bar{E}_{i,j,t}$$

For all i, j and t (5.3.11.2)

where

$E_{i,j,t}$	Total energy generated from hydropower plant at site i, in sub-basin j, in time t
$\delta_{i,j,t}$	Energy requirement in percentage at site i in sub-basin j in time t
$E_{i,j}$	Annual energy generation target for site i, in sub-basin j
$\bar{E}_{i,j,t}$	Secondary energy generated at dam in mw-h for site i, in sub-basin j, in time t

(iii) Energy production is also limited by the percent of time that the plant will produce power specified by the load factor, i.e.,

$$E_{i,j,t} = \alpha_{i,j,t} * H_{i,j} * h_{i,j,t} \qquad \text{For all i, j and t} \qquad (5.3.11.3)$$

where

$E_{i,j,t}$	Total energy generated from hydropower plant at site i, in sub-basin j, in time t
$H_{i,j}$	Hydropower capacity at dam for site i, in sub-basin j
$\alpha_{i,j,t}$	Load factor at each hydropower site i, in sub-basin j, in time t, for each period t is an indicator of the energy demand
$h_{i,j,t}$	Number of hours in the period t at dam for site i, in sub-basin j ,in time t

Chapter - 6

COMPUTATION OF INPUT DATA FOR LINEAR PROGRAMMING MODEL

6.1 GENERAL

The Cauvery river basin has been divided into sixteen sub-basins having fifteen major irrigation projects as discussed in Chapter 3. The computation of input data for linear programming model, i.e., distribution of upstream and downstream irrigation and water supply requirements from medium and minor irrigation projects to project sites, distribution of ground water at project level, estimation of various co-efficients, estimation of flows of various annual water year dependabilities have been worked in this chapter. These computed values are used in the computation for LP model developed in Chapter 5 for the objective function No.1, i.e., maximization of annual surface and ground water utilization of for irrigation, water supply for domestic use, hydro-power and environmental uses. The notations used in the preparation of a LINDO format for running the model by writing the equations for readily available LINDO software package of 6.1 version, released in August 2001, by LINDO Systems, Inc, 1415 North Dayton St. Chicago, IL, U.S.A., and the water demands for various purposes as per NWDA also are given in this chapter.

The various basic data required for preparation of water balance studies for all the sixteen sub-basins in Cauvery river basin and Cauvery river basin as a whole, and for running the linear programming, mathematical model for Cauvery river basin, are collected from the various reports of National Water Development Agency (NWDA), New Delhi and Central Ground Water Board (CGWB), Faridabad, under the Ministry of Water Resources, Government of India. The data is computed in the required form and format to feed the data for running the model in LINDO software package of version 6.1 released in August 2001, for solving the problem.

The pertinent features of the various major projects in Cauvery river basin for all sixteen sub-basins are given in Table 6.1.

The data available from various reports of NWDA and the publications of CGWB are used for computation of the data for running the LP model to get the required results to achieve the designed objective functions. Sometimes the data available are not in the form, suitable for model computation. The data to be used are usually estimated from the available data to conform to the model requirements before use.

The following data are computed and described as below.

(i) Distribution of upstream and downstream irrigation and water supply requirements from medium and minor irrigation projects to project sites,

(ii) Distribution of Ground water,

(iii) Estimation of various co-efficients, and

(iv) Estimation of flows of various annual water year dependabilities.

6.2 DISTRIBUTION OF UPSTREAM AND DOWNSTREAM IRRIGATION AND WATER SUPPLY REQUIREMENTS FROM MEDIUM AND MINOR IRRIGATION PROJECTS TO PROJECT SITES

The locations of medium irrigation schemes in the catchments area of major irrigation projects are available but the details of locations for minor irrigation schemes in the catchment area of major irrigation projects are not available, hence the utilization

Table 6.1 : Pertinent Features of Dam Sites in Cauvery River Basin

Sr.No.	Name of project	Site No.	Notation	Sub-basin	Status	State	District	Catchment area (km^2)	CCA (ha)	Storage (MCM) Live	Dead	Gross	Utilisation (MCM)	Location Longitude	Latitude
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1	Yagachi	1	YCU	Upper Cauvery	Existing	Karnataka	Hassan	557	21,450	70.58	8.89	89.54	162	75^0 11' E	13^0 11' N
2	Hemavathi	2	HCU	Upper Cauvery	Existing	Karnataka	Hassan	2810	2,65,079	915	38	1047	1536.12	76^0 03' E	12^0 45' N
3	Harangi	3	GCU	Upper Cauvery	Existing	Karnataka	Kodagu	420	53,538	216	12	241	509	75^0 54' E	12^0 29' N
4	Cauvery	4	CCU	Upper Cauvery	Proposed	Karnataka	Kodagu	280	44,500	144.4	25	169.4	433.35	NA	NA
5	KRS	5	KCU	Upper Cauvery	Existing	Karnataka	Mandya	10619	1,13,603	1172	125	1408	1483	76^0 33' E	12^0 25' N
6	Banasursagar	6	BKB	Kabini	Ongoing	Kerala	Wynad	61.44	9,200	143.1	23.8	166.9	277.5	75^0 57' E	11^0 40' N
7	Mananthvady	7	MKB	Kabini	Ongoing	Kerala	Wynad	155.4	22,500	451.6	156	607.8	495.5	75^0 54' E	11^0 47' N
8	Kabini	8	KKB	Kabini	Existing	Karnataka	Mysore	2142	45,730	453	99	552	852	76^0 21' E	11^0 55' N
9	Taraka	9	TKB	Kabini	Existing	Karnataka	Mysore	276.6	19,300	82	30	112	193	76^0 15'E	12^0 02'N
10	Sagar doddakere	10	SKB	Kabini	Proposed	Karnataka	Mysore	185	1,700	310	NA	NA	24	NA	NA
11	Upper Nugu	11	UKN	Kabini	proposed	Karnataka	Mysore	950	40,470	280	NA	280	677	76^0 26' E	11^0 54' N
12	Nugu	12	NKB	Kabini	Existing	Karnataka	Mysore	984	10,526	129.85	24.1	154	217.91	76^0 27' E	11^0 58' N
13	Mettur	13	MCH	Chinnar	Existing	Tamilnadu	Salem	42217	18212	2647	62	2709	275	77^0 48' E	11^0 47' N
14	Lower Bhavani	14	BBH	Bhavani	Existing	Tamilnadu	Periyar	4200	95,175	907.7	21.1	928.8	395.4	77^0 81' E	11^0 28' N
15	Amravathi	15	AAM	Amravathi	Existing	Tamilnadu	Coimbatore	839.13	10,118	108.1	5.19	113.3	202.26	77^0 16' E	10^0 25' N

of minor irrigation schemes was distributed on the proportion of catchment area basis of the major projects.

But the model results were not satisfactory, in the sense that the system targets met were much away from the plan proposals. Hence the minor irrigation utilization of the sub-basin was redistributed as per the state wise utilization of minor irrigation schemes data available in NWDA reports of Cauvery basin, in the proportion of catchment areas of the respective state wise projects. Hence the LP model results are improved.

The computation made for the distribution of minor irrigation schemes and medium irrigation project's contribution to the water requirements for rural human and live stock water supply, irrigation, and ground water; upstream and downstream of the major irrigation project are computed as follows:

Let,

Ca_i = Catchment area of the major irrigation project site i,

Ca_j^T = Sum of net or gross catchment area of all the major irrigation projects, depending upon series or parallel major irrigation projects, in the sub-basin j,

$Iu_{i,j}^m$ = Upstream rural water supply requirements at project level i, in sub-basin j,

$Iu_{i,j}^r$ = Upstream irrigation water requirements by minor and medium irrigation projects,

RWT_j = Total rural water supply requirements of sub-basin,

$RW_{i,j}$ = Upstream rural water requirements at project level (M),

RWMI = Upstream rural water supply requirements at project level by minor projects (Q),

RWMD = Upstream rural water supply requirements at project level by medium projects,

RWMIH = Upstream rural human water requirements from minor irrigation projects,

RWMIL = Upstream live stock water requirements from minor irrigation projects,

RWMD = Upstream rural human water supply requirements from medium irrigation projects,

RWMDL = Upstream live stock water supply requirements from medium irrigation projects.

(1) Upstream rural water supply requirements at project level (M) :

RW = [Intervening catchment area of project / Total catchment area of sub-basin] * [Total annual rural water supply requirements of sub-basin],

$= [Ca_i / Ca^T] * RWT$

$= Iu^m_{i,j}$.

(2) Upstream irrigation water requirements from minor irrigation at project level (P):

P = [Intervening catchment area of project] / [Total catchment area of sub- basin * Total minor irrigation requirements of sub-basin].

(3) Upstream rural water supply requirements at project level by minor projects (Q) :

RWMI = [Upstream irrigation water requirements from minor irrigation at project level* Upstream rural water supply requirements at project level] / [Upstream irrigation water requirements by minor irrigation at project level + Upstream irrigation water requirements by medium irrigation at project level]

$$RWMI = [P * M] / Iu^{r}_{i,j}$$

$$= [P * Iu^{m}_{i,j}] / Iu^{r}_{i,j}.$$

where M = Upstream rural water supply requirements at project level

$$= [C_{a_i}] / [C^{T}_{a}] * RWMIL]$$

(4) Upstream rural water supply requirements at project level by medium projects (R) :

RWMD = [Upstream irrigation water requirements from medium irrigation at project level * Upstream rural water supply requirements at project level] / [Upstream irrigation water requirements by minor irrigation at project level + Upstream irrigation water requirements by medium irrigation at project level]

RWMD = [Upstream irrigation water requirement from medium irrigation at project level $* Iu^{m}_{i,j}] / Iu^{r}_{i,j}$

(5) Upstream human population at project level:

= [Intervening catchment area of project / Total catchment area of sub-basin] * [Human population of the sub-basin].

(6) Upstream lives stock population at project level:

= [Intervening catchment area of project / Total catchment area of sub-basin] * [Live stock population of the sub-basin].

(7) Upstream rural human water supply requirements from minor irrigation projects: (RWMIH):

RWMIH = [Upstream rural water supply requirements from minor irrigation at project level * Upstream human population at project level]/ [Upstream human population at project level + Upstream live stock population at project level].

(8) Upstream live stock water supply requirements from minor irrigation projects (RWMIL):

RWMIL = [Upstream rural water supply requirements from minor irrigation at project level * Upstream live stock population at project level] / [Upstream human population at project level + Upstream live stock population at project level].

(9) Upstream human rural water supply requirements from medium irrigation projects (RWMDH):

(RWMDH) = [Upstream rural water supply requirements from medium irrigation at project level * Upstream human population at project level] / [Upstream human population at project level + Upstream live stock population at project level].

(10) Upstream live stock water supply requirements from medium irrigation projects (RWMDL):

RWMDL = [Upstream rural water supply requirements from medium irrigation at project level * Upstream live stock population at project level] / [Upstream human population at project level + Upstream live stock population at project level].

(11) Total rural human water supply requirement at project level (RWMIH + RWMDH):

RWMIH + RWMDH = [Upstream human rural water supply requirements from minor irrigation projects + Upstream human rural water supply requirements from medium irrigation projects].

(12) Total lives stock water requirement at project level (RWMIL + RWMDL):

(RWMIL + RWMDL) = [Upstream live stock water requirements from minor irrigation projects + Upstream live stock water supply requirements from medium irrigation projects].

(13) Industrial and urban water supply for each major irrigation project to be distributed as: the intervening net or gross catchment area of the major project depending upon series or parallel projects in the sub-basin / total catchment area of the sub-basin multiplied by total Industrial / urban water requirement of the sub-basin.

6.3 GROUND WATER COMPUTATIONS AT PROJECT LEVEL

The total ground water available in the sub-basin is distributed at project level and the ground water available at each project level is distributed as upstream and downstream ground water as below:

Total ground water in the sub-basin =

= Σ *Upstream ground water at project level*

+ Σ Downstream ground water at project level

Total ground water at project level = Upstream and downstream ground water at project level.

6.3.1 Upstream Ground Water at Project Level =

= [Intervening gross or net catchment area of the major project / Total catchment of the sub-basin] * [Total ground water available in the sub-basin].

6.3.2 Downstream Ground Water at Project Level

= [Cultivable command area of the major project / Total catchment of the sub-basin] * [Total ground water available in the sub-basin].

If, the projects are in parallel, then, Catchment area = Gross catchment area of the major project, and, If, the projects are in series, then, Catchment area = Net catchment area of the major project.

The values of the distribution of upstream and downstream irrigation and water supply demands, and ground water are computed and given in the Table 6.2.

Table 6.2: Upstream and Downstream Annual Irrigation and Water Supply Requirements of All Major Projects in Cauvery River Basin

Sl.No.	Name of project	U/S Rural Domestic Water Use			U/S Irrigation Water Use			D/S Domestic Use		D/S Irrigation Use	Exports	Ground Water Use		
		Human $Ws^{RH}_{i,j}$ IUMH	Live Stock $Ws^{RL}_{i,j}$ IUML	Total $Iu^{m}_{i,j}$ IUM	U/s Minor	U/s Medium	Total $Iu^{r}_{i,j}$ IUR	Urban $Ws^{U}_{i,j}$ WSU	Industrial $Ws^{I}_{i,j}$ WSI	$Ir'_{i,j}$ IRD	$OE^{q,j_E}_{i,j,t}$	U/S	D/S	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	Yagachi	2.48	3.42	5.90	47.46	0.00	47.46	10.96	16.84	163.02	0.00	30.34	11.69	42.03
2	Hemavathi	10.04	13.82	23.86	191.97	67.38	259.35	44.34	68.11	339.72	1334.00	111.05	144.41	255.46
3	Harangi	1.87	2.58	4.45	35.79	0.00	35.79	8.27	12.70	509.00	0.00	22.88	29.17	52.05
4	Cauvery	1.25	1.72	2.97	23.86	0.00	23.86	5.51	8.46	433.35	0.00	15.25	24.24	39.50
5	KRS	31.69	43.60	75.29	605.73	58.32	664.05	139.92	214.90	0.00	1483.00	189.46	0.00	189.46
6	Banasurasagar	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	88.50	189.00	3.37	2.09	5.46
7	Mananthvady	1.01	0.71	1.72	3.86	43.32	47.18	4.46	6.18	0.00	495.50	8.53	0.00	8.53
8	Kabini	12.53	8.79	21.32	47.78	492.55	540.33	55.23	76.56	852.00	627.35	103.57	6.60	110.17
9	Taraka	1.80	1.26	3.06	6.87	0.00	6.87	7.94	11.00	193.00	0.00	15.18	4.89	20.07
10	Sagar Doddakere	1.20	0.84	2.04	4.59	0.00	4.59	5.31	7.36	24.00	95.00	10.15	0.93	11.09
11	Upper Nugu	6.19	4.34	10.53	23.58	100.47	124.05	27.26	37.78	677.00	289.69	52.14	9.88	62.02
12	Nugu	0.22	0.16	0.38	0.84	0.00	0.84	0.98	1.35	217.91	0.00	1.87	5.78	7.64
13	Remaining area	22.64	15.63	38.27	85.69	422.73	508.42	99.07	137.32	0.00	0.00	161.43	0.00	161.43
14	Mettur	17.7	27.23	44.94	380.2	302.1	682.3	78	123	275	12712	177.6	0.00	177.6
15	Lower Bhavani	24.9	21.54	46.42	130.35	119.93	250.3	110	156.29	395.4	627.27	128.1	9.89	137.99
16	Remaining area	11.6	10.02	21.59	60.65	78.07	138.7	51.1	72.71	0.00	0.00	59.6	0.00	59.6
17	Amravathi	4.73	5.31	10.04	66.68	0	66.68	20.9	30.91	202.26	0.00	31.21	3.76	34.97
18	Remaining area	42	47.08	89.03	591.32	499	1090	185	274.9	0.0	0.00	276.79	0.00	276.79

6.4 ESTIMATION OF VARIOUS COEFFICIENTS

The following coefficients are computed as follows:

6.4.1 Reservoir Evaporation Coefficient $(K'_{i,j,t})$

Firstly, the LP model for every individual projects were run without considering evaporation losses from the reservoirs and storages of each reservoirs were obtained, by adding of the dead storages of each sites the gross storages are calculated, by knowing the area of submergence at full reservoir level. The reservoir operation table (working table) was prepared for each reservoir using average monthly flows and considering evaporation losses. From the results, $K'_{i,j,t}$ was calculated as :

$$K'_{i,j,t} = 1 + (El_{i,j,t}/S_{i,j,t}).$$

The values of $El_{i,j,t}$ and $S_{i,j,t}$ were taken from the results of LP model running on LINDO software for each site, i. Reservoir operation tables (working table) was prepared for each reservoir using average monthly flows and considering evaporation losses from the results. The values of $K'_{i,j,t}$ calculated for all the fifteen sites in Cauvery river basin are presented in Table 6.3.

6.4.2 Percent of Annual Irrigation $(K_{i,j,t})$

The values of $K_{i,j,t}$ are computed from monthly crop requirements of each crop. This is the ratio of monthly and annual crop water requirements, such that $\sum_{t=1}^{12} K_{i,j,t} = 1$.

Computation of $K_{i,j,t}$ is given below:

$$SUM_{i,j}(t) = \sum_{k=1}^{NCI^{i,j}} W^k_{i,j,t} * A^k_{i,j} \qquad \text{for all i,j, and t} \qquad (6.1)$$

$$TSUM_{i,j} = \sum_{t=1}^{12} SUM_{i,j}(t) \qquad \text{for all i and j,} \qquad (6.2)$$

Table 6.3 : Estimated Monthly Reservoir Evaporation Coefficients at Cauvery River Basin from All Major Projects

Month	Yagachi	Hemavathi	Harangi	Cauvery	KRS	Banasursagar	Mananthvady	Kabini	Sagardoddakere	Taraka	Upper Nugu	Nugu	Bhavani	Amaravathi	Mettur
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Jun	1.0271	1.0100	1.0098	1.0146	1.0113	1.0088	1.0086	1.0221	1.0080	1.0121	1.0143	1.0113	1.0121	1.0137	1.0137
Jul	1.0253	1.0094	1.0091	1.0137	1.0106	1.0082	1.0080	1.0207	1.0075	1.0113	1.0134	1.0106	1.0128	1.0143	1.0143
Aug	1.0257	1.0095	1.0093	1.0139	1.0108	1.0083	1.0081	1.0210	1.0076	1.0114	1.0136	1.0108	1.0126	1.0141	1.0141
Sep	1.0256	1.0095	1.0093	1.0138	1.0107	1.0083	1.0081	1.0210	1.0076	1.0114	1.0135	1.0107	1.0108	1.0113	1.0112
Oct	1.0242	1.0090	1.0088	1.0131	1.0101	1.0079	1.0077	1.0198	1.0071	1.0108	1.0128	1.0101	1.0095	1.0091	1.0091
Nov	1.0232	1.0086	1.0084	1.0125	1.0097	1.0075	1.0074	1.0190	1.0069	1.0103	1.0123	1.0097	1.0101	1.0099	1.0099
Dec	1.0250	1.0093	1.0091	1.0135	1.0105	1.0081	1.0079	1.0205	1.0074	1.0112	1.0132	1.0105	1.0112	1.0109	1.0109
Jan	1.0281	1.0104	1.0102	1.0152	1.0118	1.0091	1.0089	1.0230	1.0083	1.0125	1.0149	1.0118	1.0121	1.0117	1.0117
Feb	1.0293	1.0108	1.0106	1.0158	1.0123	1.0095	1.0093	1.0239	1.0086	1.0130	1.0155	1.0123	1.0156	1.0154	1.0154
Mar	1.0364	1.0135	1.0131	1.0196	1.0152	1.0118	1.0115	1.0298	1.0107	1.0162	1.0192	1.0152	1.0144	1.0147	1.0147
Apr	1.0338	1.0125	1.0122	1.0182	1.0142	1.0110	1.0107	1.0277	1.0100	1.0150	1.0179	1.0142	1.0145	1.0158	1.0158
May	1.0323	1.0120	1.0117	1.0175	1.0135	1.0105	1.0102	1.0265	1.0095	1.0144	1.0171	1.0135	1.0128	1.0147	1.0147

$$K_{i,j,t} = SUM_{i,j}(t) / TSUM_{i,t} \qquad \text{for all i,j, and t} \qquad (6.3)$$

The computed values of $K_{i,j,t}$ are given in Table 6.4.

6.4.3 Percent of Return Flow to River from Irrigation ($K''_{i,j,t}$)

The percent of return flow to river from irrigation was taken as 10 to 20 percent depending on the age of the reservoir.

6.4.4 Percent of Upstream Annual Water Use for Irrigation ($\alpha_{i,j,t}$)

The percent of upstream annual water use for irrigation is the percent ratio of monthly and annual crop water requirement. The computed values are same as given in Tables 6.4.

6.4.5 Percent of Return Flow to River from Upstream Water Use for Irrigation ($\alpha''_{i,j,t}$)

The percent of return flow to river from upstream water use for irrigation is taken as 10 to 20 percent depending on the age of the reservoir.

6.4.6 Percent of Upstream Annual Water Supply ($\beta_{i,j,t}$)

The percent of upstream annual water supply use are computed as:

$\beta_{i,j,t}$ = (Number of days in a month/ number of days in a year (365 days)*100.

6.4.7 Percent of Return Flow to River from Upstream Water Use for Water Supply ($\beta''_{i,j,t}$)

The percent of return flow to river from upstream water use for water supply is taken as 80 percent.

Table 6.4 : The Values of Percentage of Irrigation for All 16-Sub-basins in Cauvery River Basin

Upper Cauvery	Kabini	Shimsha	Arkavathi	Middle Cauvery	Suvarnavathi	Palar	Chinnar	Bhavani	Noyil	Amaravathi	Tirumani muttar	Ponnanai Ar	Upper Coleroon	Lower Coleroon	[illegible]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	[illegible]
0.0790	0.0205	0.0160	0.0265	0.0100	0.0101	0.0112	0.0730	0.1248	0.2145	0.1307	0.0548	0.0709	0.0134	0.0134	[illegible]
0.1844	0.1782	0.1059	0.0644	0.1884	0.1889	0.1977	0.0389	0.1680	0.1216	0.1743	0.0414	0.1115	0.2245	0.2245	[illegible]
0.1862	0.1744	0.1187	0.0866	0.1733	0.1736	0.1818	0.0266	0.1530	0.0948	0.1515	0.0723	0.0668	0.2403	0.2403	[illegible]
0.1823	0.1392	0.0903	0.0997	0.1391	0.1414	0.1474	0.0935	0.0680	0.0480	0.0782	0.0915	0.0584	0.2349	0.2349	[illegible]
0.1991	0.0155	0.0133	0.0721	0.0125	0.0126	0.0179	0.0765	0.0052	0.0065	0.0083	0.0732	0.1408	0.0704	0.0704	[illegible]
0.0134	0.0460	0.0743	0.0831	0.0422	0.0419	0.0512	0.0906	0.0049	0.0081	0.0057	0.0843	0.1158	0.0619	0.0619	[illegible]
0.0292	0.0910	0.1369	0.1578	0.0870	0.0896	0.0864	0.1067	0.0258	0.0319	0.0308	0.0605	0.1566	0.0488	0.0488	[illegible]
0.0343	0.1318	0.1813	0.1750	0.1243	0.1325	0.1048	0.0527	0.0880	0.0620	0.0774	0.0311	0.1237	0.0169	0.0169	[illegible]
0.0432	0.1199	0.1430	0.1127	0.1126	0.1185	0.1107	0.1092	0.1294	0.0799	0.1150	0.1303	0.0269	0.0295	0.0295	[illegible]
0.0417	0.0623	0.0772	0.0699	0.0782	0.0681	0.0660	0.1333	0.1448	0.0884	0.1322	0.1932	0.0539	0.0446	0.0446	[illegible]
0.0071	0.0146	0.0299	0.0332	0.0273	0.0179	0.0185	0.1026	0.0527	0.0673	0.0482	0.0990	0.0447	0.0124	0.0124	[illegible]
0.0000	0.0066	0.0135	0.0189	0.0050	0.0051	0.0056	0.0965	0.0353	0.1771	0.0477	0.0684	0.0302	0.0024	0.0024	[illegible]
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	[illegible]

6.4.8 Percent of Annual Surface Water Requirement for Urban Domestic Water Use ($\varphi_{i,j}^{U^s}$)

The percent of annual surface water requirement for urban domestic water use is taken as 100 percent.

6.4.9 Percent of Annual Ground Water Requirement for Urban Domestic Water Use ($\varphi_{i,j}^{U^g}$)

The percent of annual ground water requirement for urban domestic water use is taken as 0 percent.

6.4.10 Percent of Annual Surface Water Requirement for Rural Human Population Domestic Use ($\varphi_{i,j}^{RH^s}$)

The percent of annual surface water requirement for rural human population domestic use is taken as 50 percent.

6.4.11 Percent of Annual Ground Water Requirement for Rural Human Population Domestic Use ($\phi_{i,j}^{RH^g}$)

The percent of annual ground water requirement for rural human population domestic use is taken as 50 percent.

6.4.12 Percent of Annual Surface Water Requirement for Live Stock Use ($\phi_{i,j}^{RL^s}$)

The percent of annual surface water requirement for live stock use is taken as 0 percent.

6.4.13 Percent of Annual Ground Water Requirement for Live Stock Use ($\varphi_{i,j}^{RL^g}$)

The percent of annual ground water requirement for live stock use is taken as 100 percent.

6.4.14 Percent of Annual Surface Water Requirement for Industrial Use ($\varphi^{I^r}_{i,\,j}$)

The percent of annual surface water requirement for industrial use is taken as 100 percent.

6.4.15 Percent of Annual Ground Water Requirement for Industrial Use ($\varphi^{I^g}_{i,\,j}$)

The percent of annual ground water requirement for industrial use is taken as 0 percent.

6.4.16 Percent of Annual Water Use for Urban and Industrial ($\xi_{i,\,j,\,t}$)

The percent of annual water use for urban domestic and industrial use is taken as 100 percent from surface water and zero percent from ground water.

6.4.17 Percent of Import to a Site ($\psi^{q,\,j_i}_{i,\,j,\,t}$)

The percent of import to the importing site is computed in the ratio of the monthly irrigation requirements of the importing site to the total annual irrigation requirements of the importing site.

6.4.18 Percent of Export to Site ($\omega^{q,\,j_i}_{i,\,j,\,t}$)

The percent of export from site i is computed in the ratio of monthly irrigation requirements of the importing site to the total annual irrigation requirements of the importing site.

6.5 ESTIMATION OF FLOWS OF VARIOUS ANNUAL WATER YEAR DEPENDABILITIES

The computation of water year annual dependable flows for the years representing a normal, dry and wet years were calculated using flow-duration analysis of annual (water year) flows. These were (i) 75% water year annual dependable flow representing a water year under normal conditions, (ii) 90% water year annual dependable flow representing a water deficit year, (iii) 100% (lowest flow) water year annual dependable flow representing a critical water deficit year, and (iv) 50% water year annual dependable annual flow representing a water surplus year. The model constraints were written for NT = 12 months because the computations were done over one year interval only.

6.5.1 Estimation of Inflows at Project Levels

The inflow values for each reservoir in the Cauvery river basin are computed by using the rainfall data available in the various NWDA reports of compilation of basic data for all fifteen reservoirs in Cauvery river basin. The annual dependable yield of the reservoir is distributed in the proportion of the monthly rainfall data of the nearest rain gauge station to the reservoir. In the absence of catchment maps, this was adopted.

Inflows in the individual major projects in the Kabini and Upper Cauvery sub-basins are computed by considering the monthly/annual average rainfall values for the 75 percent annual water year dependable flow of the sub-basin from which the annual yield is calculated for water balance studies, from the nearest rain gauge station to that major project.

For the Krishnarajsagar (KRS) major project in the Upper Cauvery sub-basin, the inflow is computed by deducting the sum of inflows in the major project in sub-basin from total inflow of the sub-basin as this project is at the end or terminal point of the sub-basin.

For Chinnar, Bhavani and Amaravathi major projects the inflows are taken as given in these respective project reports as each of them is single major project in its respective sub-basins.

The computed 50%, 75%. 90% and 100% monthly and annual water year dependable flows are given in Table 6.5 (a) to Table 6.5 (d).

6.6 THE LP LINDO FORMAT

The LP LINDO format is prepared for running the model by writing the equations in the required format for readily available LINDO software package of 6.1 version released in August 2001, by LINDO Systems, Inc., 1415 North Dayton St. Chicago, IL, U.S.A., and is given in appendix - I. The notations used in the LP model are given as below.

The nomenclature of the variables for writing the equations for running the model on LINDO software package was done by using first single letter of the name of a project site, first two letters of the name of a sub-basin and maximum first five letters of name of a variable, because the LINDO software package version 6.1 (August 2001) allows maximum eight letters for the nomenclature of a variable for running the model to obtain a feasible solution of the problem by running the model on it.

The projectwise and variablewise notations used for running the model on the LINDO software package are given as below in Tables 6.6.1 and 6.6.2, respectively.

Table 6.5 (a): Annual Flows with Different Dependabilities at Various Sites in Upper Cauvery Sub-basin

Name of Project	% Dep.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Yagachi	50%*	22.6	88.2	7.1	16.5	74.7	12.6	0.0	0.0	0.0	10.7	39.0	55.7	327.0
Hemavathi		91.4	356.5	28.7	66.8	301.8	50.7	0.0	0.0	0.0	43.2	157.6	225.2	1321.9
Harangi		24.9	131.2	28.4	8.4	26.1	12.0	1.5	0.0	0.0	2.0	14.8	11.1	246.4
Cauvery		28.1	76.6	25.5	12.2	7.5	4.5	0.8	0.0	0.0	1.3	5.6	1.9	164.0
Remaining area		440.9	1552.4	389.6	280.3	545.0	217.3	21.7	0.0	30.3	73.7	351.7	342.4	4171.0
Total		**607.9**	**2204.7**	**479.4**	**384.3**	**955.1**	**297.1**	**24.0**	**0.0**	**30.3**	**130.9**	**568.6**	**636.3**	**6230.3**
Yagachi	75%	7.7	15.7	19.8	15.9	17.6	6.9	1	0	0	0	15.3	15.4	115.3
Hemavathi		114.1	232.1	292.4	235.4	260.1	102.4	15.1	0.0	0.0	0.0	226.6	227.4	1705.5
Harangi		38.3	180.7	88.2	65.2	27.1	11	4.7	2.1	2.3	10.2	30.3	10.9	471
Cauvery		61.4	193.1	79.9	50.7	16.6	8.4	4.1	0.0	0.0	3.4	13.1	27.9	458.6
Remaining area		248.4	738.0	311.8	193.4	247.3	87.4	41.7	11.5	2.5	27.3	183.1	334.2	2426.6
Total		**470.0**	**1359.6**	**792.1**	**560.6**	**568.7**	**216.1**	**66.6**	**13.6**	**4.8**	**40.9**	**468.4**	**615.8**	**5177.0**
Yagachi	90%	10.6	30.3	12.0	26.8	43.4	16.5	12.2	2.8	0.0	0.1	44.1	55.3	254.0
Hemavathi		42.8	122.4	48.7	108.5	175.4	66.6	49.4	11.3	0.0	0.3	178.4	223.7	1027.0
Harangi		19.0	57.1	30.0	13.1	18.2	9.6	2.0	0.3	0.0	0.0	8.6	10.2	191.0
Cauvery		20.7	37.6	29.7	10.9	11.5	6.5	0.9	0.2	0.1	0.0	4.6	5.4	128.0
Remaining area		257.4	746.7	280.5	392.3	567.2	327.2	31.0	11.8	7.4	0.5	282.0	346.1	3240.0
Total		**350.4**	**994.0**	**400.9**	**551.6**	**815.7**	**426.4**	**95.4**	**26.5**	**7.5**	**0.9**	**517.6**	**640.7**	**4840.0**
Yagachi	100%	7.13	36.19	7.45	43.16	25.29	8.61	0	0	15.4	0	8.01	13.74	165
Hemavathi		29.03	147.3	30.32	175.7	103	35.07	0	0	62.8	0	32.63	55.95	668
Harangi		15.11	45.92	26.79	14.84	7.66	5.83	0	0	2.01	0	2.24	4.56	125
Cauvery		14.2	29.72	15.48	9.27	4.36	2.81	0	0	0.41	0	3.6	3.14	83
Remaining area		238.2	623.6	211.1	265.7	255	108.64	0	0	16.4	0	139.97	248.5	2109
Total		303.7	882.7	291.1	508.7	395.3	161.0	0.0	0.0	97.0	0.0	186.5	325.9	3150.0

*- Annual flow of given dependability

Table 6.5 (b): Annual Flows with Different Dependabilities at Various Sites in Kabini Sub-basin

Name of Project	% Dep.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Banasurasagar	50%*	57.1	142.7	70.0	52.7	28.4	8.8	1.5	1.0	0.0	0.8	5.3	24.6	392.9
Mananthvady		98.3	315.8	75.4	66.7	103.1	47.5	1.9	0.0	3.5	15.7	35.1	24.1	787.1
Taraka		20.7	17.0	18.9	47.0	56.7	37.3	1.3	0.0	0.2	1.8	10.6	10.3	221.9
Sagar Doddakere		10.3	56.4	9.6	84.6	67.3	84.6	1.9	10.9	0.0	0.0	16.0	50.0	391.7
Kabini		253.5	208.6	231.1	576.5	695.4	457.6	15.7	0.0	2.2	22.4	130.1	125.6	2718.8
Upper Nugu		19.3	105.9	18.0	158.8	126.4	161.3	3.6	20.5	0.0	0.0	30.1	93.9	737.7
Nugu,		9.4	51.5	8.8	77.2	61.4	78.4	1.7	9.9	0.0	0.0	14.6	45.6	358.7
Remaining area		48.2	94.9	60.3	153.2	230.9	132.2	16.2	10.1	5.0	11.8	118.5	82.7	964.1
Total		533.4	1023.7	499.3	1232.3	1351.4	1017.3	37.9	50.9	8.9	50.1	320.4	447.2	6572.7
Banasurasagar	75%	45.0	112.6	55.2	41.6	22.4	7.0	1.2	0.8	0.0	0.6	4.2	19.4	310.0
Mananthvady		77.6	249.2	59.5	52.6	81.4	37.5	1.5	0.0	2.8	12.4	27.7	19.0	621.0
Taraka		16.4	13.5	15.0	37.3	45.0	29.6	1.0	0.0	0.2	1.5	8.4	8.1	175.9
Sagar Doddakere		8.1	44.5	7.6	66.8	53.1	66.8	1.5	8.6	0.0	0.0	12.6	39.5	309.0
Kabini		200.0	164.6	182.3	454.8	548.6	361.0	12.4	0.0	1.8	17.7	102.7	99.1	2145.0
Upper Nugu		15.2	83.6	14.2	125.3	99.7	127.2	2.9	16.1	0.0	0.0	23.7	74.1	582.0
Nugu,		7.4	40.6	6.9	60.9	48.5	61.9	1.4	7.9	0.0	0.0	11.5	36.0	283.0
Remaining area		38.0	74.9	47.6	120.9	182.2	104.3	12.8	8.0	4.0	9.3	93.5	65.3	760.6
Total		407.6	783.4	388.3	960.3	1080.9	795.3	34.6	41.3	8.6	41.5	284.4	360.4	5186.6
Banasurasagar	90%	6.2	9.2	6.5	0.5	1.7	0.4	0.0	0.2	0.0	0.1	1.0	0.7	26.5
Mananthvady		21.8	17.7	9.9	6.0	5.6	0.3	0.2	0.0	0.1	0.5	3.8	1.0	67.0
Taraka		8.3	5.0	11.8	6.2	46.3	11.5	0.1	0.0	0.0	1.3	8.3	20.3	119.0
Sagar Doddakere		16.7	5.7	5.9	0.0	14.1	2.5	0.0	0.0	0.0	10.7	7.3	17.1	80.0
Kabini		57.7	34.8	82.3	43.3	323.1	80.6	0.9	0.0	0.0	9.3	57.7	141.6	831.0
Upper Nugu		85.7	29.2	30.5	0.0	72.4	12.7	0.0	0.0	0.0	54.6	37.5	87.6	410.0
Nugu,		3.1	1.1	1.1	0.0	2.7	0.5	0.0	0.0	0.0	2.0	1.4	3.2	15.0
Remaining area		150.3	389.4	393.5	188.0	132.3	85.6	43.4	12.7	10.6	15.6	26.6	43.0	1491.0
Total		349.7	492.1	541.4	244.0	598.0	194.1	44.6	12.9	10.8	94.0	143.5	314.5	3039.5
Banasurasagar	100%	3.1	2.0	5.1	1.1	1.1	2.3	0.1	0.0	0.0	0.0	1.3	1.2	17.3
Mananthvady		7.8	5.2	13.0	2.9	2.7	5.8	0.2	0.0	0.1	0.0	3.4	3.1	44.0
Taraka		1.0	8.8	5.8	10.1	10.2	18.5	0.1	0.7	0.0	3.3	2.1	17.4	78.0
Sagar Doddakere		0.6	7.2	7.2	1.7	3.2	11.4	0.4	0.1	0.0	0.6	8.0	11.5	52.0
Kabini		6.6	61.2	40.6	70.1	70.8	128.3	0.7	5.2	0.0	22.9	14.8	120.9	542.0
Upper Nugu		2.9	37.0	37.0	8.8	16.5	58.3	2.2	0.7	0.0	3.3	41.1	59.1	267.0
Nugu,		0.1	1.4	1.4	0.3	0.6	2.2	0.1	0.0	0.0	0.1	1.5	2.2	10.0
Remaining area		98.0	253.9	256.5	122.5	86.2	55.8	28.3	8.3	6.9	10.1	17.4	28.0	972.0
Total		120.0	376.8	366.6	217.5	191.3	282.4	32.1	15.1	7.1	40.4	89.5	243.5	1982.3

*- Annual flow of given dependability

Table 6.5 (c): Annual Flows with Different Dependabilities at Various Sites in Bhavani Sub-basin

Name of Project	% Dep.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Bhavani		168.8	146.0	152.2	172.3	264.3	141.4	113.6	69.1	90.8	150.9	66.0	137.5	1668.0
Remaining area	50%*	78.5	67.9	70.8	80.2	123.0	65.8	52.8	32.1	42.2	70.2	30.7	64.0	776.0
Total		**247.3**	**213.9**	**223.0**	**252.4**	**387.3**	**207.2**	**166.4**	**101.2**	**133.0**	**221.1**	**96.8**	**201.4**	**2443.9**
Bhavani		106.1	255.9	183.1	97.9	143.5	178.2	103.4	55.9	48.1	48.1	39.7	55.4	1315.2
Remaining area	75%	48.5	117.1	83.3	44.8	65.7	81.6	47.3	25.6	22.0	22.0	16.8	25.4	600.1
Total		**154.6**	**373.0**	**266.4**	**142.7**	**209.2**	**259.7**	**150.8**	**81.4**	**70.1**	**70.2**	**56.5**	**80.7**	**1915.3**
Bhavani		46.4	148.8	85.8	93.5	91.9	129.1	154.5	97.8	10.8	34.8	71.6	67.9	1033
Remaining area	90%	21.6	69.2	39.9	43.5	42.7	60.0	71.8	45.4	5.0	16.2	33.3	31.5	480.0
Total		**68.0**	**218.0**	**125.7**	**137.0**	**134.7**	**189.1**	**226.2**	**143.2**	**15.8**	**51.0**	**104.9**	**99.4**	**1513**
Bhavani		54.2	92.2	64.4	54.6	107.3	35.7	180.3	31.9	27.9	18.3	127.1	36.6	831.0
Remaining area	100%	25.2	42.9	30.0	25.4	50.0	16.6	84.0	14.9	13.0	8.5	59.2	17.1	387.0
Total		**79.5**	**135.1**	**94.4**	**80.0**	**157.3**	**52.3**	**264.3**	**46.8**	**40.9**	**26.9**	**186.3**	**53.7**	**1218.0**

*- Annual flow of given dependability

Table 6.5 (d): Annual Flows with Different Dependabilities at Various Sites in Amaravathi Sub-basin

Name of Project	% Dep.	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Amaravathi		3.5	2.7	5.7	26.5	16.6	22.3	4.9	10.2	0.5	4.3	5.0	10.1	112.3
Remaining area	50%*	30.9	23.9	50.6	235.0	147.4	197.3	43.7	90.6	4.3	38.3	44.1	89.4	995.6
Total		**34.4**	**26.6**	**56.3**	**261.5**	**164.0**	**219.6**	**48.7**	**100.9**	**4.8**	**42.6**	**49.1**	**99.5**	**1108.0**
Amaravathi		27.9	27.8	61.3	34.0	47.7	65.0	45.9	15.7	5.8	4.1	5.5	10.9	351.4
Remaining area	75%	35.3	92.0	77.5	43.0	60.4	82.3	58.0	20.1	7.3	5.2	7.0	13.8	501.8
Total		**63.2**	**119.8**	**138.8**	**76.9**	**108.1**	**147.3**	**103.9**	**35.8**	**13.1**	**9.2**	**12.5**	**24.6**	**853.2**
Amaravathi		6.9	9.4	9.6	6.5	17.0	7.1	4.9	0.5	0.6	3.4	10.7	5.2	81.9
Remaining area	90%	61.0	83.2	84.6	57.7	150.0	62.5	43.3	4.7	5.5	30.2	94.5	45.8	722.4
Total		**67.9**	**92.6**	**94.2**	**64.3**	**167.0**	**69.6**	**48.3**	**5.2**	**6.1**	**33.6**	**105.2**	**51.0**	**804.3**
Amaravathi		4.3	9.3	9.8	7.1	5.7	3.3	5.1	3.5	0.8	3.3	8.2	4.6	64.9
Remaining area	100%	37.8	82.6	87.4	62.6	50.7	29.2	45.1	30.9	7.2	29.2	72.8	41.0	576.5
Total		**42.1**	**91.9**	**97.3**	**69.7**	**56.4**	**32.4**	**50.2**	**34.4**	**8.0**	**32.5**	**81.0**	**45.7**	**641.5**

*- Annual flow of given dependability

Table 6.6.1: Notations Used in the LP LINDO Format for Projects

Sl. No.	Name of project	Name of sub-basin	Notations used in the LINDO format
(1)	(2)	(3)	(4)
	(i)	(j)	
1	Hemavathi	Upper Cauvery	HCU
2	Yagachi	Upper Cauvery	YCU
3	Harangi	Upper Cauvery	GCU
4	KRS	Upper Cauvery	KCU
5	Cauvery	Upper Cauvery	CCU
6	Banasursagar	Kabini	BKB
7	Mananthyadi	Kabini	MKB
8	Kabini	Kabini	KKB
9	Taraka	Kabini	TKB
10	Sagar Doddakere	Kabini	SKB
11	Upper Nugu dam	Kabini	UKN
12	Nugu	Kabini	NKB
13	Mettur	Chinnar	MCH
14	Lower Bhavani	Bhavani	BBH
15	Amaravathi	Amaravathi	AAM

Table 6.6.2: Notations Used in the LP LINDO Format for Variables

Variable	Notation used in LINDO format	Variable	Notation used in LINDO format	Variable	Notation used in LINDO format
(1)	(2)	(1)	(2)	(1)	(2)
$I_{i,j,t}$	I	$Ir^{g}_{i,j}$	IURG	$Iu^{r}_{i,j}$	IUR
$Ir^{r}_{i,j}$	IUR	$Ir^{s}_{i,j}$	IURS	$Iu^{r,s}_{i,j}$	IURS
$Iu^{r,g}_{i,j}$	IURG	$Og_{i,j}$	OG	$Sp_{i,j,t}$	SP
$Iu^{m}_{i,j}$	IUM	$Og^{m}_{i,j,t}$	OGM	$Ws^{'}_{i,j}$	WSD
$Iu^{m,s}_{i,j}$	IUMS	$OI^{q,j_1}_{i,j,p}$	OI	$Ws^{l}_{i,j}$	WSI
$Iu^{m,g}_{i,j}$	IUMG	$O_{i,j,t}$	O	$Ws^{RH}_{i,j}$	IUMH
$OC^{m}_{i,j}$	OCM	$O^{m}_{i,j,t}$	OM	$Ws^{R}_{i,j}$	IUR
$Od_{i,j,t}$	OD	$Og^{r}_{i,j,t}$	OGR	$Ws^{RL}_{i,j}$	IUML
$Od^{m}_{i,j,t}$	ODM	$S_{i,j,t-1}$	S0	$Ws^{U}_{i,j}$	WSU
$Od^{r}_{i,j,t}$	ODR	$S_{i,j,t}$	S	$OE^{q,j_E}_{i,j,p}$	OE

6.7 THE VARIOUS DEMANDS AS PER NWDA

The water demands for various purposes as per NWDA are given in Table 6.7.

6.8 COMPUTATION OF WATER REQUIREMENT TO MEET THE MINIMUM FOOD REQUIREMENTS OF THE AGRICULTURAL POPULATION IN THE COMMAND OF MAJOR RESERVOIRS

6.8.1 Estimation of Agriculture Population

The sub-basinwise rural and urban population within the Cauvery river basin is obtained from the various reports of compilation of basic data and preliminary water balance studies of NWDA. The rural and urban population for the year 1981 taken from the census figures is projected for the year 2050. The year 2050 is chosen as the water balance studies are carried out for the year 2050, after which a reassessment may be done. The total agricultural population at each major project level is computed in the proportion of the command area of each major project lying in the sub-basin for all the fifteen major reservoirs having irrigation component in sub-basins as per their culturable command areas. The computation of the agricultural population for all the fifteen major reservoirs in the basin having irrigation component in shown in Table 6.8.2.

6.8.2 Minimum Food Requirements

Nutritional requirements (proteins and calories) per capita per day: The daily dietary allowances of proteins and calories for male and female in different age groups are obtained from Ghei and Ghei (1973) and Thaper (1981). The daily dietary allowances are shown in Table 6.8.1.

Table 6.7: The Various Demands as per National Water Development Agency (NWDA)

Sl.No.	Name of Sub-basin	$Iu^{m}_{i,j}$ IUM	$Iu^{r}_{i,j}$ IUR	$Ws^{U}_{i,j}$ WSU	$Ws^{I}_{i,j}$ WSI	$Ws'_{i,j}$ WSD	$Ir'_{i,j}$ IRD	$OE^{q,i_E}_{i,j,t}$ OE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Yagachi	5.9	47.45	10.96	16.84	83.97	27.80	0.00
2	Hemavathi	23.86	259.35	44.34	68.11	339.72	112.45	1134.0
3	Harangi	5.9	47.6	10.96	16.84	471.24	27.80	0.00
4	Cauvery	2.97	23.86	5.51	8.46	413.35	13.97	0.00
5	KRS	75.29	664.05	139.92	214.9	0	354.82	1483.0
Total Upper Cauvery s.b.		113.92	1042.3	211.69	325.15	1308.3	536.84	2617.0
6	Banasursagar	0.68	40.82	1.76	2.44	66.40	4.20	189.00
7	Mananthvady	1.72	146.65	4.46	6.18	7.43	10.64	475.50
8	Kabini	21.32	530.4	55.23	76.56	710	131.79	627.35
9	Taraka	3.06	1.24	7.94	11	157.87	18.94	0.00
10	Sagardoddakere	2.05	0.83	5.31	7.36	197.18	12.67	95.00
11	Upper Nagu	10.5	104.72	27.26	37.77	179.0	65.03	289.60
12	Nugu	0.38	0.15	0.98	1.35	181.64	2.33	0.00
13	Kabini s.b.r.area	236.39	362.25	99.07	137.32	0.00	236.39	98.55
Total Kabini sub-basin		276.1	1187.1	202.01	279.98	1499.6	481.99	1775.00
14	Shimsha s.b.	115.0	3150.69	233.0	348.0	0.00	581.00	15.00
15	Arkavathi s.b.	989.00	759.28	430.00	559.00	0.00	989.00	810.29
16	Middle C.s.b.	183.00	1788.47	74.00	109.00	0.00	183.00	211.00
17	Suvarnavathi s.b.	95.00	500.66	32.00	63.00	0.00	95.00	0.00
18	Palar s.b.	36.93	267.53	0.00	44.0	0.00	44.00	0.00
19	Chinnar s.b.r.area	0	177.6	0.00	0.00	0.00	0.00	0.00
20	Mettur	201.00	275.00	78	123	275	201.00	12712
Total Chinnar sub-basin		201.00	452.60	78.00	123.00	275.00	201.00	12712
21	Lower Bhawani	46.42	250.28	109.87	156.29	334.77	266.16	627.39
22	Bhavani s.b.r.area	21.59	138.72	51.12	72.71	0.00	123.83	0.00
Total Bhavani sub-basin		68.01	389	160.99	229	334.77	389.99	627.39
23	Noyil s.b.	58.24	208.79	189.00	252.00	0.00	441.00	0.00
24	Amaravathi	10.04	66.68	20.88	30.91	159.86	51.79	0.00
25	Amaravathi s.b.r.area	89.03	336.11	185.12	274.09	0.00	459.21	0.00
Total Amaravathi s.b.		99.07	402.79	206.00	305.00	159.86	511.00	0.00
26	Tirumanimuttar s.b.	418.46	2728.5	370.00	530.00	0.00	900.00	0.00
27	Ponnai Ar s.b.	26.44	693	113.00	155.00	0.00	268.00	0.00
28	Upper Coleroon s.b.	45.02	578.7	90.00	130.00	0.00	220.00	0.00
29	Lower Coleroon s.b.	10.97	536.00	63.00	83.00	0.00	146.00	0.00
30	Cauvery Delta s.b.	294.71	3475.00	349.00	461.00	0.00	810.00	0.00

Table 6.8.1: Daily Dietary Allowances

Age group	Requirement of male		Requirement of female	
	Proteins	Calories	Proteins	Calories
(1)	(2)	(3)	(4)	(5)
0 to 9 years	42.00	1500	42.00	1500
10 to 19 years	83.33	2600	73.33	2133
20 to 39 years	65.00	3000	60.00	2200
40 to 59 years	65.00	2800	60.00	2100
Above 60 years	65.00	2500	60.00	2000

The agricultural population projected for year 2050 in the command of major reservoirs in Cauvery River Basin is presented in Table 6.9.2 as below.

Table 6.8.2: Agricultural Population in the Command of Major Reservoirs in Cauvery River Basin

Sl. No.	Name of reservoir	CCA (Ha)	Agricultural Population (Nos.)
(1)	(2)	(3)	(4)
1	Hemavathi	265079	993907
2	Yagachi	21450	80445
3	Harangi	53,538	200739
4	KRS	1,13,603	425951
5	Cauvery	44,500	151854
6	Kabini	45,730	549034
7	Sagar Doddakere	1,700	126375
8	Taraka	19,300	270135
9	Nugu	10,526	485882
10	Mananthyadi	22,50	270135
11	Banasursagar	9,200	126375
12	Upper Nugu dam	40,470	20410
13	Mettur	18212	693044
14	Lower Bhavani	95,175	1426764
15	Amaravathi	10,118	1827334

The population projection in terms of age group and sex as obtained from the population projection for India, 1981-2001 and shown in Table 6.8.3 is used for the present analysis.

Table 6.8.3: Population Projection in India in Terms of Age Group and Sex

Age group	Male (%)	Female (%)
(1)	(2)	(3)
	100	100
0 to9 years	21.42	21.44
10 to 19 years	20.23	20.20
20 to 39 years	33.16	32.51
40 to 59 years	17.69	18.48
Above 60 years	7.50	7.37

The average per day requirement of Proteins and calories for males and females are worked out separately by using the weighted average method. The male female ratio is used to obtain the weighted average of protein and calorie requirement on a per capita per day basis. The male female ratio of 931 females per 1000 males for Cauvery river basin gives a percentage of 53.45% males and 46.55% females. The computations for obtaining per capita per day requirement of calorie and protein are shown below:

A) Calorie requirement

(i) Weighted average of calorie requirement for males

$$= [(21.42 * 1500) + (20.23 * 2600) + (33.16 * 3000) + (17.69 * 2800) + (7.5 * 2500)] / 100$$

= 2524.90 calorie units

(ii) Weighted average of calorie requirement for females

= [(21.42 * 1500) + (20.23 * 2133) + (32.51 * 2200) + (18.48 * 2100)

+ (7.37 * 2200)] / 100

= 2003.17 calorie units

The combined weighted average calorie requirement per capita per day for the whole population shall be

= [(53.45*2524.90) + (46.55*2003.17)]/100

= 2282 calorie units

B) Protein requirement

(i) Weighted average of protein requirement for males

= [(21.42 * 42) + (20.23 * 83.33) + (33.16 * 65) + (17.69 * 65)

+ (7.5 * 65)] / 100

= 63.78 grams

(i) Weighted average of protein requirement for females

= [(21.42 * 42) + (20.20 * 73.33) + (32.51 * 60) + (18.48 * 60)

+ (7.37 * 60)] / 100

= 58.83 grams

The combined weighted average calorie requirement per capita per day for the whole population shall be:

= [(53.45 * 63.78) + (46.55 * 58.33)] / 100

The calculations done for all the remaining projects being similar except for minor difference in the male female ratio (number of females per 1000 males), are not shown here.

Crop produce requirement per capita per day:

The protein and calorie content of different crops as obtained from Ghei and Ghei (1973) and Thaper (1981) are shown in Table 6.8.4.

Table 6.8.4: Protein and Calorie Content of Different Crops

Crop	Proteins (Grams/Kilogram)	Calories (Units/Kilograms)
(1)	(2)	(3)
Paddy	75	3460
Maize (HY)	111	3420
Jowar (HY)	104	3490
Soyabeen	432	4320
Red Gram	223	3350
B Gram	240	3470
Vegetables (K)	40	800
Wheat	121	3410
Gram	121	3600
Linseed (Alsi)	203	5300
Peas	197	3150
Ground nut	315	5610
Vegetables (R)	40	800

Table 6.8.5(a): Per Capita per Day Crop Produce to Satisfy the Nutritional Requirements for the Population in the Command of Major Projects

Crop	Crop produce required (Kg per capita per day)	Protein content of crop (Grams/Kg)	Calorie content of crop (Units/Kg)	Proteins (per capita per day) Grams)	Calories (per capita per day) (Units)
(1)	(2)	(3)	(4)	(5)	(6)
Paddy	0.15	75	3460	11.25	519
Jowar/Ragi	0.075	104	3420	7.8	256.5
Groundnut	0.06	315	5610	18.9	336.6
Vegetables	0.25	40	800	10	200
Wheat	0.095	121	3410	11.495	323.95
Gram	0.12	121	3600	14.52	432
Peas	0.25	40	800	10	200
			Total	101.37	2686.5

The cropping patterns suggested by NWDA are considered, and taking into account the average food habits of people, the per capita per day crop produce for each food crop is decided so as to fulfill the per capita per day nutritional requirement (proteins and calories) of the population. The calculations are shown in Table 6.8.5(a). The calculated per capita per day requirements of crops should give a higher per capita per day nutritional (protein and calorie) content than the per capita per day nutritional requirement obtained as per the daily dietary allowances. Computation of crop production to meet the minimum food requirement of agricultural population is given in Table 6.8.5(b).

6.8.3 Water Requirements to Meet the Minimum Food Requirements

The average yield of crops per unit area (hectare) is obtained from the data available in the Agricultural Statistics by Narmada Planning group (1989). As Narmada river basin being near to Cauvery river basin the easily available data is used. The crop coefficients (depicting the proportion of crop produce to the yield of crop) are considered for crops such as paddy and groundnut to decide the crop produce (on an average one quintal of paddy gives 66.0 Kilograms of milled rice, and one quintal of groundnut gives 70Kilograms of groundnut seed). The area of a crop to be brought under cultivation for meeting the crop produce requirement of each crop is worked out on an annual basis for the agricultural population in the command of each major reservoir. The average field water requirements (depth in m) of individual crops in the respective sub-basins are used to work out the annual water requirement for each crop. The summation of all the crops gives the annual field water requirements sufficient to fulfill the minimum food requirements of the agricultural population in the command area of each major reservoir. The computed values are shown in Table 6.8.6.

Table 6.8.5(b) : Computation of Crop Production to Meet the Minimum Food Requirement of Agricultural Population

Name of crop	Upper Cauvery Sub-basin							
	(1) Hemavathi		(2) Yagachi		(3) Harangi		(4) KRS	
	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement
	Ha	Quintals	Ha	Quintals	Ha	Quintals	Ha	Quintals
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
kh.Paddy	281.7	1491	22.8	121	56.9	301	120.7	639
kh.Jowar	93.4	745	7.6	60	18.9	151	40.0	319
kh.Ragi	200.2	745	16.2	60	40.4	151	85.8	319
Total		2982		241		602		1278
Pulses	90.4	298	7.3	24	18.2	60	38.7	128
Fruits & veg.	24.8	2485	2.0	201	5.0	502	10.6	1065
Ground nut	160.1	596	13.0	48	32.3	120	68.6	256

Name of crop	Kabini Sub-basin							
	(6) Banasurasagar		(7) Mananthvady		(8) Kabini		(9) Taraka	
	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement
	Ha	Quintals	Ha	Quintals	Ha	Quintals	Ha	Quintals
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
kh.Paddy	35.81	190	76.55	405	155.59	824	33	174
kh.Jowar	11.88	95	25.39	203	51.60	412	22	174
kh.Ragi	25.45	95	54.40	203	110.57	412	19	70
		379		810		1647	21	417
Pulses	11.49	38	24.56	81	49.91	165	1	5
							0	
Ground nut	20.36	76	43.52	162	88.46	329		0
Fruits & veg.	3.16	316	6.75	675	13.73	1373	1.39	139

Table 6.8.5(b) (Contd….)

Name of crop	(10) Sagerdoddakere		(11) upper Nugu		(12) Nugu		(5) Cauvery	
	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement
	Ha	Quintals	Ha	Quintals	Ha	Quintals	Ha	Quintals
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
kh.Paddy	31.30	166	5.78	31	137.70	729	43.0	228
kh.Jowar	10.38	83	1.92	15	45.67	364	14.3	114
kh.Ragi	22.25	83	4.11	15	97.85	364	30.6	114
		331		**61**		**1458**		**456**
Pulses	10.04	**33**	1.86	6	44.17	**146**	**13.8**	**46**
							0	
Ground nut	17.80	66	3.29	12	78.28	**292**	**3.8**	**380**
Fruits & veg.	2.76	**276**	0.51	**51**	12.15	**1215**	**24.5**	**91**

Name of crop	(13) Mettur		(14) Bhavani		(15)Amaravathi	
	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement	Crop area to meet min. food requirement	Crop production to meet min. food requirement
	Ha	Quintals	Ha	Quintals	Ha	Quintals
(1)	(2)	(3)	(4)	(5)	(6)	(7)
kh.Paddy	196.4	1040	404.3	2140	517.9	2741
kh.Jowar	65.1	520	134.1	1070	171.7	1371
kh.Ragi	139.6	520	287.3	1070	368.0	1371
		2079		**4280**		**5482**
Pulses	**63.0**	208	**129.7**	428	**166.1**	548
Ground nut	**17.3**	1733	35.7	3567	45.7	4568
Fruits & veg.	**111.7**	**416**	229.9	856	**294.4**	**1096**

Table 6.8.6: Crop Produce, Yields and Crop Water Requirements

	Name of Crop	Crop produce required Qtl per Capita per day	Yield of crop (Qtl. / ha)	Field water Requirement of crop (m)
1	2	3	4	5
Cereals	Kharif Paddy	0.0015	5.293	0.482
	Kharif Jowar	0.00075	7.980	0.152
	Kharif Ragi	0.00075	3.724	0.152
Pulses	Pulses	0.00030	3.300	0.306
Oil seed	Ground nut	0.00060	3.724	0.102
Fruits & vegetables	Fruits & veg.	0.00250	100	0.761

COMPUTATION AND RESULTS OF LINEAR PROGRAMMING MODEL

7.1 GENERAL

A linear programming model for Cauvery river basin has been developed in Chapter 5. This model has constraints based on continuity equation of reservoir sites, total release from the reservoir, projectwise and sub-basinwise irrigation, domestic water supply for rural human population, live stock and urban population from surface and ground water, industrial use, hydropower, and environmental use, exports and imports from irrigation projects, regeneration from irrigation, domestic and industrial water use, availability of surface and ground water, land use and crop water requirements, hydro electric energy and some design constraints according to the interim award of Cauvery Water Dispute Tribunal (CWDT), about the water sharing among the co-basin states, i.e., Karnataka, Kerala, Tamilnadu and Pondicherry. The characteristics of the Cauvery river system and interim award of CWDT, under taken for this study and the data required for this purpose are given in Chapter 3.

The data such as inflows to reservoirs and sub-basins, capacities of reservoirs and canals, monthly water requirements and time period for each crop, projectwise cultivable command area (CCA), percentage CCA of each crop for each project and each sub-basin, availability of surface water were collected from various technical reports of National Water Development Agency (NWDA), New Delhi, a autonomous body under the Ministry of Water Resources, Government of India as given in the list of references and the data about ground water availability was collected from the report of Ground Water Resources of India (1995), published by Central Ground Water Board, under the Ministry of Water Resources, Government of India, Faridabad. Some additional constraints were added in the model, in terms of sharing of river water and limiting its use under numerous techno-economic and management constraints pertaining to CWDT, and the detailed modeling of many more site specific hydrological/physical constraints of the problem. In addition certain data have been computed from available information in Chapter-6. It includes the computation of various coefficients such as reservoir evaporation coefficients, computation of percent annual water use for irrigation and water supply from each site and sub-basin, monthly percent of export and imports for each project and sub-basin, estimation of flows of various annual water year dependabilities and computation of ground water availability for each project and sub-basin from the district wise ground water data available from publication, ground water resources of India published by Central Ground Water Board (CGWB) under the Ministry of Water Resources, Government of India, Faridabad, (1995).

The mathematical formulation of linear programming model has 3650 constraints. Out of these 3578 are equalities, 60 are of less than or equal to type, and 12 are greater than or equal to type. The number of unknown decision variables are 1000 which includes variables relating to crop area, reservoir storage, reservoir releases and spills, diversion of water for irrigation and water supply, capacity of reservoirs, upstream and downstream annual irrigation and water supply, ground water use. Models of many practical problems under investigation in water resources development programmes may be generally solved on personal computers using simplex-based algorithms.

In this research work the readily available LINDO package of 6.1 version released in August 2001, by LINDO Systems, Inc. 1415 North Dayton St. Chicago, IL, USA, having the maximum capacity of 4000 constraints and 8000 variables with 100 integer variables and 2000000 non zeros, was used to solve the LP model problem, as there are many constraints and variables to handle such a big problem.

7.2 COMPUTATION OF LP MODEL

The computations were carried out for various water year dependable flows representing a normal, dry and wet years. These were calculated using flow–duration analysis of annual (water year) flows. These were: (i) 75% water year dependable flow representing a water year for water sharing under normal condition as per the interim award of Cauvery Water Dispute Tribunal (CWDT), (ii) 90% water year dependable flow representing a water deficit year, (iii) 100% water year dependable flow resenting a critical water deficit year, and (iv) 50% water year dependable flow representing a water surplus year. The model constraints were written for NT = 12 months because the computations were done over one year interval only.

In the LP model, constraints were written only for one year. Computation of LP model has been done on the basis of monthly flows, using 50%, 75%, 90% and 100% water year dependable flows. The reservoir storage at the end of year (June to May) was taken to be same as at the beginning of the same year, i.e., $S_{i,12} = S_{i,0}$, assuming no over the year carry over storages in reservoirs. The return flows from irrigation and water supply and industrial water uses were taken as 10% to 20%, 80% and 80% respectively, as per norms of NWDA.

All the values of $\bar{I}_{i,t}$, $P_{i,t}$ and $O^{m}_{i,j,t}$ in equation (3) were taken as zero. Based on the CWDT some additional constraints on various design variables were added in terms of either upper bounds or limiting their values. In this chapter, we briefly review as to how far we have succeeded in this effort, i.e., an attempt made to add additional constraints in the model as per the CWDT award and analyzing the results by applying the LP model developed in Chapter 5 to Cauvery river basin.

As the first objective function of the problem is for, maximization of annual water utilization for irrigation, water supply, industrial, hydropower and environmental uses from surface water and ground water, the model was first run for 75% water year dependable flow. The model was run for each project in parallel separately, without consideration of the contribution from the upstream project within a sub-basin, and then it was combined at a sub-basin level with consideration of the contribution of inflows from the projects in series and for remaining area.

In the Upper Cauvery sub-basin, there are five irrigation projects, in Kabini sub-basin, there are seven irrigation projects and in Chinnar, Bhavani and Amaravathi sub-basins there is one project in each sub-basin. In other sub-basins there are no major irrigation projects. For such sub-basin, having no major irrigation project, the LP model is run as a single model for that sub-basin as a whole at the end point of the sub-basin. Then combining all the models for each sub-basin, a single model for Cauvery river basin as a whole is obtained with consideration of the sub-basins in parallel or in series for contribution of inflows from upper irrigation projects and the upper sub-basins in series.

The computational methodology for LP model run for the whole Cauvery river system is explained below, with a simple example of Upper Cauvery sub-basin with details of what exactly is the configuration for which LP model is run. The input data where exact possible mentioning the notations used in LP model is given in Chapter 6. The list of output decision variables, resulting from model are given in Table 6.6.2.

The methodology adopted while running the LP model at a project level, a sub-asin level and Cauvery basin as a whole level as follows:

1. Select the upper most sub-basin, i.e., Upper Cauvery in the Cauvery basin.
2. Analyze each major reservoir one-by-one in Upper Cauvery sub-basin Fig.3.3.1, as follows:
    (a) Analyze Yagachi as an independent reservoir.
    (b) (i) Analyze downstream Hemavathi as an independent reservoir without any regulated contribution from upstream Yagachi reservoir.
    (ii) Analyze downstream Hemavathi reservoir in series with upstream Yagachi reservoir with regulated contribution Yagachi.
    (c) Analyze Harangi as an independent reservoir.
    (d) Analyze Cauvery as an independent reservoir.
    (e) (i) Analyze downstream KRS as an independent reservoir without any regulated contribution from upstream reservoirs mentioned as above.
    (ii) Analyze downstream KRS in series with upstream reservoirs with regulated contributions from upstream Hemavathi, Harangi and Cauvery reservoirs. Thus analyzing the entire Upper Cauvery sub-basin as as an one entity.

(3) Like in step-2, all the sub-basins having major reservoirs are first analyzed as individual sub-basins.

(4) Whole sub-basin not having any major reservoir is analyzed assuming that all the water is being utilized at the end of the sub-basin.

(5) Lastly, ~~all the 16 sub-basins are combined together and the entire Cauvery basin is analyzed as a whole.~~ a basinwide model run was made for entire Cauvery basin.

According to the interim award of Cauvery Water Dispute Tribunal (CWDT), 205 TMC ft (5800 MCM) of water is to be released to Tamilnadu state at Mettur, the 13th reservoir in the 8th sub-basin from the upstream reservoirs in Karnataka state, and its monthwise releases are also maintained in the interim award. Firstly, to run the model the annual export of water from Mettur was taken, equal to the CWDT value of 5800 MCM through Mettur reservoir and monthly exports were taken as per the monthly quantities maintained in CWDT. Then the model was run by changing the export quantities from Mettur to the sub-basins below Metter as less than and greater than the 5800 MCM, to check the effect on upstream and downstream irrigation and water supply in the sub-basins above and below of Mettur reservoir. The export quantities taken for running the model were 4200MCM, 6200 MCM and the highest maximum possible values for various dependabilities flows were found out as 6700 MCM, 6900MCM, 7200 MCM and 7800 MCM in case of 100%, 90%, 75% and 50% water year dependable flows, respectively. Hence the upper bound or limiting the values of monthly releases were taken in the proportion of the monthly quantities of export maintained in CWDT. These include upper bound and equal values on monthly irrigation diversions through Mettur, equal to bounds on capacities of reservoirs and canals, and mixed bounds on ground water availability and uses, annual downstream and upstream irrigation, domestic (rural, urban and live stock population water requirements) and industrial water uses, exports. Then the model was run on the basis of monthly flows, of 50%, 90% and 100% water year dependabilities. The results of LP model for Cauvery river basin for 75%, 50%, 90%, and 100% water year dependable flows are presented in this chapter. While running the LP model for Cauvery river basin, the following points are observed and the steps taken while running the model are given as below.

7.2.1 Sample Computational Steps (for Kabini Sub-Basin)

The following steps are taken while running the model for Kabini sub-basin with all major projects and remaining area for improvements of objective function values so as to make the system efficient for irrigation and water supply use

Step (1): The locations of medium irrigation schemes in the catchments area of major projects are available but the details of locations for minor irrigation schemes in the catchment area of major projects are not available hence the utilization of minor irrigation schemes was distributed on the proportion of catchment area basis of the major projects.

But the model results were not satisfactory in the sense that the system targets met were much away from the plan proposals. Hence the minor irrigation utilization of the sub-basin was redistributed as per the state wise utilization of minor irrigation schemes data available in NWDA reports of Cauvery basin, in the proportion of catchment areas of the respective state wise projects.

Step (2): (a) The inflow data for the major projects were taken from the salient features of the respective major projects, as per the yield availability data at the time of preparation of project reports by the respective state governments and was distributed in the proportion of monthly inflows of water balance studies of sub-basin with and without ground water, but the total sum of individual projects was not tallying to the total water available in water balance studies of the sub-basin.

Step (2): (b) Then the rainfall data is taken from the nearest rain-gauge stations of the respective major projects of 75% water year dependable flow and multiplied by the catchment area of the respective projects for getting the monthwise run-off or monthwise inflows available at the respective major projects. The data was taken from the basic data booklet of the Kabini sub-basin prepared by NWDA.

Inflows for the remaining area is kept equal to the water demands of urban and industrial water requirements for remaining area and balance inflows (i.e. in flow calculated in step 2(a)- Urban and industrial water requirements) from the remaining area is distributed to upstream major projects in the proportion of the catchment areas of the upstream major projects and added to flows in step 2(a)

Step (3): Initially satisfactory results were not obtained as the model was utilizing water for irrigation, only from ground water and not from surface water. Further modifications were made while running the model was that the spills for Banasursagar project were kept equal to zero for each month in Banasursagar project. Then the results were improved.

Case (1): The proposed export quantity of 495.50 MCM was reduced to 400 MCM from the ongoing Manathvady multipurpose project to get a feasible solution from the model.

Case (2): Flow pattern was changed and was taken as per the average month wise inflows of Manathvady and Banasursagar, keeping the annual rainfall values the same.

Case (3): Number of trials were made while running the model by changing the storage capacities of Nugu and Sagar Doddakere project for various alternatives but values of the objective functions were not improved hence,

Case (4): Further modification for model was made by increasing the storage capacity of Kabini project-I from the existing storage capacity of 453 MCM to 610 MCM, the value of objective function was increased from 1464.27 MCM to 1683.60 MCM, with a very good and satisfactory results for utilization of water for irrigation and water supply from all the major projects in the Kabini sub-basin. But for final results of the model the capacity of the Kabini project is kept as per its designed capacity and the final results of the LP model are obtained and presented in this chapter.

Assumptions :

The following observations were found while running the optimization LP model for the Cauvery river basin.

(1) The changes were done while running the model that the exports from the various major irrigation project / sub-basins were taken in the proportion of monthly irrigation requirements of the importing sub-basins instead of exports in the monthly water availability in the exporting sub-basins

(2) The main Cauvery river bifurcates at Grand anicut into Upper Coleroon and Cauvery Delta, the total discharge of river is considered as 60% and 40% to Cauvery delta and Upper Coleroon sub-basins respectively.

(3) Model was checked by running as per the monthly releases as per the interim award of Cauvery Water Dispute Tribunal and it also was checked for the

values greater than and less than the values of tribunal award and it was also observed that what is the effect on upstream and downstream of the Mettur dam, to fulfill the various requirements of irrigation and water supply to the sub-basins below Mettur reservoir.

(4) The environmental requirements were considered as 1% of the monthly inflows in the sub-basins and regeneration from irrigation was considered as 10% to 20% as per age consideration of the dams, of net irrigation requirements at field level and 80% from domestic and industrial water requirements.

(5) Ground water utilization was considered as 100% and the available ground water was calculated from data collected from the Central Ground Water Board (CGWB), Faridabad, India. It was calculated in proportionate area basis of the districts in the catchments of each sub-basin.

(6) For 75% water year dependable flows, the monthly distribution of export from Mettur for 4200 MCM annual value was take as less than or equal to the monthly values of tribunal award but in the results the values in the month of June, January, February and April were taking equal to zero hence 4200 MCM value was distributed in the proportion of, the values of monthly releases as per interim award of Cauvery Water Dispute Tribunal's Award (CWDT).

(7) For 75% water year yield for 4200 MCM, 5800 MCM, 6200 MCM and 7200 MCM export from Mettur to the sub-basins below Mettur reservoir, in the proportion of, the values of monthly releases as per interim award of Cauvery Water Dispute Tribunal's Award (CWDT).

(8) Changes observed in the values of utilization in case of 7200 MCM:

(a) Above Mettur: In case of Nugu reservoir down stream irrigation changes from 137 to 440 MCM.

(b) Below Mettur: In case of Noyil sub-basin utilization for irrigation is equal to zero.

The results obtained by running the LP model for Cauvery basin as a whole with 50%, 75%, 90% and 100% water year dependable flows with various export quantities of 4200 MCM, 5800 MCM, 6200 MCM, 6700 MCM, 6900 MCM and 7200 MCM, are presented in Tables 7.1.1 to 7.1.4, respectively.

7.3 RESULTS OF LP MODEL FOR 75% WATER YEAR DEPENDABLE FLOW (A NORMAL YEAR) (FOR MAXIMIZATION OF WATER UTILIZATION)

Based on the steps as given in Section 7.2.1, the model was first run by using 75% water year dependable flow. The results of LP model for Cauvery river basin as a whole are presented in Tables 7.1.1(a) to 7.1.1(d). The results of LP model for the values of other design variables and exporting quantity of 4200 MCM, 5800 MCM, 6200 MCM, and 7200 MCM, from Mettur reservoir to the downstream sub-basins below Mettur reservoir, respectively, are presented in Tables 7.1.1(a), 7.1.1(b), 7.1.1(c), and 7.1.1(d). As per the NWDA reports, the maximum designed exports from Mettur reservoir to the sub-basins below the Mettur reservoir and out side of Cauvery basin is found 12712 MCM. But as per LP model, the maximum possible quantity of exports from Mettur to the downstream sub-basins and out of basin, at 75% water year dependable flow was found equal to 7200 MCM. As per NWDA the export value from the Mettur reservoir is given as 12712 MCM, while from the results of LP model the maximum export of 7200 MCM only is possible. The final combined results all the 16 cases of model running with 75%, 90%, 100% and 50% water year dependable flows with 7200 MCM, 6200 MCM, 4200 MCM, and 7800 MCM exports from Mettur reservoir are presented in Table 7.1.5(a) to Table 7.1.5(c).

7.4 RESULTS OF LP MODEL FOR 90% WATER YEAR DEPENDABLE FLOW (A WATER DEFICIT YEAR) (FOR MAXIMIZATION OF WATER UTILIZATION)

The model was run for Cauvery river basin for 90% water year dependable flow. The results are presented in Tables 7.1.2(a) to 7.1.2(d). The Tables 7.1.2(a), 7.1.2(b), 7.1.2(c), and 7.1.2(d) for the values of other design variables and exporting quantity of 4200 MCM, 5800 MCM, 6200 MCM, and 6900 MCM from Mettur reservoir to the sub-basins below Mettur reservoir, respectively. As per the NWDA reports, the maximum designed exports from Mettur reservoir to the sub-basins below the Mettur reservoir and out side of Cauvery basin is found 12712 MCM. But as per LP model, the maximum possible quantity of exports from Mettur to the downstream sub-basins and out of basin, at 90% water year dependable flow was found equal to 6900 MCM. The final combined results all the 16 cases of model running with 75%, 90%, 100% and 50% water year dependable flows with 7200 MCM, 6200 MCM, 4200 MCM, and 7800 MCM exports from Mettur reservoir are presented in Table 7.1.5(a) to Table 7.1.5(c).

7.5 RESULTS OF LP MODEL FOR 100% WATER YEAR DEPENDABLE FLOW (A CRITICAL WATER DEFICIT YEAR) (FOR MAXIMIZATION OF WATER UTILIZATION)

The model was run for the Cauvery river basin using 100% water year dependable flow. The results are presented in Tables 7.1.3(a) to 7.1.3(d). The Tables 7.1.3(a), 7.1.3(b), 7.1.3(c), and 7.1.3(d) for the values of other design variables and exporting quantity of 4200 MCM, 5800 MCM, 6200 MCM, and 6700 MCM from Mettur reservoir to the downstream sub-basins below Mettur reservoir respectively. As per the NWDA reports, the maximum designed exports from Mettur reservoir to the sub-basins below the Mettur reservoir and out side of Cauvery river basin was found 12712 MCM. But as per LP model, the maximum possible quantity of exports from Mettur to the downstream sub-basins and out of basin, at 100% water year dependable flow was found equal to 6700 MCM. The final combined results all the 16 cases of model running with 75%, 90%, 100% and 50% water year dependable flows with 7200 MCM, 6200 MCM, 4200 MCM, and 7800 MCM exports from Mettur reservoir are presented in Table 7.1.5(a) to Table 7.1.5(c).

7.6 COMPUTATION OF LP MODEL FOR 50% WATER YEAR DEPENDABLE FLOW (A WATER SURPLUS YEAR) (FOR MAXIMIZATION OF WATER UTILIZATION)

The model was run for the Cauvery river basin for 50% water year dependable flow. The results are presented in Tables 7.1.4(a) to 7.1.4(d). The Tables 7.1.4(a), 7.1.4(b), 7.1.4(c), and 7.1.4(d) for the values of other design variables and exporting quantity of 4200 MCM, 5800 MCM, 6200 MCM, and 7800 MCM from Mettur reservoir to the sub-basins below Mettur reservoir, respectively. As per the NWDA reports, the maximum designed exports from Mettur reservoir to the sub-basins below the Mettur reservoir and out side of Cauvery basin was found 12712 MCM. But as per LP model, the maximum possible quantity of exports from Mettur to the downstream sub-basins and out of basin, at 50% water year dependable flow *was* found equal to 7800 MCM. The final combined results all the 16 cases of model running with 75%, 90%, 100% and 50% water year dependable flows with 7200 MCM, 6200 MCM, 4200 MCM, and 7800 MCM exports from Mettur reservoir are presented in Table 7.1.5(a) to Table 7.1.5(c).

7.7 COMPUTATION OF LP MODEL RESULTS WITH CROP CONSIDERATIONS

The LP model was run for the objective functions given by equations 5.2.1-II, 5.2.2, 5.2.3 and 5.2.4, with crops being considered as the decision variables in the model, and the results were obtained for all the objectives for analysis, only for the

75% annual dependable flow. The model runs were made at the individual project/site level, i.e., for all the 15 major projects in the Cauvery river system. The surface water contribution as diversions for irrigation from a reservoir, were made available from the LP model results in Section 7.3. Similarly, the ground water contributions towards irrigation were also obtained from the results in Section 7.3. The model was run for monthly time periods on an annual basis. The results are given in Tables 7.2.1 to 7.2.16.

7.8 HYDROPOWER COMPUTATION

The efficiency for energy generation is assumed to be 85% with a hydropower plant factor of 0.6 for all periods in a year. The values of heads for energy generation are computed externally by independent computer programs using the storage elevation curve for each of the multipurpose hydropower reservoirs (i.e., Kabini, Banasurasagar, Mananthvady and Mettur). At variable head sites, average storage head was determined by trial and error.

The nonlinear constraint equation 5.3.11.1 was linearized by assuming an effective head and comparing it with the head specified in the model solution. The values of productive heads are to be substituted externally into the model and are varied after obtaining the solution because of the nonlinear nature of the hydropower generation equation. The parameters used in hydropower energy computations are given in Table 7.3.1. The process was repeated till the reservoir storages obtained are equivalent to the values of heads and the annual system hydropower values get stabilized. The results are given in Tables 7.3.2 to 7.3.5.

Table 7.1.1(a): Results of LP Model for 75% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 4200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.9	25.68	18.08	43.76	10.96	16.84	27.8	11.69	71.33	83.02	0	118.45	42.03	160.48
2	Hemavathi	5.02	5.02	10	13.8	23.9	92.21	148.30	240.5	44.34	68.11	112.5	144.41	84.26	228.7	1134	1484.03	255.5	1739.5
3	Harangi	1.24	1.24	2.48	3.42	5.9	18.22	21.39	39.61	10.96	16.84	27.8	29.17	219.2	248.4	0	269.62	52.05	321.67
4	Cauvery	0.625	0.625	1.25	1.72	2.97	12.90	9.44	22.34	5.51	8.46	13.97	24.24	389.1	413.3	0	413.14	39.49	452.63
5	KRS	15.85	15.85	31.7	43.6	75.3	130.0	634.21	764.2	139.9	214.9	354.8	0	0	0	1506	2510.87	189.5	2700.3
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**831**	**1110**	**212**	**325**	**537**	**210**	**764**	**973**	**2640**	**4796**	**578**	**5375**
6	Banasursagar	0.2	0.2	0.4	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.2	2.09	64.31	66.4	189	257.71	4.09	261.8
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	139.65	146.7	4.46	6.18	10.64	0.00	0.00	0	276.0	426.80	8.235	435.03
8	Kabini	6.27	6.27	12.5	8.79	21.3	88.51	530.40	618.9	55.23	76.56	131.8	6.6	849.4	856	202	1719.86	110.2	1830
9	Taraka	0.9	0.9	1.8	1.26	3.06	1.24	0.00	1.24	7.94	11	18.94	4.89	153	157.9	0	172.82	8.29	181.11
10	Sagardoddakere	0.6	0.6	1.2	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.5	44.70	82.17	126.9	27.26	37.78	65.04	9.88	430.1	440	290	870.41	62	932.41
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	195	196.9	0	197.48	2.29	199.77
13	Kabini s.b.r.area	11.32	11.32	22.6	15.6	38.3	134.5	327.77	462.25	99.07	137.3	236.4	0	0	0	99	674.50	161.4	835.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**1080**	**1362**	**202**	**280**	**482**	**26**	**1715**	**1741**	**1151**	**4451**	**363**	**4814**
14	Shimsha.	26.5	26.5	53	62	115	506.0	294.7	1000.7	233.0	348.0	581.0	0.00	0	0	0.00	902.19	594.5	1496.7
15	Arkavathi	48.5	48.5	97	32	129	22.5	30.3	52.8	155.0	0.0	155.0	0.00	0	0	0.00	233.80	103	336.8
16	Middle Cauvery	8.5	8.5	17	18	35	178.5	2010.0	2188.5	74.0	109.0	183.0	0.00	0	0	14.00	2215.47	205	2420.5
17	Suvarnavathi	3.5	3.5	7	24	31	36.40	0.00	36.40	32.00	33.00	65.00	0.00	0	0	0.00	68.50	63.9	132.4
18	Palar	11.6	11.6	23.2	21	44.2	100.5	20.80	121.30	11.00	10.00	21.00	0.00	0	0	0.00	53.40	133.1	186.52
19	Chinnar s.b.r.area	8.855	8.855	17.7	27.2	44.9	124.6	82.97	207.60	0.00	0.00	0.00	0.00	0	0	0.00	91.83	160.7	252.54
20	Mettur	0	0	0	0	0	0.00	0.00	0	78.00	123.0	201.0	0.00	275	275	4200.00	4676.00	0	4676
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**83**	**208**	**78**	**123**	**201**	**0**	**275**	**275**	**4200**	**4768**	**161**	**4929**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**4350**	**6080**	**997**	**1228**	**2225**	**236**	**2754**	**2990**		**9483**	**2202**	**19690**

Table 7.1.1(a) continued...

Table 7.1.1(a) continued...

Table 7.1.1(a): Results of LP Model for 75% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 4200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhavani	12.44	12.44	24.88	21.54	46.42	84.20	250.28	334.48	109.9	156.3	266.2	0.00	334.8	334.77	0	863.66	118.18	981.84
22	Bhavani s.b.r.area	5.785	5.785	11.57	10.02	21.59	43.79	138.72	182.51	51.12	72.71	123.8	0.00	0	0	408	676.33	59.595	735.93
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**390**	**0**	**335**	**335**	**408**	**1540**	**178**	**1718**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	123	0.00	123	0.00	0.00	0	0.00	130.96	32.29	163.25
24	Amaravathi	2.365	2.365	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	51.79	13.76	198.5	212.26	0.00	295.80	44.965	340.77
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.6	400.32	537.962	185	274.1	459.2	0.00	0.00	0.00	0.00	880.51	205.69	1086.20
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**443**	**605**	**206**	**305**	**511**	**14**	**199**	**212**	**0**	**1176**	**251**	**1427**
26	Tirumanimuttar	109.74	109.74	219.5	199	418.5	41.28	150.00	191.28	370.00	216.00	586.00	0.00	0.00	0.00	0.00	845.74	350	1195.74
27	Ponnai Ar	8.125	8.125	16.25	10.19	26.44	175.5	108.2	283.7	113.0	155.0	268.0	0.00	0.00	0.00	0.00	384.34	193.8	578.13
28	Upper Coleroon	10.745	10.745	21.49	23.53	45.02	180.0	630.7	810.7	90.0	130.0	220.0	0.00	0.00	0.00	0.00	861.40	214.28	1075.67
29	Lower Coleroon	3.05	3.05	6.1	4.87	10.97	105.0	536.0	641.0	63.0	83.0	146.0	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.815	80.815	161.6	133.1	294.7	11.1	3250.4	3261.5	349.0	461.0	810.0	0.00	0.00	0.00	0.00	4141.21	225	4366.21
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5510**	**6330**	**1475**	**1579**	**3054**	**14**	**533**	**547**		**9357**	**1557**	**10914**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**9860**	**12410**	**2472**	**2807**	**5279**	**250**	**3287**	**3537**		**18840**	**3759**	**30604**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE
(5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.1(b): Results of LP Model for 75% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 5800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	17.12	42.80	10.96	16.84	27.80	11.69	71.33	83.02	0	117.49	42.03	159.52
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	148.30	240.51	44.34	68.11	112.45	144.41	84.26	228.67	1134	1484.0	255.5	1739.49
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	17.26	35.48	10.96	16.84	27.80	29.17	209.2	238.36	0	255.49	52.05	307.54
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	9.44	22.34	5.51	8.46	13.97	24.24	389.1	413.35	0	413.14	39.49	452.63
5	KRS	15.85	15.85	31.69	43.60	75.29	130.01	664.05	794.06	139.92	214.90	354.82	0.00	0.0	0.00	1506	2540.71	189.5	2730.17
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**856**	**1135**	**212**	**325**	**537**	**210**	**753.9**	**963**	**2640**	**4811**	**578**	**5389**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	64.3	66.40	189	257.71	4.09	261.80
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	139.65	146.67	4.46	6.18	10.64	0.00	0.0	0.00	276.0	426.80	8.235	435.03
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	530.40	618.91	55.23	76.56	131.79	6.60	845.4	852.00	202	1715.86	110.2	1826.02
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	153.0	157.87	0	172.82	8.29	181.11
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.1	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	82.17	126.87	27.26	37.78	65.04	9.88	430.1	440.00	290	870.41	62	932.41
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	196.0	197.91	0	198.48	2.29	200.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.5	317.77	452.25	99.07	137.34	236.41	0.00	0.00	0.00	99	664.50	161.4	825.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**1070**	**1352**	**202**	**280**	**482**	**26**	**1712**	**1738**	**1151**	**4438**	**363**	**4801**
14	Shimsha.	26.50	26.50	53.00	62.00	115.0	506.0	274.7	1000.7	233.0	348.0	581.00	0.00	0.00	0.00	0.00	882.19	594.5	1476.69
15	Arkavathi	48.50	48.50	97.00	32.00	129.0	22.5	30.3	52.8	124.0	0.0	124.00	0.00	0.00	0.00	0.00	202.80	103	305.80
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.0	178.5	1510.0	1688.5	74.0	109.0	183.00	0.00	0.00	0.00	14.00	1715.47	205	1920.47
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.40	0.00	36.40	32	33	65.00	0.00	0.00	0.00	0.00	68.50	63.9	132.40
18	Palar	11.60	11.60	23.19	21.03	44.22	100.5	20.80	121.30	11.00	10.00	21.00	0.00	0.00	0.00	0.00	53.40	133.1	186.52
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.6	72.97	197.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	81.83	160.7	242.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	123.0	201.00	0.00	275.0	275.00	5800.0	6276.00	0	6276.00
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**73**	**198**	**78**	**123**	**201**	**0**	**275**	**275**	**5800**	**6358**	**161**	**6519**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**3835**	**5585**	**966**	**1228**	**2194**	**236**	**2741**	**2977**		**18529**	**2202**	**20731**

Table 7.1.1(b) continued...

Table 7.1.1(b) continued…

Table 7.1.1(b): Results of LP Model for 75% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 5800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.28	334.48	109.88	156.3	266.17	9.89	324.9	334.77	0	853.77	128.1	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.72	182.51	51.12	72.71	123.83	0.00	0.00	0.00	408	676.33	59.6	735.93
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**390**	**10**	**325**	**335**	**408**	**1530**	**188**	**1718**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	123.00	0.00	123.00	0.00	0.00	0.00	0.00	130.96	32.29	163.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	51.79	3.76	154.92	158.68	0.00	252.22	34.97	287.19
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	400.32	537.96	185.12	274.1	459.21	0.00	0.00	0.00	0.00	880.51	205.7	1086.20
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**443**	**605**	**206**	**305**	**511**	**4**	**155**	**159**	**0**	**1133**	**241**	**1373**
26	Tirumanimuttar	109.74	109.74	219.5	199.0	418.5	41.3	191.2	232.5	370.00	305.0	675.00	0.00	0.00	0.00	0.00	975.95	350	1325.95
27	Ponnai Ar	8.13	8.13	16.3	10.2	26.4	175.5	115.2	290.7	113.00	155.0	268.00	0.00	0.00	0.00	0.00	391.34	193.8	585.13
28	Upper Coleroon	10.75	10.75	21.5	23.5	45.0	180.0	630.7	810.7	90.00	130.0	220.00	0.00	0.00	0.00	0.00	861.40	214.3	1075.67
29	Lower Coleroon	3.05	3.05	6.1	4.9	11.0	105.0	536.0	641.0	63.00	83.00	146.00	0.00	0.00	0.00	0.00	685.05	112.9	797.97
30	Cauvery Delta	80.82	80.82	161.6	133.1	294.7	11.1	3350.4	3361.5	349	461.0	810.00	0.00	0.00	0.00	0.00	4241.21	225	4466.21
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5658**	**6478**	**1475**	**1668**	**3143**	**14**	**480**	**493**		**9541**	**1557**	**11097**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**9493**	**12063**	**2441**	**2896**	**5337**	**249**	**3221**	**3470**		**28070**	**3759**	**31828**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. .no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE
(5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.1(c): Results of LP Model for 75% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws^{'}_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir^{'}_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	17.12	42.80	10.96	16.84	27.80	11.69	71.33	83.02	0	117.49	42.03	159.52
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	148.30	240.51	44.34	68.11	112.45	144.41	84.26	228.67	1134	1484.03	255.5	1739.5
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	17.26	35.48	10.96	16.84	27.80	29.17	189.23	218.40	0	235.53	52.05	287.58
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	9.44	22.34	5.51	8.46	13.97	24.24	389.11	413.35	0	413.14	39.49	452.63
5	KRS	15.85	15.85	31.69	43.60	75.29	130.0	474.59	604.60	139.92	214.90	354.82	0.00	0.00	0.00	1506	2351.25	189.5	2540.7
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**667**	**946**	**212**	**325**	**537**	**210**	**734**	**943**	**2640**	**4601**	**578**	**5180**
6	Banasursagar	0.20	0.20	0.4	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	64.31	66.40	189	257.71	4.09	261.8
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	139.65	146.67	4.46	6.18	10.64	0.00	0.00	0.00	276.0	426.80	8.235	435.03
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	530.40	618.91	55.23	76.56	131.79	6.60	845.40	852.00	202	1715.86	110.2	1826
9	Taraka	0.90	0.90	1.8	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	141.98	146.87	0	161.82	8.29	170.11
10	Sagardoddakere	0.60	0.60	1.2	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	79.35	124.05	27.26	37.78	65.04	9.88	430.12	440.00	290	867.59	62	929.59
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	175.04	176.91	0	177.48	2.29	179.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.5	300.77	435.25	99.07	137.34	236.41	0.00	0.00	0.00	99	647.50	161.4	808.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**1050**	**1332**	**202**	**280**	**482**	**26**	**1680**	**1706**	**1151**	**4386**	**363**	**4750**
14	Shimsha.	26.50	26.50	53	62.00	115.00	506.0	254.69	1000.69	233.00	348.00	581.00	0.00	0.00	0.00	0.00	862.19	594.5	1456.7
15	Arkavathi	48.50	48.50	97	32.00	129.00	22.50	30.30	52.80	117.00	0.00	117.00	0.00	0.00	0.00	0.00	195.80	103	298.8
16	Middle Cauvery	8.50	8.50	17	18.00	35.00	178.5	1409.97	1588.47	74.00	109.00	183.00	0.00	0.00	0.00	14.00	1615.47	205	1820.5
17	Suvarnavathi	3.50	3.50	7	24.00	31.00	36.40	0.00	36.40	32	33	65.00	0.00	0.00	0.00	0.00	68.50	63.9	132.4
18	Palar	11.60	11.60	23.19	21.03	44.22	100.5	20.80	121.30	11.00	14.00	25.00	0.00	0.00	0.00	0.00	57.40	133.1	190.52
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.6	62.97	187.60	0.00	0.00	0.00	0.00	40.00	40.00	0.00	111.83	160.7	272.54
20	Mettur	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	78.00	123.00	201.00	0.00	275.00	275.00	6200.0	6676.00	0	6676
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**63**	**188**	**78**	**123**	**201**	**0**	**315**	**315**	**6200**	**6788**	**161**	**6949**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**3496**	**5265**	**959**	**1232**	**2191**	**236**	**2729**	**2965**		**18575**	**2202**	**20777**

Table 7.1.1(c) continued…

Table 7.1.1(c) continued...

Table 7.1.1(c): Results of LP Model for 75% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_g}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.28	334.48	109.88	156.29	145.29	9.89	324.88	334.77	0	732.89	128.1	860.96
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.72	182.51	51.12	72.71	182.59	0.00	0.00	0.00	408	735.09	59.6	794.69
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**280**	**10**	**325**	**335**	**408**	**1420**	**188**	**1608**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	123.00	0.00	161.00	0.00	0.00	0.00	0.00	168.96	32.29	201.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	153.91	3.76	154.92	158.68	0.00	354.34	34.97	389.31
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	336.11	473.75	185.12	274.09	294.97	0.00	0.00	0.00	0.00	652.06	205.7	857.75
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**379**	**540**	**206**	**305**	**490**	**4**	**155**	**159**	**0**	**1048**	**241**	**1288**
26	Tirumanimuttar	109.74	109.74	219.5	198.98	418.5	41.28	210.32	251.6	370.00	401.00	607.00	0.00	0.00	0.00	0.00	927.06	350	1277.1
27	Ponnai Ar	8.13	8.13	16.25	10.19	26.44	175.5	133.9	309.4	113.00	155.00	525.00	0.00	0.00	0.00	0.00	667.03	193.8	860.83
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.0	630.7	810.7	90.00	130.00	243.00	0.00	0.00	0.00	0.00	884.40	214.3	1098.7
29	Lower Coleroon	3.05	3.05	6.1	4.87	10.97	105.0	536.0	641.0	63.00	83.00	173.00	0.00	0.00	0.00	0.00	712.05	112.9	824.97
30	Cauvery Delta	80.82	80.82	161.6	133.08	294.7	11.1	3675.0	3686.1	349	461.00	524.00	0.00	0.00	0.00	0.00	4279.82	225	4504.8
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5956**	**6776**	**1475**	**1764**	**3003**	**14**	**480**	**493**		**9699**	**1557**	**11256**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**9452**	**12042**	**2434**	**2996**	**5194**	**249**	**3209**	**3458**		**28274**	**3759**	**32033**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. .no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE
(5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.1(d): Results of LP Model for 75% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir ≈ 7200 MCM														Exports	Water utilization		
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects									
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_e}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.9	25.68	17.12	42.80	10.96	16.84	27.80	11.69	71.33	83.02	0	117.49	42.03	159.52
2	Hemavathi	5.02	5.02	10.04	13.82	23.9	92.21	148.30	240.51	44.34	68.11	112.45	144.41	84.26	228.67	1134	1484.03	255.5	1739.49
3	Harangi	1.24	1.24	2.48	3.42	5.9	18.22	17.26	35.48	10.96	16.84	27.80	29.17	119.19	148.36	0	165.49	52.05	217.54
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	9.44	22.34	5.51	8.46	13.97	24.24	389.11	413.35	0	413.14	39.49	452.63
5	KRS	15.85	15.85	31.69	43.60	75.3	130.0	474.59	604.60	139.92	214.90	354.82	0.00	0.00	0.00	1506	2351.25	189.5	2540.71
Total Upper Cauvry s.b.		24	24	48	66	114	279	667	946	212	325	537	210	664	873	2640	4531	578	5110
6	Banasursagar	0.20	0.20	0.4	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	64.31	66.40	189	257.71	4.09	261.80
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	146.65	153.67	4.46	6.18	10.64	0.00	0.00	0.00	276.0	433.79	8.235	442.03
8	Kabini	6.27	6.27	12.53	8.79	21.3	88.51	530.40	618.91	55.23	76.56	131.79	6.60	845.40	852.00	202	1715.86	110.2	1826.02
9	Taraka	0.90	0.90	1.8	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	152.98	157.87	0	172.82	8.29	181.11
10	Sagardoddakere	0.60	0.60	1.2	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	22.07	23.00	95	130.34	6.97	137.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.5	44.70	79.35	124.05	27.26	37.78	65.04	9.88	430.12	440.00	290	867.59	62	929.59
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	175.04	176.91	0	177.48	2.29	179.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.3	134.5	272.77	407.25	99.07	137.34	236.41	0.00	0.00	0.00	99	619.50	161.4	780.93
Total Kabini s.b.		23	23	46	32	78	282	1029	1311	202	280	482	26	1690	1716	1151	4375	363	4739
14	Shimsha.	26.50	26.50	53	62.00	115	506.0	244.69	1000.7	233.00	348.00	581.00	0.00	0.00	0.00	0.00	852.19	594.5	1446.69
15	Arkavathi	48.50	48.50	97	32.00	129	22.50	30.30	52.80	113.00	0.00	113.00	0.00	0.00	0.00	0.00	191.80	103	294.80
16	Middle Cauvery	8.50	8.50	17	18.00	35	178.5	1310.0	1488	74.00	109.00	183.00	0.00	0.00	0.00	14.00	1515.47	205	1720.47
17	Suvarnavathi	3.50	3.50	7	24.00	31	36.4	0.00	36.40	32	33	65	0.00	0.00	0.00	0.00	68.50	63.9	132.40
18	Palar	11.60	11.60	23.19	21.03	44.2	100.5	20.80	121.3	11.00	14.00	25.00	0.00	0.00	0.00	0.00	57.40	133.1	190.52
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.9	124.6	52.97	177.6	0.00	0.00	0.00	0.00	40.00	40.00	0.00	101.83	160.7	262.54
20	Mettur	0.00	0.00	0	0.00	0	0.00	0.00	0.00	78.00	123.0	201.0	0.0	275.0	275.0	7200.00	7676.00	0	7676.00
Total Chinnar s.b		9	9	18	27	45	125	53	178	78	123	201	0	315	315	7200	7778	161	7939
Total above Mettur		154	154	309	282	591	1530	3355	5134	955	1232	2187	236	2669	2905	11005	19370	2202	21572

Table 7.1.1(d) continued…

Table 7.1.1(d) continued…

Table 7.1.1(d): Results of LP Model for 75% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 7200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.28	334.48	109.88	156.29	266.17	9.89	324.88	334.77	0	853.77	128.1	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.72	182.51	51.12	72.71	182.59	0.00	0.00	0.00	408	735.09	59.6	794.69
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**449**	**10**	**325**	**335**	**408**	**1589**	**188**	**1777**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	123.00	0.00	161.00	0.00	0.00	0.00	0.00	168.96	32.29	201.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	153.91	3.76	154.92	158.68	0.00	354.34	34.97	389.31
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	336.11	473.75	185.12	274.09	294.97	0.00	0.00	0.00	0.00	652.06	205.7	857.75
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**379**	**540**	**206**	**305**	**449**	**4**	**155**	**159**	**0**	**1006**	**241**	**1247**
26	Tirumanimuttar	109.74	109.74	219.5	198.98	418.5	41.28	231.10	272.38	370.00	530.00	736.00	0.00	0.00	0.00	0.00	1076.84	350	1426.8
27	Ponnai Ar	8.13	8.13	16.25	10.19	26.44	175.48	142.36	317.84	113.00	155.00	525.00	0.00	0.00	0.00	0.00	675.49	193.8	869.28
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.00	630.65	810.65	90.00	130.00	243.00	0.00	0.00	0.00	0.00	884.40	214.3	1098.7
29	Lower Coleroon	3.05	3.05	6.1	4.87	10.97	105.00	536.00	641.00	63.00	83.00	173.00	0.00	0.00	0.00	0.00	712.05	112.9	824.97
30	Cauvery Delta	80.82	80.82	161.6	133.08	294.7	11.10	3875.0	3886.1	349	461.00	524.00	0.00	0.00	0.00	0.00	4479.82	225	4704.8
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**6185**	**7005**	**1475**	**1893**	**3260**	**14**	**480**	**493**	**408**	**10593**	**1557**	**12149**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**9540**	**12140**	**2430**	**3125**	**5446**	**249**	**3149**	**3398**		**18549**	**3759**	**33721**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. .no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE
(5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.2(a): Results of LP Model for 50% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 4200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_e}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	117.12	142.80	10.96	16.84	27.80	11.69	112.23	123.92	0	258.39	42.03	300.42
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	248.50	340.71	44.34	68.11	112.45	###	84.26	228.67	1134	1584.23	255.46	1839.69
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	21.40	39.62	10.96	16.84	27.80	29.17	216.90	246.07	0	267.34	52.05	319.39
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	8.61	21.51	5.51	8.46	13.97	24.24	389.1	413.35	0	412.31	39.49	451.80
5	KRS	15.85	15.85	31.69	43.60	75.29	130.01	664.60	794.61	139.92	214.90	354.82	0.00	0.00	0.00	1506	2541.26	189.45	2730.72
Total Upper Cauvry s.b.		24	24	48	66	114	279	1060	1339	212	325	537	210	802	1012	2640	5064	578	5642
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	64.31	66.40	189	257.71	4.09	261.80
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	139.65	146.67	4.46	6.18	10.64	0.00	0.00	0.00	276.0	426.80	8.24	435.03
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	630.40	718.91	55.23	76.56	131.79	6.60	845.40	852.00	202	1815.86	110.17	1926.02
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	169.54	174.43	0	189.38	8.29	197.67
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	182.17	226.87	27.26	37.78	65.04	9.88	430.12	440.00	290	970.41	62.00	1032.41
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	295.04	296.91	0	297.48	2.29	299.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.48	727.77	862.25	99.07	137.34	236.41	0.00	0.00	0.00	99	1074.50	161.43	1235.93
Total Kabini s.b.		23	23	46	32	78	282	1680	1962	202	280	482	26	1827	1854	1151	5163	363	5527
14	Shimsha.	26.50	26.50	53.00	62.00	115.0	506.00	494.69	1000.7	233.00	348.00	581.00	0.00	0.0	0.0	0.00	1102.19	594.5	1696.69
15	Arkavathi	48.50	48.50	97.00	32.00	129.0	22.50	30.30	52.80	223.00	0.00	223.00	0.00	0.00	0.00	0.00	301.80	103.00	404.80
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.00	178.50	1910.0	2088.5	74.00	109.00	183.00	0.00	0.00	0.00	14.00	2115.47	205.00	2320.47
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.40	0.00	36.40	32.00	63.00	95.00	0.00	0.00	0.00	0.00	98.50	63.90	162.40
18	Palar	11.60	11.60	23.19	21.03	44.22	100.50	138.40	238.90	21.00	0.00	21.00	0.00	0.00	0.00	0.00	171.00	133.13	304.12
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.63	92.97	217.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	101.83	160.71	262.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	123.00	201.00	0.00	275.00	275.00	4200.0	4676.00	0.00	4676.00
Total Chinnar s.b		9	9	18	27	45	125	93	218	78	123	201	0	275	275	4200	4778	161	4938.54
Total above Mettur		154	154	309	282	591	1530	5407	6936	1075	1248	2323	236	2905	3141		18794	2202	20996

Table 7.1.2(a) continued…

Table 7.1.2(a) continued...

Table 7.1.2(a): Results of LP Model for 50% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 4200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$ IUMHG	$Iu^{m,s}_{i,j}$ IUMHS	$Ws^{RH}_{i,j}$ IUMH	$Ws^{RL}_{i,j}$ IUML	$Iu^{m}_{i,j}$ IUM	$Iu^{r,g}_{i,j}$ IURG	$Iu^{r,s}_{i,j}$ IURS	$Iu^{r}_{i,j}$ IUR	$Ws^{U}_{i,j}$ WSU	$Ws^{I}_{i,j}$ WSI	$Ws'_{i,j}$ WSD	$Ir^{g}_{i,j}$ IRG	$Ir^{s}_{i,j}$ IRS	$Ir'_{i,j}$ IRD	$OE^{q,j_E}_{i,j,p}$ OE	Surface water	Ground water	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.28	334.48	109.88	156.29	266.17	9.89	324.88	334.77	0	853.77	128.07	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.67	182.46	51.12	72.71	123.83	0.00	0.00	0.00	408	676.28	59.60	735.88
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**390**	**10**	**325**	**335**	**408**	**1530**	**188**	**1718**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	131.00	0.00	131.00	0.00	0.00	0.00	0.00	138.96	32.29	171.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	51.79	3.76	198.50	202.26	0.00	295.80	34.97	330.77
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	262.68	400.32	185.12	274.09	459.21	0.00	0.00	0.00	0.00	742.87	205.69	948.56
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**306**	**467**	**206**	**305**	**511**	**4**	**199**	**202**	**0**	**1039**	**241**	**1279**
26	Tirumanimuttar	109.74	109.74	219.5	199.0	418.5	41.28	240.00	281.28	370.00	282.00	652.00	0.00	0.00	0.00	0.00	1001.74	350.00	1351.74
27	Ponnai Ar	8.13	8.13	16.25	10.19	26.44	175.48	122.52	298.00	113.00	155.00	268.00	0.00	0.00	0.00	0.00	398.64	193.80	592.44
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.00	630.65	810.65	90.00	130.00	220.00	0.00	0.00	0.00	0.00	861.40	214.28	1075.67
29	Lower Coleroon	3.05	3.05	6.10	4.87	10.97	105.00	536.00	641.00	63.00	83.00	146.00	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.82	80.82	161.6	133.1	294.7	11.10	3310.4	3321.5	349.00	461.00	810.00	0.00	0.00	0.00	0.00	4201.21	225.00	4426.21
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5536**	**6356**	**1483**	**1645**	**3128**	**14**	**523**	**537**	**408**	**9856**	**1557**	**11412**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**10943**	**13293**	**2558**	**2893**	**5451**	**249**	**3428**	**3678**		**28650**	**3759**	**32408**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. .no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE (5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.2(b): Results of LP Model for 50% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 5800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws^{'}_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir^{'}_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	107.12	132.80	10.96	16.84	27.80	11.69	111.17	122.86	0	247.33	42.03	289.36
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	231.32	323.53	44.34	68.11	112.45	144.41	84.26	228.67	1134	1567.05	255.46	1822.51
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	17.26	35.48	10.96	16.84	27.80	29.17	216.86	246.03	0	263.16	52.05	315.21
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	8.61	21.51	5.51	8.46	13.97	24.24	389.1	413.35	0	412.31	39.49	451.80
5	KRS	15.85	15.85	31.69	43.60	75.29	130.01	604.05	734.06	139.92	214.90	354.82	0.00	0.00	0.00	1506	2480.71	189.45	2670.2
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**968**	**1247**	**212**	**325**	**537**	**210**	**801**	**1011**	**2640**	**4971**	**578**	**5549**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	64.31	66.40	189	257.71	4.09	261.80
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	139.65	146.67	4.46	6.18	10.64	0.00	0.00	0.00	276.0	426.80	8.24	435.03
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	620.40	708.91	55.23	76.56	131.79	6.60	845.40	852.00	202	1805.86	110.17	1916.02
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	161.54	166.43	0	181.38	8.29	189.67
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	172.17	216.87	27.26	37.78	65.04	9.88	430.12	440.00	290	960.41	62.00	1022.41
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	185.04	186.91	0	187.48	2.29	189.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.48	407.77	542.25	99.07	137.34	236.41	0.00	0.00	0.00	99	754.50	161.43	915.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**1340**	**1622**	**202**	**280**	**482**	**26**	**1709**	**1736**	**1151**	**4705**	**363**	**5069**
14	Shimsha.	26.50	26.50	53.00	62.00	115.0	506.00	494.69	1000.7	233.00	348.00	581.00	0.00	0.00	0.00	0.00	1102.19	594.50	1696.69
15	Arkavathi	48.50	48.50	97.00	32.00	129.0	22.50	30.30	52.80	185.00	0.00	185.00	0.00	0.00	0.00	0.00	263.80	103.00	366.80
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.00	178.50	1810.0	1988.5	74.0	109.00	183.00	0.00	0.00	0.00	14.00	2015.47	205.00	2220.47
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.40	0.00	36.40	32.00	63.00	95.00	0.00	0.00	0.00	0.00	98.50	63.90	162.40
18	Palar	11.60	11.60	23.19	21.03	44.22	100.50	138.40	238.90	18.00	0.00	18.00	0.00	0.00	0.00	0.00	168.00	133.13	301.12
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.63	82.97	207.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91.83	160.71	252.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	123.00	201.00	0.00	275.00	275.00	4200.00	4676.00	0.00	4676.00
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**83**	**208**	**78**	**123**	**201**	**0**	**275**	**275**	**5800**	**6368**	**161**	**6529**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**4865**	**6394**	**1034**	**1248**	**2282**	**236**	**2786**	**3022**		**18092**	**2202**	**20294**

Table 7.1.2(b) continued…

Table 7.1.2(b) continued…

Table 7.1.2(b): Results of LP Model for 50% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 5800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.28	334.48	109.88	156.29	266.17	9.89	324.88	334.77	0	853.77	128.07	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.72	182.51	51.12	72.71	123.83	0.00	0.00	0.00	408	676.33	59.60	735.93
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**390**	**10**	**325**	**335**	**408**	**1530**	**188**	**1718**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	123.00	0.00	123.00	0.00	0.00	0.00	0.00	130.96	32.29	163.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	51.79	3.76	198.50	202.26	0.00	295.80	34.97	330.77
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	400.32	537.96	185.12	274.09	459.21	0.00	0.00	0.00	0.00	880.51	205.69	1086.2
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**443**	**605**	**206**	**305**	**511**	**4**	**199**	**202**	**0**	**1176**	**241**	**1417.0**
26	Tirumanimuttar	109.74	109.74	219.48	198.98	418.5	41.28	250.00	291.28	370.00	379.00	749.00	0.00	0.00	0.00	0.00	1108.74	350.00	1458.7
27	Ponnai Ar	8.13	8.13	16.25	10.19	26.44	175.48	134.81	310.29	113.00	155.00	268.00	0.00	0.00	0.00	0.00	410.94	193.80	604.7
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.00	630.65	810.65	90.00	130.00	220.00	0.00	0.00	0.00	0.00	861.40	214.28	1075.7
29	Lower Coleroon	3.05	3.05	6.10	4.87	10.97	105.00	536.00	641.00	63.00	83.00	146.00	0.00	0.00	0.00	0.00	685.05	112.92	798.0
30	Cauvery Delta	80.82	80.82	161.63	133.08	294.7	11.10	3475.0	3486.1	349.00	461.00	810.00	0.00	0.00	0.00	0.00	4365.82	225.00	4590.8
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5861**	**6681**	**1475**	**1742**	**3217**	**14**	**523**	**537**		**10269**	**1557**	**11826**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**10726**	**13075**	**2509**	**2990**	**5499**	**249**	**3309**	**3559**		**28361**	**3759**	**32120**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE (5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.2(c): Results of LP Model for 50% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_g}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	97.12	122.80	10.96	16.84	27.80	11.69	93.52	105.21	0	219.68	42.03	261.71
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	163.20	255.41	44.34	68.11	112.45	144.41	84.26	228.67	1134	1498.93	255.46	1754.39
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	17.26	35.48	10.96	16.84	27.80	29.17	216.86	246.03	0	263.16	52.05	315.21
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	8.61	23.86	5.51	8.46	13.97	24.24	389.11	413.35	0	412.31	39.49	451.80
5	KRS	15.85	15.85	31.69	43.60	75.29	130.0	534.04	664.05	139.92	214.90	354.82	0.00	0.00	0.00	1506	2410.70	189.45	2600.2
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**820**	**1102**	**212**	**325**	**537**	**210**	**784**	**993**	**2640**	**4805**	**578**	**5383**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	64.31	66.40	189	257.71	4.09	261.80
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	139.65	146.67	4.46	6.18	10.64	0.00	0.00	0.00	276.0	426.80	8.24	435.03
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	530.40	618.91	57.23	76.56	133.79	6.60	845.40	852.00	202	1717.86	110.17	1828.0
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	157.54	162.43	0	177.38	8.29	185.67
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	162.17	206.87	27.26	37.78	65.04	9.88	430.12	440.00	290	950.41	62.00	1012.41
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	265.04	266.91	0	267.48	2.29	269.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.5	379.77	514.25	99.07	137.34	236.41	0.00	0.00	0.00	99	726.50	161.43	887.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**1212**	**1494**	**204**	**280**	**484**	**26**	**1785**	**1812**	**1151**	**4655**	**363**	**5019**
14	Shimsha.	26.50	26.50	53.00	62.00	115.00	506.0	494.7	1000.7	233.00	348.00	581.00	0.00	0.00	0.0	0.00	1102.19	594.50	1696.7
15	Arkavathi	48.50	48.50	97.00	32.00	129.00	22.50	30.30	52.80	117.00	0.00	117.00	0.00	0.00	0.0	0.00	195.80	103.00	298.8
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.00	178.5	1710.0	1888.5	74.00	109.00	183.00	0.00	0.00	0.0	14.00	1915.47	205.00	2120.5
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.40	0.00	36.40	32.00	63.00	95.00	0.00	0.00	0.00	0.00	98.50	63.90	162.40
18	Palar	11.60	11.60	23.19	21.03	44.22	100.5	138.40	238.90	17.00	0.00	17.00	0.00	0.00	0.00	0.00	167.00	133.13	300.12
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.6	72.97	197.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	81.83	160.71	242.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	123.00	201.00	0.00	275.00	275.00	6200	6676.00	0.00	6676.00
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**73**	**198**	**78**	**123**	**201**	**0**	**275**	**275**	**6200**	**6757.83**	**161**	**6919**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**4479**	**6011**	**967**	**1248**	**2215**	**236**	**2844**	**3080**		**19697**	**2202**	**21899**

Table 7.1.2(c) continued…

Table 7.1.2(c) continued…

Table 7.1.2(c): Results of LP Model for 50% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws^{'}_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir^{'}_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.3	334.5	109.9	156.3	266.17	9.89	324.9	334.77	0	853.77	128.07	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.7	182.5	51.1	72.7	123.83	0.00	0.00	0.00	408	268.33	59.60	327.93
Total Bhawani s.b.		18	18	36	32	68	128	389.0	517.0	161.0	229.0	390	10	325	335	408	1122	188	1310
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.1	129.0	0.0	129.00	0.00	0.00	0.00	0.00	136.96	32.29	169.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.7	20.9	30.9	51.79	3.76	198.5	202.26	0.00	295.80	34.97	330.77
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	400.32	538.0	185.1	274.1	459.21	0.00	0.00	0.00	0.00	880.51	205.69	1086.2
Total Amaravathi s.b.		23	23	47	52	99	161	443	604.6	206.0	305.0	511	4	199	202	0	1176	241	1417
26	Tirumanimuttar	109.74	109.7	219.5	199.0	418.5	41.3	295.32	336.6	370.0	453.0	823.00	0.00	0.00	0.00	0.00	1228.06	350.00	1578.1
27	Ponnai Ar	8.13	8.1	16.3	10.2	26.4	175.5	152.32	327.8	113.0	155.0	268.00	0.00	0.00	0.00	0.00	428.45	193.80	622.2
28	Upper Coleroon	10.75	10.7	21.5	23.5	45.0	180.0	630.65	810.7	90.0	130.0	220.00	0.00	0.00	0.00	0.00	861.40	214.28	1075.7
29	Lower Coleroon	3.05	3.1	6.1	4.9	11.0	105.0	536.00	641.0	63.0	83.0	146.00	0.00	0.00	0.00	0.00	685.05	112.92	798.0
30	Cauvery Delta	80.82	80.8	161.6	133.1	294.7	11.1	3475.0	3486	349.0	461.0	810.00	0.00	0.00	0.00	0.00	4365.82	225.00	4590.8
Total below Mettur		260	260	520	463	983	820	5924	6744	1481	1816	3297	14	523	537		10004	1557	11561
Gross Total		414	414	829	745	1574	2350	10402	12755	2470	3064	5512	249	3368	3617		29701	3759	33460

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. .no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE
(5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.2(d): Results of LP Model for 50% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 7800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws^{'}_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir^{'}_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	67.12	92.80	10.96	16.84	27.80	11.69	71.30	82.99	0	167.46	42.03	209.49
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	148.3	240.51	44.34	68.11	112.45	144.41	84.26	228.67	1134	1484.03	255.46	1739.49
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	17.26	35.48	10.96	16.84	27.80	29.17	216.86	246.03	0	263.16	52.05	315.21
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	8.61	21.51	5.51	8.46	13.97	24.24	389.1	413.35	0	412.31	39.49	451.80
5	KRS	15.85	15.85	31.69	43.60	75.29	130.0	564.0	694.1	139.9	214.9	354.82	0.00	0.00	0.00	1506	2440.71	189.45	2630.17
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**805**	**1084**	**212**	**325**	**537**	**210**	**762**	**971**	**2640**	**4768**	**578**	**5346**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	64.31	66.40	189	257.71	4.09	261.80
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	139.65	146.67	4.46	6.18	10.64	0.00	0.00	0.00	276.0	426.80	8.24	435.03
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	530.40	618.91	55.23	76.56	131.79	6.60	845.40	852.00	202	1715.86	110.17	1826.02
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	147.54	152.43	0	167.38	8.29	175.67
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	142.17	186.87	27.26	37.78	65.04	9.88	430.12	440.00	290	930.41	62.00	992.41
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	275.04	276.91	0	277.48	2.29	279.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.5	323.8	458.3	99.1	137.3	236.41	0.00	0.00	0.00	99	670.50	161.43	831.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**1136**	**1418**	**202**	**280**	**482**	**26**	**1785**	**1812**	**1151**	**4577**	**363**	**4941**
14	Shimsha.	26.50	26.50	53.00	62.00	115.0	506.0	494.7	1000.7	233.0	348.0	581.00	0.00	0.00	0.00	0.00	1102.19	594.50	1696.69
15	Arkavathi	48.50	48.50	97.00	32.00	129.0	22.5	30.3	52.8	53.0	0.0	53.00	0.00	0.00	0.00	0.00	131.80	103.00	234.80
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.0	178.5	1410	1588.5	74.0	109.0	183.00	0.00	0.00	0.00	14.00	1615.47	205.00	1820.47
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.4	0.0	36.40	32.00	63.00	95.00	0.00	0.00	0.00	0.00	98.50	63.90	162.40
18	Palar	11.60	11.60	23.19	21.03	44.22	100.5	138.4	238.90	11.00	0.00	11.00	0.00	0.00	0.00	0.00	161.00	133.13	294.12
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.6	53.0	177.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61.83	160.71	222.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	123.0	201.00	0.00	275.00	275.00	7800	8276.00	0.00	8276.00
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**53**	**178**	**78**	**123**	**201**	**0**	**275**	**275**	**7800**	**8338**	**161**	**8499**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**4068**	**5597**	**895**	**1248**	**2143**	**236**	**2822**	**3058**		**20792**	**2202**	**22994**

Table 7.1.2(d) continued…

Table 7.1.2(d) continued...

Table 7.1.2(d): Results of LP Model for 50% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 7800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws^{'}_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir^{'}_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.28	334.48	109.9	156.29	266.17	9.89	324.88	334.77	0	853.77	128.07	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.72	182.51	51.1	72.71	123.83	0.00	0.00	0.00	408	676.33	59.60	735.93
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161.0**	**229**	**390**	**10**	**325**	**335**	**408**	**1530**	**188**	**1718**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	153.0	0.00	153.00	0.00	0.00	0.00	0.00	160.96	32.29	193.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.9	30.91	51.79	3.76	198.50	202.26	0.00	295.80	34.97	330.77
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	400.32	537.96	185.1	274.09	459.21	0.00	0.00	0.00	0.00	880.51	205.69	1086.20
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**443**	**605**	**206.0**	**305**	**511**	**4**	**199**	**202**	**0**	**1176**	**241**	**1417**
26	Tirumanimuttar	109.7	109.74	219.48	198.98	418.5	41.28	321.25	362.53	370.0	530.00	900.00	0.00	0.00	0.00	0.00	1330.99	350.00	1680.99
27	Ponnai Ar	8.13	8.13	16.25	10.19	26.44	175.48	169.27	344.75	113.0	155.00	268.00	0.00	0.00	0.00	0.00	445.40	193.80	639.19
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.00	630.65	810.65	90.0	130.00	220.00	0.00	0.00	0.00	0.00	861.40	214.28	1075.67
29	Lower Coleroon	3.05	3.05	6.10	4.87	10.97	105.00	536.00	641.00	63.0	83.00	146.00	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.82	80.82	161.63	133.08	294.7	11.10	3475.0	3486.1	349.0	461.00	810.00	0.00	0.00	0.00	0.00	4365.82	225.00	4590.81
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5967**	**6787**	**1505.0**	**1893**	**3398**	**14**	**523**	**537**		**10148**	**1557**	**12113**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**10034**	**12384**	**2470**	**3141**	**5541**	**249**	**3345**	**3595**		**30940**	**3759**	**35107**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE (5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.3(a): Results of LP Model for 90% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 4200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,J_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.9	25.68	17.12	42.8	10.96	16.84	27.8	11.69	71.33	83.02	0	117.49	42.03	159.52
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	48.30	140.5	44.34	68.11	112.5	144.4	84.3	228.7	1134	1384.03	255.5	1639.49
3	Harangi	1.24	1.24	2.48	3.42	5.9	18.22	0	18.22	10.96	16.84	27.8	29.2	142.8	171.9	0	171.80	52.05	223.847
4	Cauvery	0.625	0.625	1.25	1.72	2.97	12.90	8.61	21.51	5.51	8.46	13.97	24.2	105.6	129.9	0	128.83	39.49	168.315
5	KRS	15.85	15.85	31.69	43.6	75.29	130.0	474.6	604.6	139.9	214.9	354.8	0	0.00	0.00	1506	2351.25	189.5	2540.71
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	279	**549**	**828**	**212**	**325**	537	**210**	404	**613**	**2640**	**4153**	**578**	**4732**
6	Banasursagar	0.20	0.20	0.4	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.2	2.09	22.05	24.14	189	215.45	4.09	219.54
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	0.00	7.02	4.46	6.18	10.64	0.00	0.00	0.00	276.0	287.15	8.235	295.38
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	####	530.4	55.23	76.56	131.8	6.60	457.8	464.4	202	1239.77	110.2	1349.94
9	Taraka	0.90	0.90	1.8	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	97.7	102.6	0	117.56	8.29	125.853
10	Sagardoddakere	0.60	0.60	1.2	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.5	44.70	79.30	124	27.26	37.78	65.04	9.88	252.4	262.3	290	689.84	62	751.837
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	75.04	76.91	0	77.48	2.29	79.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.5	227.8	362.3	99.1	137.3	236.4	0.00	0.00	0.00	99	574.50	161.4	735.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	749	**1031**	**202**	**280**	**482**	**26**	**928**	**954**	**1151**	**3333**	**363**	**3697**
14	Shimsha.	26.5	26.5	53.00	62.00	115.0	506.0	0.0	506.0	233.0	348.0	581.0	0.00	0.00	0.00	0.00	607.50	594.5	1202
15	Arkavathi	48.5	48.5	97.00	32.00	129.0	22.5	20.3	42.8	53.0	0.0	53.0	0.00	0.00	0.00	0.00	121.80	103	224.8
16	Middle Cauvery	8.5	8.5	17.00	18.00	35.0	178.5	1810	1988	74.0	109.0	183.0	0.00	0.00	0.00	14.00	2015.47	205	2220.47
17	Suvarnavathi	3.5	3.5	7.00	24.00	31.0	36.4	0.0	36.4	32.0	7.0	39.0	0.00	0.00	0.00	0.00	42.50	63.9	106.4
18	Palar	11.6	11.6	23.19	21.03	44.2	100.5	14.0	114.5	52.0	0.0	52.0	0.00	0.00	0.00	0.00	77.60	133.1	210.72
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.6	72.97	197.6	0.00	0.00	0	0.00	0.00	0.00	0.00	81.83	160.7	242.54
20	Mettur	0.00	0.00	0	0.00	0	0.00	0.00	0	78.00	123.0	201	0.00	275.0	275.0	4200	4676.00	0	4676
Total Chinnar s.b		**9**	**9**	**18**	27	**45**	125	73	198	78	**123**	201	0	**275**	**275**	**4200**	**4758**	**161**	**4919**
Total above Mettur		**154**	**154**	309	282	**591**	**1530**	**3215**	**4745**	936	**1192**	2128	236	1607	**1843**		**15109**	**2202**	**17311**

Table 7.1.3(a) continued…

Table 7.1.3(a) continued...

Table 7.1.3(a): Results of LP Model for 90% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 4200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_g}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.3	334.5	109.9	156.3	266.2	9.9	324.9	334.8	0	853.77	128.07	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.7	182.5	51.1	72.7	123.8	0.0	0.0	0.0	408	676.33	59.60	735.93
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**390**	**10**	**325**	**335**	**408**	**1530**	**188**	**1718**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	103.0	0.00	103.00	0.00	0.00	0.00	0.00	110.96	32.29	**143.25**
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	51.79	3.76	154.9	158.7	0.00	252.22	34.97	287.19
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.6	262.7	400.3	185.1	274.1	459.2	0.00	0.00	0.00	0.00	742.87	205.69	948.56
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161.2**	**305.8**	**467.0**	**206.0**	**305.0**	**511.0**	**4**	**155**	**159**	**0**	**995**	**241**	**1236**
26	Tirumanimuttar	109.7	109.7	219.5	199.0	418.5	41.3	155.2	196.5	370.0	353.0	723.0	0.00	0.00	0.00	0.00	987.95	350.00	1337.95
27	Ponnai Ar	8.125	8.125	16.25	10.19	26.44	175.5	122.5	298.0	113.0	155.0	268.0	0.00	0.00	0.00	0.00	398.64	193.80	592.44
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.0	630.7	810.7	90.0	130.0	220.0	0.00	0.00	0.00	0.00	861.40	214.28	1075.67
29	Lower Coleroon	3.05	3.05	6.10	4.87	10.97	105.0	536.0	641.0	63.0	83.0	146.0	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.82	80.82	161.6	133.1	294.7	11.1	3250	3261	349.0	461.0	810.0	0.00	0.00	0.00	0.00	4141.21	225.00	4366.21
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5392**	**6212**	**1483**	**1716**	**3199**	**14**	**480**	**493**		**9330**	**1557**	**11267**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**8606**	**10956**	**2470**	**2908**	**5378**	**249**	**2087**	**2336**		**24440**	**3759**	**28578**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE
(5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.3(b): Results of LP Model for 90% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 5800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,P}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	17.12	42.80	10.96	16.84	27.80	11.69	71.33	83.02	0	117.49	42.03	159.52
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	48.30	140.5	44.34	68.11	112.5	144.4	84.3	228.7	1134	1384.0	255.46	1639.49
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	17.26	35.48	10.96	16.84	27.8	29.2	127.2	156.4	0	173.54	52.05	225.59
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	8.61	21.51	5.51	8.46	14.0	24.2	105.6	129.9	0	128.83	39.49	168.32
5	KRS	15.85	15.85	31.69	43.60	75.29	130.0	474.6	604.6	139.9	214.9	354.8	0.0	0.00	0.00	1506	2351	189.45	2540.71
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**566**	**845**	**212**	**325**	**537**	**210**	**388**	**598**	**2640**	**4155**	**578**	**4734**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	22.05	24.14	189	215.45	4.09	219.54
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	0.00	7.02	4.46	6.18	10.64	0.00	0.00	0.00	276.0	287.15	8.24	295.38
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	441.9	530.4	55.2	76.6	131.8	6.60	357.8	364.4	202	1139.8	110.17	1249.94
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	97.7	102.6	0	117.56	8.29	125.85
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	79.35	124.05	27.26	37.78	65.04	9.88	252.4	262.3	290	689.89	62.00	751.89
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	65.04	66.91	0	67.48	2.29	69.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.5	227.8	362.3	99.1	137.3	236.4	0.00	0.00	0.00	99	574.50	161.43	735.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**749**	**1031**	**202**	**280**	**482**	**26**	**818**	**844**	**1151**	**3223**	**363**	**3587**
14	Shimsha.	26.50	26.50	53.00	62.00	115.0	506.0	0.0	506.0	233.0	348.0	581.0	0.00	0.00	0.00	0.00	607.50	594.50	1202.00
15	Arkavathi	48.5	48.5	97.00	32.00	129.0	22.5	20.3	42.8	23.0	0.0	23.0	0.00	0.00	0.00	0.00	91.80	103.00	194.80
16	Middle Cauvery	8.5	8.5	17.00	18.00	35.0	178.5	1510	1688	74.0	109.0	183.0	0.00	0.00	0.00	14.00	1715.5	205.00	1920.47
17	Suvarnavathi	3.5	3.5	7.00	24.00	31.0	36.4	0.0	36.4	32.0	7.0	39.0	0.00	0.00	0.00	0.00	42.50	63.90	· 106.40
18	Palar	11.6	11.6	23.19	21.03	44.2	100.5	14.0	114.5	41.0	0.0	41.0	0.00	0.00	0.00	0.00	66.60	133.13	199.72
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.9	124.6	63.0	187.6	0.0	0.0	0.0	0.00	0.00	0.00	0.00	71.83	160.71	232.54
20	Mettur	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	78.0	123.0	201.0	0.00	275.0	275.0	5800.0	6276.0	0.00	6276.0
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**63**	**188**	**78**	**123**	**201**	**0**	**275**	**275**	**5800**	**6348**	**161**	**6509**
Total above Mettur		**154**	**154**	309	**282**	591	1530	2922	4452	895	**1192**	2087	236	1482	**1717**		**16250**	**2202**	**18452**

Table 7.1.3(b) continued…

Table 7.1.3(b) continued...

Table 7.1.3(b): Results of LP Model for 90% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 5800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.3	334.5	109.9	156.3	266.2	9.90	334.8	344.7	0	863.66	128.08	991.74
22	Bhavani s.b.r.area	5.785	5.785	11.57	10.02	21.59	43.79	138.7	182.51	51.12	72.71	123.8	0.00	0.00	0.00	408	676.33	59.60	735.93
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**390**	**10**	**335**	**345**	**408**	**1540**	**188**	**1728**
23	Noyil	5.95	5.95	11.9	8.25	20.15	18.09	2.01	20.10	113.0	0.00	113	0.00	0.00	0.00	0.00	120.96	32.29	153.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	51.79	3.76	154.9	158.7	0.00	252.22	34.97	287.19
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.6	231.0	368.7	185.1	274.1	459.2	0.00	0.00	0.00	0.00	711.21	205.69	916.90
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**274**	**435**	**206**	**305**	**511**	**4**	**155**	**159**	**0**	**963**	**241**	**1204**
26	Tirumanimuttar	109.7	109.7	219.5	199	418.5	41.28	162.0	203.3	370.0	402.0	772.0	0.00	0.00	0.00	0.00	1043.74	350.00	1393.74
27	Ponnai Ar	8.125	8.125	16.25	10.19	26.44	175.5	122.5	298.0	113.0	155.0	268.0	0.00	0.00	0.00	0.00	398.64	193.80	592.44
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.0	630.7	810.7	90.0	130.0	220.0	0.00	0.00	0.00	0.00	861.40	214.28	1075.67
29	Lower Coleroon	3.05	3.05	6.1	4.87	10.97	105.0	536.0	641.0	63.0	83.0	146.0	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.82	80.82	161.6	133.1	294.7	11.1	3575	3586	349.0	461.0	810.0	0.00	0.00	0.00	0.00	4465.82	225.00	4690.81
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5691**	**6511**	**1483**	**1765**	**3248**	**14**	**490**	**503**		**9689**	**1557**	**11636**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**8613**	**10963**	**2470**	**2957**	**5427**	**249**	**1971**	**2221**		**25939**	**3759**	**30088**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE
(5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.3(c): Results of LP Model for 90% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	17.12	42.80	10.96	16.84	27.80	11.69	71.33	83.02	0	117.49	42.03	159.52
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	48.30	140.5	44.34	68.11	112.5	144.4	84.3	228.7	1134	1384.0	255.46	1639.49
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	17.26	35.48	10.96	16.84	27.8	29.2	127.2	156.4	0	173.54	52.05	225.59
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	8.61	21.51	5.51	8.46	13.97	24.24	105.6	129.9	0	128.83	39.49	168.32
5	KRS	15.85	15.85	31.69	43.60	75.29	130.0	474.6	604.6	139.9	214.9	354.8	0.0	0.00	0.00	1506	2351.3	189.45	2540.71
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**566**	**845**	**212**	**325**	**537**	**210**	**388**	**598**	**2640**	**4155**	**578**	**4734**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	22.05	24.14	189	215.45	4.09	219.54
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	0.00	7.02	4.46	6.18	10.64	0.00	0.00	0.00	276.0	287.15	8.24	295.38
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	441.89	530.40	55.23	76.56	131.8	6.60	357.8	364.4	202	1139.8	110.17	1249.94
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	97.7	102.6	0	117.56	8.29	125.85
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	79.35	124.05	27.26	37.78	65.04	9.88	252.4	262.3	290	689.89	62.00	751.89
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	55.04	56.91	0	57.48	2.29	59.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.5	227.8	362.3	99.1	137.3	236.4	0.00	0.00	0.00	99	574.50	161.43	735.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282.2**	**749.0**	**1031.2**	**202.0**	**280.0**	**482.0**	**26**	**808**	**834**	**1151**	**3213**	**363**	**3577**
14	Shimsha.	26.50	26.50	53.00	62.00	115.0	506.0	0.0	506.0	233.0	348.0	581.0	0.00	0.00	0.00	0.00	607.50	594.50	1202.00
15	Arkavathi	48.50	48.50	97.00	32.00	129.0	22.50	20.30	42.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.80	103.00	171.80
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.00	178.5	1410	1588	74.0	109.0	183.0	0.00	0.00	0.00	14.00	1615.5	205.00	1820.47
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.4	0.0	36.4	32.0	7.0	39.0	0.00	0.00	0.00	0.00	42.50	63.90	106.40
18	Palar	11.60	11.60	23.19	21.03	44.22	100.5	14.0	114.5	31.0	0.0	31.0	0.00	0.00	0.00	0.00	56.60	133.13	189.72
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.6	53.0	177.6	0.0	0.0	0.0	0.00	0.00	0.00	0.00	61.83	160.71	222.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	78.0	123.0	201.0	0.00	275.0	275.0	6200	6676	0.00	6676.00
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**53**	**178**	**78**	**123**	**201**	**0**	**275**	**275**	**6200**	**6738**	**161**	**6899**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**2812**	**4342**	**862**	**1192**	**2054**	**236**	**1472**	**1707**		**16497**	**2202**	**18699**

Table 7.1.3(c) continued…

Table 7.1.3(c) continued...

Table 7.1.3(c): Results of LP Model for 90% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws^{'}_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir^{'}_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.3	334.5	109.9	156.3	266.2	9.9	334.8	344.7	0.0	863.66	128.08	991.74
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.7	182.5	51.1	72.7	123.8	0.0	0.0	0.0	408.0	676.33	59.60	735.93
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**390**	**10**	**335**	**345**	**408**	**1540**	**188**	**1728**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	113.0	0.00	113.00	0.00	0.00	0.00	0.00	120.96	32.29	153.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	51.79	3.76	47.82	51.58	0.00	145.12	34.97	180.09
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.6	231.0	368.7	185.1	274.1	459.2	0.00	0.00	0.00	0.00	711.21	205.69	916.90
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**274**	**435**	**206**	**305**	**511**	**4**	**48**	**52**	**0**	**856**	**241**	**1097**
26	Tirumanimuttar	109.7	109.7	219.5	199.0	418.5	41.3	195.0	236.3	370.0	473.0	843.0	0.00	0.00	0.00	0.00	1147.7	350.00	1497.74
27	Ponnai Ar	8.1	8.1	16.3	10.2	26.4	175.5	122.5	298.0	113.0	155.0	268.0	0.00	0.00	0.00	0.00	398.64	193.80	592.44
28	Upper Coleroon	10.7	10.7	21.5	23.5	45.0	180.0	630.7	810.7	90.0	130.0	220.0	0.00	0.00	0.00	0.00	861.40	214.28	1075.67
29	Lower Coleroon	3.1	3.1	6.1	4.9	11.0	105.0	536.0	641.0	63.0	83.0	146.0	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.8	80.8	161.6	133.1	294.7	11.1	3675	3686	349.0	461.0	810.0	0.00	0.00	0.00	0.00	4566	225.00	4790.81
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5824**	**6644**	**1483**	**1836**	**3319.00**	**14**	**383**	**396**		**9786**	**1557**	**11733**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**8636**	**10986**	**2470**	**3028**	**5497.9**	**249**	**1854**	**2104**		**26283**	**3759**	**30432**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. .no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE
(5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.3(d): Results of LP Model for 90% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6900 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	17.12	42.80	10.96	16.84	27.80	11.69	71.33	83.02	0	117.49	42.03	159.52
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	48.30	140.5	44.3	68.1	112.5	144.4	84.3	228.7	1134	1384.03	255.46	1639.49
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	0.00	18.2	11.0	16.8	27.8	29.2	120.0	149.2	0	149.04	52.05	201.09
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	8.61	21.5	5.5	8.5	14.0	24.2	105.6	129.9	0	128.83	39.49	168.32
5	KRS	15.85	15.85	31.69	43.60	75.29	130.0	474.6	604.6	139.9	214.9	354.8	0.0	0.0	0.00	1506	2351.25	189.45	2540.71
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**549**	**828**	**212**	**325**	**537**	**210**	**381**	**591**	**2640**	**4131**	**578**	**4709**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	22.05	24.14	189	215.45	4.09	219.54
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	0.00	7.02	4.46	6.18	10.64	0.00	0.00	0.00	276.0	287.15	8.24	295.38
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	88.51	341.89	55.23	76.56	131.8	6.60	307.8	314.4	202	989.75	110.17	1099.91
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	97.7	102.6	0	117.56	8.29	125.85
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.1	24.0	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	0.00	44.70	27.26	37.78	65.04	9.88	252.4	262.3	290	610.54	62.00	672.54
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	45.04	46.91	0	47.48	2.29	49.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.5	227.8	362.3	99.1	137.3	236.4	0.0	0.0	0.00	99	574.50	161.43	735.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**570**	**852**	**202**	**280**	**482**	**26**	**748**	**774**	**1151**	**2974**	**363**	**3337**
14	Shimsha.	26.50	26.50	53.00	62.00	115.0	506.0	0.0	506.0	233.0	348.0	581.0	0.00	0.00	0.00	0.00	607.50	594.50	1202.00
15	Arkavathi	48.50	48.50	97.00	32.00	129.0	22.5	20.3	42.8	0.0	0.0	0.0	0.00	0.00	0.00	0.00	68.80	103.00	171.80
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.0	178.5	1260	1438	74.0	109.0	183.0	0.00	0.00	0.00	14.00	1465.5	205.00	1670.47
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.0	36.4	0.0	36.4	32.0	7.0	39.0	0.00	0.00	0.00	0.00	42.5	63.90	106.40
18	Palar	11.60	11.60	23.19	21.03	44.2	100.5	14.0	114.5	11.0	0.0	11.0	0.00	0.00	0.00	0.00	36.6	133.13	169.72
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.9	124.6	43.0	167.6	0.0	0.0	0.0	0.00	0.00	0.00	0.00	51.8	160.71	212.54
20	Mettur	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	78.0	123.0	201.0	0.00	275.00	275.00	6900	7376.0	0.00	7376.00
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**43**	**168**	**78**	**123**	**201**	**0**	**275**	**275**	**6900**	**7428**	**161**	**7589**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**2456**	**3985**	**842**	**1192**	**2034**	**236**	**1404**	**1640**		**16753**	**2202**	**18955**

Table 7.1.3(d) continued…

Table 7.1.3(d) continued...

Table 7.1.3(d): Results of LP Model for 90% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6900 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_g}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.3	334.5	109.9	156.3	266.2	9.9	334.8	344.7	0	863.66	128.1	991.74
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	138.7	182.5	51.1	72.7	123.8	0.0	0.0	0.0	408	676.33	59.6	735.93
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**389**	**517**	**161**	**229**	**390**	**10**	**335**	**345**	**408**	**1540**	**188**	**1728**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	101.0	0.0	101.0	0.00	0.00	0.00	0.00	108.96	32.29	141.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	43.15	66.68	20.88	30.91	51.79	3.76	47.82	51.58	0.00	145.12	34.97	180.086
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.6	221.0	358.6	185.1	274.1	459.2	0.00	0.00	0.00	0.00	701.19	205.7	906.883
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**264**	**425**	**206**	**305**	**511**	**4**	**48**	**52**	**0**	**846**	**241**	**1087**
26	Tirumanimuttar	109.7	109.7	219.5	199.0	418.5	41.3	211.3	252.6	370.0	530.0	900.0	0.00	0.00	0.00	0.00	1221.1	350	1571.06
27	Ponnai Ar	8.1	8.1	16.3	10.2	26.4	175.5	122.5	298.0	113.0	155.0	268.0	0.00	0.00	0.00	0.00	398.64	193.8	592.44
28	Upper Coleroon	10.7	10.7	21.5	23.5	45.0	180.0	630.7	810.7	90.0	130.0	220.0	0.00	0.00	0.00	0.00	861.40	214.3	1075.67
29	Lower Coleroon	3.1	3.1	6.1	4.9	11.0	105.0	536.0	641.0	63.0	83.0	146.0	0.00	0.00	0.00	0.00	685.05	112.9	797.97
30	Cauvery Delta	80.8	80.8	161.6	133.1	294.7	11.1	3850	3861	349	461.0	810.0	0.00	0.00	0.00	0.00	4741.2	225	4966.21
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**6006**	**6826**	**1453**	**1893**	**3346**	**14**	**383**	**396**		**9995**	**1557**	**11959**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**8462**	**10811**	**2295**	**3085**	**5380**	**249**	**1787**	**2036**		**26748**	**3759**	**30915**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE (5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.4(a): Results of LP Model for 100% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 4200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	0.00	25.68	10.96	16.84	27.80	11.69	71.33	83.02	0	100.37	42.03	142.40
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	48.30	140.51	44.34	68.11	112.45	144.41	84.26	228.67	1134	1384.03	255.46	1639.49
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	0.00	18.22	10.96	16.84	27.80	29.17	111.10	140.27	0	140.14	52.05	192.19
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	0.00	12.90	5.51	8.46	13.97	24.24	69.43	93.67	0	84.02	39.49	123.51
5	KRS	15.85	15.85	31.69	43.60	75.29	130.01	474.59	604.60	139.92	214.90	354.82	0.00	0.00	0.00	1506	2351.25	189.45	2540.7
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**523**	**802**	**212**	**325**	**537**	**210**	**336**	**546**	**2640**	**4060**	**578**	**4638**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	13.11	15.20	189	206.51	4.09	210.60
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	0.00	7.02	4.46	6.18	10.64	0.00	0.00	0.00	276.0	287.15	8.24	295.38
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	0.00	88.51	55.23	76.56	131.79	6.60	474.17	480.77	202	814.23	110.17	924.39
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	21.29	26.18	0	41.13	8.29	49.42
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	0.00	44.70	27.26	37.78	65.04	9.88	99.23	109.11	290	457.35	62.00	519.35
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	75.04	76.91	0	77.48	2.29	79.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.48	327.77	462.25	99.07	137.34	236.41	0.00	0.00	0.00	99	674.50	161.43	835.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**328**	**610**	**202**	**280**	**482**	**26**	**706**	**732**	**1151**	**2690**	**363**	**3053**
14	Shimsha	26.50	26.50	53.00	62.00	115.0	506.00	0.00	506.00	233.00	348.00	581.00	0.00	0.00	0.00	0.00	607.50	594.50	1202.0
15	Arkavathi	48.50	48.50	97.00	32.00	129.0	22.50	30.30	52.80	17.00	0.00	17.00	0.00	0.00	0.00	0.00	95.80	103.00	198.80
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.00	178.50	1610.0	1788.5	74.00	109.00	183.00	0.00	0.00	0.00	14.00	1815.47	205.0	2020.5
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.40	0.00	36.40	32.00	0.00	32.00	0.00	0.00	0.00	0.00	35.50	63.90	99.40
18	Palar	11.60	11.60	23.19	21.03	44.22	100.53	0.00	100.53	11.00	10.00	21.00	0.00	0.00	0.00	0.00	32.60	133.16	165.75
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.63	52.97	177.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61.83	160.71	222.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	123.00	201.00	0.00	275.00	275.00	4200	4676.00	0.00	4676.0
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**53**	**178**	**78**	**123**	**201**	**0**	**275**	**275**	**4200**	**4738**	**161**	**4899**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**2544**	**4074**	**859**	**1195**	**2054**	**236**	**1317**	**1553**		**14074**	**2202**	**16276**

Table 7.1.4(a) continued…

Table 7.1.4(a) continued...

Table 7.1.4(a): Results of LP Model for 100% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 4200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.28	334.48	109.88	156.29	266.17	9.89	324.88	334.77	0	853.77	128.07	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	79.12	122.91	51.12	72.71	123.83	0.00	0.00	0.00	408	616.74	59.60	676.33
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**329**	**457**	**161**	**229**	**390**	**10**	**325**	**335**	**408**	**1471**	**188**	**1658**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	93.00	0.00	93.00	0.00	0.00	0.00	0.00	100.96	32.29	133.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	0.00	23.53	20.88	30.91	51.79	3.76	36.21	39.97	0.00	90.36	34.97	125.33
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	231.00	368.64	185.12	274.09	459.21	0.00	0.00	0.00	0.00	711.19	205.69	916.88
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**231**	**392**	**206**	**305**	**511**	**4**	**36**	**40**	**0**	**802**	**241**	**1042**
26	Tirumanimuttar	109.74	109.74	219.48	198.98	418.4	41.28	129.21	170.49	370.00	350.00	720.00	0.00	0.00	0.00	0.00	958.95	350.00	1308.9
27	Ponnai Ar	8.13	8.13	16.25	10.19	26.44	175.48	125.32	300.80	113.00	155.00	268.00	0.00	0.00	0.00	0.00	401.45	193.80	595.24
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.00	630.65	810.65	90.00	130.00	220.00	0.00	0.00	0.00	0.00	861.40	214.28	1075.7
29	Lower Coleroon	3.05	3.05	6.10	4.87	10.97	105.00	536.00	641.00	63.00	83.00	146.00	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.82	80.82	161.63	133.08	294.7	11.10	3250.4	3261.5	349.00	461.00	810.00	0.00	0.00	0.00	0.00	4141.21	225.00	4366.2
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5234**	**6054**	**1483**	**1713**	**3158**	**14**	**361**	**375**		**9013**	**1557**	**10978**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**7778**	**10128**	**2470**	**2908**	**5212**	**249**	**1678**	**1928**		**23087**	**3759**	**27254**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE
(5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.4(b): Results of LP Model for 100% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 5800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws^{'}_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir^{'}_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	0.00	25.68	10.96	16.84	27.80	11.69	71.33	83.02	0	100.37	42.03	142.4
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	48.30	140.51	44.34	68.11	112.45	144.41	84.26	228.67	1134	1384.03	255.46	1639.49
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	0.00	18.22	10.96	16.84	27.80	29.17	111.10	140.27	0	140.14	52.05	192.193
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	0.00	12.90	5.51	8.46	13.97	24.24	69.43	93.67	0	84.02	39.485	123.507
5	KRS	15.85	15.85	31.69	43.60	75.29	130.01	474.59	604.60	139.92	214.90	354.82	0.00	0.00	0.00	1506	2351.25	189.455	2540.71
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**523**	**802**	**212**	**325**	**537**	**210**	**336**	**546**	**2640**	**4060**	**578**	**4638**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	13.11	15.20	189	206.51	4.09	210.595
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	0.00	7.02	4.46	6.18	10.64	0.00	0.00	0.00	276.0	287.15	8.235	295.38
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	0.00	88.51	55.23	70.56	125.79	6.60	263.17	269.77	202	597.23	110.165	707.394
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	21.29	26.18	0	41.13	8.29	49.4206
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	0.00	44.70	27.26	37.78	65.04	9.88	99.23	109.11	290	457.35	62	519.353
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	65.04	66.91	0	67.48	2.29	69.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.48	227.77	362.25	99.07	137.34	236.41	0.00	0.00	0.00	99	574.50	161.43	735.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**228**	**510**	**202**	**274**	**476**	**26**	**485**	**511**	**1151**	**2363**	**363**	**2726**
14	Shimsha.	26.50	26.50	53.00	62.00	115.0	506.00	0.00	506.00	233.00	348.00	581.00	0.00	0.00	0.00	0.00	607.50	594.5	1202
15	Arkavathi	48.50	48.50	97.00	32.00	129.0	22.50	30.30	52.80	10.00	0.00	10.00	0.00	0.00	0.00	0.00	88.80	103	191.8
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.00	178.50	1509.97	1688.47	74.00	109.00	183.00	0.00	0.00	0.00	14.00	1715.47	205	1920.47
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.40	0.00	36.40	32.00	0.00	32.00	0.00	0.00	0.00	0.00	35.50	63.9	99.4
18	Palar	11.60	11.60	23.19	21.03	44.22	100.50	0.00	100.50	11.00	10.00	21.00	0.00	0.00	0.00	0.00	32.60	133.125	165.72
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.63	52.97	177.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61.83	160.714	222.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	123.00	201.00	0.00	275.00	275.00	5800	6276.00	0	6276
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**53**	**178**	**78**	**123**	**201**	**0**	**275**	**275**	**5800**	**6338**	**161**	**6499**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**2344**	**3874**	**852**	**1189**	**2041**	**236**	**1096**	**1332**		**15240**	**2202**	**17442**

Table 7.1.4(b) continued…

Table 7.1.4(b) continued...

Table 7.1.4(b): Results of LP Model for 100% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 5800 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws^{'}_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir^{'}_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.3	334.5	109.9	156.3	266.2	9.9	324.9	334.8	0	853.77	128.07	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	79.10	122.9	51.1	72.7	123.8	0.00	0.00	0.00	408	616.71	59.60	676.31
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**329**	**457**	**161**	**229**	**390**	**10**	**325**	**335**	**408**	**1470**	**188**	**1658**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	81.00	0.00	81.00	0.00	0.00	0.00	0.00	88.96	32.29	121.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	0.00	23.53	20.88	30.91	51.79	3.76	29.30	33.06	0.00	83.45	34.97	118.42
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	262.32	399.96	185.12	274.09		0.00	0.00	0.00	0.00	283.30	205.69	488.99
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**262**	**423**	**206**	**305**	**52**	**4**	**29**	**33**	**0**	**367**	**241**	**607**
26	Tirumanimuttar	109.74	109.74	219.48	198.98	418.4	41.28	142.65	183.93	370.00	350.00	720.00	0.00	0.00	0.00	0.00	972.39	350.00	1322.4
27	Ponnai Ar	8.13	8.13	16.25	10.19	26.44	175.48	126.32	301.80	113.00	155.00	268.00	0.00	0.00	0.00	0.00	402.45	193.80	596.24
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.00	630.65	810.65	90.00	130.00	220.00	0.00	0.00	0.00	0.00	861.40	214.28	1075.67
29	Lower Coleroon	3.05	3.05	6.10	4.87	10.97	105.00	536.00	641.00	63.00	83.00	146.00	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.82	80.82	161.63	133.08	294.7	11.10	3475.0	3486.1	349.00	461.00	810.00	0.00	0.00	0.00	0.00	4366	225.0	4590.8
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5504**	**6324**	**1483**	**1713**	**2687**	**14**	**354**	**368**		**8805**	**1557**	**10770**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**7848**	**10198**	**2470**	**2902**	**4728**	**249**	**1450**	**1700**		**24045**	**3759**	**28212**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. .no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE (5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.4(c): Results of LP Model for 100% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu_{i,j}^{m,g}$	$Iu_{i,j}^{m,s}$	$Ws_{i,j}^{RH}$	$Ws_{i,j}^{RL}$	$Iu_{i,j}^{m}$	$Iu_{i,j}^{r,g}$	$Iu_{i,j}^{r,s}$	$Iu_{i,j}^{r}$	$Ws_{i,j}^{U}$	$Ws_{i,j}^{I}$	$Ws_{i,j}^{'}$	$Ir_{i,j}^{g}$	$Ir_{i,j}^{s}$	$Ir_{i,j}^{'}$	$OE_{i,j,p}^{q,j_g}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	0.00	25.68	10.96	16.84	27.80	11.69	71.33	83.02	0	100.37	42.03	142.40
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	48.30	140.51	44.34	68.11	112.45	144.41	84.26	228.67	1134	1384.0	255.46	1639.49
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	0.00	18.22	10.96	16.84	27.80	29.17	111.10	140.27	0	140.14	52.05	192.19
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	0.00	12.90	5.51	8.46	13.97	24.24	69.43	93.67	0	84.02	39.49	123.51
5	KRS	15.85	15.85	31.69	43.60	75.29	130.0	474.59	604.60	139.92	214.90	354.82	0.00	0.00	0.00	1506	2351.3	189.45	2540.71
Total Upper Cauvry s.b.		24	24	48	66	114	279	523	802	212	325	537	210	336	546	2640	4060	578	4638
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	13.11	15.20	189	206.51	4.09	210.60
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	0.00	7.02	4.46	6.18	10.64	0.00	0.00	0.00	276.0	287.15	8.24	295.38
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	0.00	88.51	55.23	76.56	131.79	6.60	265.17	271.77	202	605.23	110.17	715.39
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	21.29	26.18	0	41.13	8.29	49.42
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	0.00	44.70	27.26	37.78	65.04	9.88	99.23	109.11	290	457.35	62.00	519.35
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	55.04	56.91	0	57.48	2.29	59.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.4	227.77	362.25	99.07	137.34	236.41	0.00	0.00	0.00	99	574.50	161.43	735.93
Total Kabini s.b.		23	23	46	32	78	282	228	510	202	280	482	26	477	503	1151	2361	363	2724
14	Shimsha.	26.50	26.50	53.00	62.00	115.00	506.0	0.00	506.00	233.00	348.00	581.00	0.00	0.00	0.00	0.00	607.50	594.50	1202.00
15	Arkavathi	48.50	48.50	97.00	32.00	129.00	22.50	20.30	42.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.80	103.00	171.80
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.00	178.5	1509.97	1688.47	74.00	109.00	183.00	0.00	0.00	0.00	14.00	1715.47	205.00	1920.47
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.40	0.00	36.40	32.00	0.00	32.00	0.00	0.00	0.00	0.00	35.50	63.90	99.40
18	Palar	11.60	11.60	23.19	21.03	44.22	100.5	0.00	100.53	12.00	0.00	12.00	0.00	0.00	0.00	0.00	23.60	133.16	156.75
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.6	52.97	177.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61.83	160.71	222.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	123.00	201.00	0.00	275.00	275.00	6200	6676.0	0.00	6676.00
Total Chinnar s.b		9	9	18	27	45	125	53	178	78	123	201	0	275	275	6200	6738	161	6899
Total above Mettur		154	154	309	282	591	1530	2334	3864	843	1185	2028	236	1088	1324		15609	2202	17811

Table 7.1.4(c) continued...

Table 7.1.4(c) continued...

Table 7.1.4(c): Results of LP Model for 100% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6200 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu_{i,j}^{m,g}$	$Iu_{i,j}^{m,s}$	$Ws_{i,j}^{RH}$	$Ws_{i,j}^{RL}$	$Iu_{i,j}^{m}$	$Iu_{i,j}^{r,g}$	$Iu_{i,j}^{r,s}$	$Iu_{i,j}^{r}$	$Ws_{i,j}^{U}$	$Ws_{i,j}^{l}$	$Ws'_{i,j}$	$Ir_{i,j}^{g}$	$Ir_{i,j}^{s}$	$Ir'_{i,j}$	$OE_{i,j,p}^{q,j_E}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.3	334.5	109.9	156.3	266.2	9.89	324.88	334.77	0	853.77	128.07	981.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	79.12	122.91	51.12	72.71	123.83	0.00	0.00	0.00	408	616.74	59.60	676.33
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**329**	**457**	**161**	**229**	**390**	**10**	**325**	**335**	**408**	**1471**	**188**	**1658**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	69.00	0.00	69.00	0.00	0.00	0.00	0.00	76.96	32.29	109.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	0.00	23.53	20.88	30.91	51.79	3.76	26.30	30.06	0.00	80.46	34.97	115.42
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	289.45	427.09	185.12	274.09	459.21	0.00	0.00	0.00	0.00	769.64	205.69	975.33
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**289**	**451**	**206**	**305**	**511**	**4**	**26**	**30**	**0**	**850**	**241**	**1091**
26	Tirumanimuttar	109.74	109.74	219.48	198.98	418.46	41.28	159.65	200.93	370.00	350.00	720.00	0.00	0.00	0.00	0.00	989.39	350.00	1339.4
27	Ponnai Ar	8.13	8.13	16.25	10.19	26.44	175.48	158.21	333.69	113.00	155.00	268.00	0.00	0.00	0.00	0.00	434.34	193.80	628.13
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.00	630.65	810.65	90.00	130.00	220.00	0.00	0.00	0.00	0.00	861.40	214.28	1075.7
29	Lower Coleroon	3.05	3.05	6.10	4.87	10.97	105.00	536.00	641.00	63.00	83.00	146.00	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.82	80.82	161.63	133.08	294.7	11.10	3450.4	3461.5	349.00	461.00	810.00	0.00	0.00	0.00	0.00	4341	225.00	4566.2
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5556**	**6376**	**1483**	**1713**	**3134**	**14**	**351**	**365**		**9301**	**1557**	**11266**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**7890**	**10240**	**2470**	**2898**	**5162**	**249**	**1439**	**1689**		**24910**	**3759**	**29077**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. .no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE (5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.4(d): Results of LP Model for 100% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6700 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{l}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_e}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
1	Yagachi	1.24	1.24	2.48	3.42	5.90	25.68	0.00	25.68	10.96	16.84	27.80	11.69	71.33	83.02	0	100.37	42.03	142.40
2	Hemavathi	5.02	5.02	10.04	13.82	23.86	92.21	48.30	140.51	44.34	68.11	112.45	144.41	84.26	228.67	1134	1384.03	255.46	1639.49
3	Harangi	1.24	1.24	2.48	3.42	5.90	18.22	0.00	18.22	10.96	16.84	27.80	29.17	111.10	140.27	0	140.14	52.05	192.19
4	Cauvery	0.63	0.63	1.25	1.72	2.97	12.90	0.00	12.90	5.51	8.46	13.97	24.24	69.43	93.67	0	84.02	39.49	123.51
5	KRS	15.85	15.85	31.69	43.60	75.29	130.0	474.59	604.60	139.92	214.90	354.82	0.00	0.00	0.00	1506	2351.25	189.45	2540.71
Total Upper Cauvry s.b.		**24**	**24**	**48**	**66**	**114**	**279**	**523**	**802**	**212**	**325**	**537**	**210**	**336**	**546**	**2640**	**4059.82**	**578**	**4638**
6	Banasursagar	0.20	0.20	0.40	0.28	0.68	1.52	0.00	1.52	1.76	2.44	4.20	2.09	13.11	15.20	189	206.51	4.09	210.60
7	Mananthvady	0.51	0.51	1.01	0.71	1.72	7.02	0.00	7.02	4.46	6.18	10.64	0.00	0.00	0.00	276.0	287.15	8.24	295.38
8	Kabini	6.27	6.27	12.53	8.79	21.32	88.51	0.00	88.51	55.23	76.56	131.79	6.60	263.17	269.77	202	603.23	110.17	713.39
9	Taraka	0.90	0.90	1.80	1.26	3.06	1.24	0.00	1.24	7.94	11.00	18.94	4.89	21.29	26.18	0	41.13	8.29	49.42
10	Sagardoddakere	0.60	0.60	1.20	0.85	2.05	4.59	0.00	4.59	5.31	7.36	12.67	0.93	23.07	24.00	95	131.34	6.97	138.31
11	Upper Nagu	3.08	3.08	6.16	4.34	10.50	44.70	0.00	44.70	27.26	37.78	65.04	9.88	99.23	109.11	290	457.35	62.00	519.35
12	Nugu	0.11	0.11	0.22	0.16	0.38	0.15	0.00	0.15	0.98	1.35	2.33	1.87	45.04	46.91	0	47.48	2.29	49.77
13	Kabini s.b.r.area	11.32	11.32	22.64	15.63	38.27	134.4	227.77	362.25	99.07	137.34	236.41	0.00	0.00	0.00	99	574.50	161.43	735.93
Total Kabini s.b.		**23**	**23**	**46**	**32**	**78**	**282**	**228**	**510**	**202**	**280**	**482**	**26**	**465**	**491**	**1151**	**2348.68**	**363**	**2712**
14	Shimsha.	26.50	26.50	53.00	62.00	115.00	506.0	0.00	506.00	233.00	348.00	581.00	0.00	0.00	0.00	0.00	607.50	594.50	1202.00
15	Arkavathi	48.50	48.50	97.00	32.00	129.00	22.50	20.30	42.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.80	103.00	171.80
16	Middle Cauvery	8.50	8.50	17.00	18.00	35.00	178.5	1410.0	1588.5	74.00	109.00	183.00	0.00	0.00	0.00	14.00	1615.47	205.00	1820.47
17	Suvarnavathi	3.50	3.50	7.00	24.00	31.00	36.40	0.00	36.40	32.00	0.00	32.00	0.00	0.00	0.00	0.00	35.50	63.90	99.40
18	Palar	11.60	11.60	23.19	21.03	44.22	100.5	0.00	100.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.60	133.16	144.75
19	Chinnar s.b.r.area	8.86	8.86	17.71	27.23	44.94	124.6	52.97	177.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61.83	160.71	222.54
20	Mettur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.00	123.00	201.00	0.00	275.00	275.00	6700	7176.00	0.00	7176.00
Total Chinnar s.b		**9**	**9**	**18**	**27**	**45**	**125**	**53**	**178**	**78**	**123**	**201**	**0**	**275**	**275**	**6700**	**7237.8**	**161**	**7399**
Total above Mettur		**154**	**154**	**309**	**282**	**591**	**1530**	**2234**	**3764**	**831**	**1185**	**2016**	**236**	**1076**	**1312**		**15985**	**2202**	**18187**

Table 7.1.4(d) continued…

Table 7.1.4(d) continued…

Table 7.1.4(d): Results of LP Model for 100% Water Year Annual Dependable Flow (Maximization of Water Utilization)

Sl.No.	Sub-basin/ Project	Export From Mettur Reservoir = 6700 MCM																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
		IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
21	Lower Bhawani	12.44	12.44	24.88	21.54	46.42	84.20	250.28	334.48	109.88	56.29	166.17	9.89	324.88	334.77	0	753.77	128.07	881.84
22	Bhavani s.b.r.area	5.79	5.79	11.57	10.02	21.59	43.79	79.12	122.91	51.12	72.71	123.83	0.00	0.00	0.00	408	616.74	59.60	676.33
Total Bhawani s.b.		**18**	**18**	**36**	**32**	**68**	**128**	**329**	**457**	**161**	**129**	**290**	**10**	**325**	**335**	**408**	**1371**	**188**	**1558**
23	Noyil	5.95	5.95	11.90	8.25	20.15	18.09	2.01	20.10	61.00	0.00	61.00	0.00	0.00	0.00	0.00	68.96	32.29	101.25
24	Amaravathi	2.37	2.37	4.73	5.31	10.04	23.53	0.00	23.53	20.88	30.91	51.79	3.76	26.30	30.06	0.00	80.46	34.97	115.42
25	Amaravathi s.b.r.area	20.98	20.98	41.96	47.07	89.03	137.64	312.21	449.85	185.12	274.09	459.21	0.00	0.00	0.00	0.00	792.40	205.69	998.09
Total Amaravathi s.b.		**23**	**23**	**47**	**52**	**99**	**161**	**312**	**473**	**206**	**305**	**511**	**4**	**26**	**30**	**0**	**872.9**	**241**	**1114**
26	Tirumanimuttar	109.74	109.74	219.48	198.98	418.4	41.28	169.87	211.15	370.00	350.00	720.00	0.00	0.00	0.00	0.00	999.61	350.00	1349.6
27	Ponnai Ar	8.13	8.13	16.25	10.19	26.44	175.48	169.32	344.80	113.00	155.00	268.00	0.00	0.00	0.00	0.00	445.45	193.80	639.24
28	Upper Coleroon	10.75	10.75	21.49	23.53	45.02	180.00	830.65	1010.7	90.00	130.00	220.00	0.00	0.00	0.00	0.00	1061.40	214.28	1275.7
29	Lower Coleroon	3.05	3.05	6.10	4.87	10.97	105.00	536.00	641.00	63.00	83.00	146.00	0.00	0.00	0.00	0.00	685.05	112.92	797.97
30	Cauvery Delta	80.82	80.82	161.63	133.08	294.7	11.10	3475.0	3486.1	349.00	461.00	810.00	0.00	0.00	0.00	0.00	4365.82	225.00	4590.8
Total below Mettur		**260**	**260**	**520**	**463**	**983**	**820**	**5824**	**6645**	**1483**	**1613**	**3026**	**14**	**351**	**365**		**9461.6**	**1557**	**11018**
Gross Total		**414**	**414**	**829**	**745**	**1574**	**2350**	**8058**	**10408**	**2470**	**2798**	**5042**	**249**	**1427**	**1677**		**14942**	**3759**	**29206**

* Includes sub-basin remaining areas (s.b.r.areas)

Note: (A) Col. no. (5) = Col. no. (3) + Col. no. (4); Col. no. (7) = Col. no. (5) + Col. no. (6); Col. no. (10) = Col. no.(8) + Col. no (9); Col. no. (16) = Col. no.(14) + Col. no(15); Col. no. (13) = Col. no.(11) + Col. no(12); Col. no. (18) = Col. no.(4) + Col. no(13) + Col. no.(15) + Col. no.(17); Col. no. (19) = Col. no.(3) + Col. no (6) + Col. no. (14). Col. no. (20) = Col. no. (18) + Col. no. (19).

(B) (1) IUM = IUMH + IUML; (2) IUR = IURG + IURS; (3) IRD = IRG + IRS; (4) Total surface water utilization = IUMHS + IRS + WSD + IRD + OE (5) Total ground water utilization = IUMHG + IUML + IRG; (6) Total water Utilization = [IUM + IUR] + [WSD + IRD] + [OE].

Table 7.1.5(a): Results of LP Model for 50%, 75%, 90%, 100% Water Year Annual Dependable Flows with Various Exports from Mettur to the Sub-Basins Below Mettur Reservoir (Above Mettur)

Dep. %	Exports from Mettur	Above Mettur																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu_{i,j}^{m,g}$	$Iu_{i,j}^{m,s}$	$Ws_{i,j}^{RH}$	$Ws_{i,j}^{RL}$	$Iu_{i,j}^{m}$	$Iu_{i,j}^{r,g}$	$Iu_{i,j}^{r,s}$	$Iu_{i,j}^{r}$	$Ws_{i,j}^{U}$	$Ws_{i,j}^{l}$	$Ws_{i,j}^{'}$	$Ir_{i,j}^{g}$	$Ir_{i,j}^{s}$	$Ir_{i,j}^{'}$	$OE_{i,j,p}^{q,j_g}$	Surface water	Ground water	Total
	Reservoir	IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
50	4200	155	154	309	282	591	1530	4350	6080	997	1228	2225	236	2754	2990	-	9483	2202	19690
	5800	155	154	309	282	591	1530	4865	6394	952	1278	2230	236	2786	3022	-	10035	2202	12237
	6200	155	154	309	282	591	1530	4479	6011	932	1278	2210	236	2844	3080	-	9687	2202	11889
	7800	155	154	309	282	591	1530	4068	5597	912	1278	2190	236	2822	3058	-	9234	2202	11436
75	4200	155	154	309	282	591	1527		6077	900	1248	2148	236	2730	2966	-	9382	2199	11582
	5800	155	154	309	282	591	1527	3835	5582	880	1248	2128	236	2720	2956	-	8837	2199	11036
	6200	155	154	309	282	591	1530	3496	5265	870	1252	2122	236	2740	2976	-	8512	2202	10714
	7800	155	154	309	282	591	1530	3355	5134	870	1252	2122	236	2670	2906	-	8301	2202	10503
90	4200	155	154	309	282	591	1530	3215	4745	880	1222	2102	236	1607	1843	-	7078	2202	9280
	5800	155	154	309	282	591	1530	2922	4452	870	1222	2092	236	1482	1717	-	6650	2202	8852
	6200	155	154	309	282	591	1530	2812	4342	860	1222	2082	236	1472	1707	-	6520	2202	8722
	7800	155	154	309	282	591	1530	2456	3985	850	1222	2072	236	1404	1640	-	6086	2202	8288
100	4200	155	154	309	282	591	1530	2544	4074	803	1215	2018	236	1304	1540	-	6020	2202	8222
	5800	155	154	309	282	591	1530	2344	3874	793	1215	2008	236	1094	1330	-	5600	2202	7802
	6200	155	154	309	282	591	1530	2334	3864	783	1215	1998	236	1084	1320	-	5570	2202	7772
	7800	155	154	309	282	591	1530	2234	3764	773	1215	1988	236	1074	1310	-	5404	2202	7652

Table 7.1.5(b): Results of LP Model for 50%, 75%, 90%, 100% Water Year Annual Dependable Flows with Various Exports from Mettur to the Sub-Basins Below Mettur Reservoir (Below Mettur)

Dep. %	Exports from Mettur	Below Mettur																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws^{'}_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir^{'}_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
	Reservoir	IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
50	4200	260	260	520	463	983	820	5536	6356	1441	1756	3197	14	523	537	-	9517	1557	**11073**
	5800	260	260	519.99	462.84	982.83	820.12	5860.9	6681.06	1441	1753	3194	14	523	537	-	9838	1557	**11394.92**
	6200	260	260	519.99	462.84	982.83	820.12	5923.8	6743.89	1441	1753	3194	14	523	537	-	9901	1557	**11457.75**
	7800	260	260	519.99	462.84	982.83	820.12	5966.7	6786.77	1441	1753	3194	14	523	537	-	9944	1557	**11500.63**
75	4200	260	260	520	463	983	820	5510	6330	1441	1756	3197	4	533	537	-	9500	1547	**11047**
	5800	260	260	519.99	462.84	982.83	820.12	5658	6478.07	1441	1753	3194	14	480	493	-	9592	1557	**11148.34**
	6200	260	260	519.99	462.84	982.83	820.12	5756.1	6576.27	1441	1753	3194	14	480	493	-	9690	1557	**11246.54**
	7800	260	260	519.99	462.84	982.83	820.12	5785.4	6605.5	1441	1753	3194	14	480	493	-	9719	1557	**11275.77**
90	4200	260	260	520	463	983	820	5392	6212	1441	1756	3197	14	480	493	-	9328	1557	**10885**
	5800	260	260	520	463	983	820	5691	6511	1441	1756	3197	14	490	503	-	9638	1557	**11195**
	6200	260	260	520	463	983	820	5824	6644	1441	1756	3197	14	383	396	-	9664	1557	**11221**
	7800	260	260	520	651	1171	820	6006	6826	1441	1756	3197	14	383	396	-	9846	1745	**11591**
100	4200	260	260	520	463	983	820	5234	6054	1441	1753	3194	14	361	375	-	9049	1557	**10606**
	5800	260	260	519.99	462.84	982.83	820.12	5504.3	6324.45	1441	1753	3194	14	354	368	-	9313	1557	**10869.11**
	6200	260	260	519.99	462.84	982.83	820.12	5555.8	6375.89	1441	1753	3194	14	351	365	-	9361	1557	**10917.55**
	7800	260	260	519.99	462.84	982.83	820.12	5824.5	6644.58	1441	1653	3094	14	351	365	-	9530	1557	**11086.24**

Table 7.1.5(c): Results of LP Model for 50%, 75%, 90%, 100% Water Year Annual Dependable Flows with Various Exports from Mettur to the Sub-Basins Below Mettur Reservoir (Total)

Dep. %	Exports from Mettur	Total																	
		U/S water utilization from minor and medium irrigation projects*								D/s water utilization from major irrigation projects						Exports	Water utilization		
		$Iu^{m,g}_{i,j}$	$Iu^{m,s}_{i,j}$	$Ws^{RH}_{i,j}$	$Ws^{RL}_{i,j}$	$Iu^{m}_{i,j}$	$Iu^{r,g}_{i,j}$	$Iu^{r,s}_{i,j}$	$Iu^{r}_{i,j}$	$Ws^{U}_{i,j}$	$Ws^{I}_{i,j}$	$Ws'_{i,j}$	$Ir^{g}_{i,j}$	$Ir^{s}_{i,j}$	$Ir'_{i,j}$	$OE^{q,j_E}_{i,j,p}$	Surface water	Ground water	Total
	Reservoir	IUMHG	IUMHS	IUMH	IUML	IUM	IURG	IURS	IUR	WSU	WSI	WSD	IRG	IRS	IRD	OE			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
50	4200	414	414	829	745	1574	2350	10943	13293	2403	3034	5437	249	3428	3678	-	20223	3759	23981
	5800	414	414	829	745	1574	2350	10726	13075	2393	3031	5424	249	3060	3309	-	19624	3759	23383
	6200	414	414	829	745	1574	2350	10402	12755	2373	3031	5404	249	3118	3368	-	19339	3759	23098
	7800	414	414	829	745	1574	2350	10034	12384	2353	3031	5384	249	3096	3346	-	18929	3759	22687
75	4200	414	414	829	745	1574	2347	9860	12407	2341	3004	5345	240	3263	3503	-	18882	3746	22628
	5800	414	414	829	745	1574	2347	9493	12060	2321	3001	5322	249	3200	3449	-	18429	3756	22185
	6200	414	414	829	745	1574	2350	9452	12042	2311	3005	5316	249	3220	3469	-	18402	3759	22160
	7800	414	414	829	745	1574	2350	9252	11842	2311	3005	5316	249	3220	3469	-	18202	3759	21960
90	4200	414.4	414.4	829	745	1574	2349.9	8606	10956	2321	2978.2	5298.9	249.42	2086.9	2336	-	16407	3758.8	20165.38
	5800	414	414	829	745	1574	2350	8613	10963	2311	2978	5289	249	1971	2221	-	16288	3759	20047
	6200	414	414	829	745	1574	2350	8636	10986	2301	2978	5279	249	1854	2104	-	16184	3759	19943
	7800	414	414	829	934	1762	2350	8462	10811	2291	2978	5269	249	1787	2036	-	15932	3947	19879
100	4200	414	414	829	745	1574	2350	7778	10128	2244	2968	5212	249	1665	1915	-	15069	3759	18828
	5800	414	414	829	745	1574	2350	7848	10198	2234	2968	5202	249	1448	1698	-	14913	3759	18671
	6200	414	414	829	745	1574	2350	7890	10240	2224	2968	5192	249	1435	1685	-	14931	3759	18690
	7800	414	414	829	745	1574	2350	8058	10408	2214	2868	5082	249	1425	1675	-	14980	3759	18739

Table 7.2.1: Yagachi Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy (cereals)	12323	100	100	100	100	541
2	Kh.Jowar (cereals)	1042	100	100	100	100	138
3	Kh.Ragi (cereals)	3861	100	100	100	100	238
4	Fodder	2060	100	100	0	100	0
5	Tobacco	1042	100	100	0	100	0
6	Pulses	1801	100	100	87	100	215
7	Fruits & Veg.	2060	100	100	198	100	202
8	Groundnut (Oilseeds)	1042	99	99	58	99	47
9	Sugarcane	515	99	99	0	99	0
Total		25746	100	100	71	100	153
Objective function value			25736	25736	18280	25734	39391

Table 7.2.2: Hemavathi Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy (cereals)	127238	100	100	100	100	452
2	Kh.Jowar (cereals)	10603	100	100	100	100	114
3	Kh.Ragi (cereals)	39762	100	100	100	100	199
4	Fodder	21206	100	100	0	100	0
5	Tobacco	10603	100	100	0	100	0
6	Pulses	18556	100	100	88	100	205
7	Fruits & Veg.	21206	100	100	200	100	853
8	Groundnut	10603	100	100	57	100	66
9	Sugarcane	5302	100	100	0	100	0
Total		265079	100	100	72	100	210
Objective function value			265079	265079	190857	265079	112434

Table 7.2.3: Harangi Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity					
			Objective Function					
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy (cereals)	25698	100	100	100	100	452
2	Kh.Jowar (cereals)	2142	100	100	100	100	114
3	Kh.Ragi (cereals)	8031	100	100	100	100	199
4	Fodder	4283	100	100	0	100	0
5	Tobacco	2142	100	100	0	100	0
6	Pulses	3748	100	100	88	100	205
7	Fruits & Veg.	4283	100	100	200	100	853
8	Groundnut	2142	100	100	57	100	66
9	Sugarcane	1071	100	100	0	100	0
Total		53540	100	100	72	100	210
Objective function value			53540	53540	38549	53540	112434

Table 7.2.4: Cauvery Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy (cereals)	19440	100	100	100	100	452
2	Kh.Jowar (cereals)	1620	100	100	100	100	114
3	Kh.Ragi (cereals)	6075	100	100	100	100	199
4	Fodder	3290	100	100	0	100	0
5	Tobacco	1620	97	97	0	100	0
6	Pulses	1620	100	100	49	100	117
7	Fruits & Veg.	2835	100	100	175	98	747
8	Groundnut	3240	100	100	200	100	132
9	Sugarcane	810	100	94	0	100	0
Total		40550	100	99	80	100	196
Objective function value			40541	40410	32440	40550	79478

Table 7.2.5: Krishnarajasagar (KRS) Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy (cereals)	54529	100	100	100	100	452
2	Kh.Jowar (cereals)	4544	100	100	100	100	114
3	Kh.Ragi (cereals)	17040	100	100	100	100	199
4	Fodder	9088	100	100	0	100	0
5	Tobacco	4544	100	100	0	100	0
6	Pulses	7952	100	100	88	100	205
7	Fruits & Veg.	9088	100	100	200	100	853
8	Groundnut	4544	100	100	57	100	66
9	Sugarcane	2272	100	100	0	100	0
Total		113601	100	100	72	100	210
Objective function value			113601	113601	81793	113601	23856

Table 7.2.6: Banasuasagar Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	276	525	525	584	525	77
2	Kh.Jowar	460	100	100	100	100	387
3	Kh.Ragi	920	100	100	100	100	361
4	Fodder	460	100	100	0	100	0
5	Cotton	460	17	17	0	17	0
6	Rabi Paddy	460	75	75	89	75	400
7	Pulses	1380	100	100	300	100	436
8	Fruits & Veg.	736	100	100	160	100	361
9	Groundnut	644	100	100	47	100	0
10	Sugarcane	460	2	2	0	2	0
11	Coconut	180	15	100	100	0	0
Total		6436	137	147	164	135	225
Objective function value			8817	9461	10555	8688	14481

Table 7.2.7: Mananthvady Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	6750	78	99	99	99	88
2	Kh.Jowar	1125	87	91	100	100	100
3	Kh.Ragi	2250	100	100	100	100	41
4	Fodder	1125	100	100	100	100	0
5	Cotton	1125	100	100	100	100	0
6	Rabi Paddy	1125	100	100	100	100	100
7	Pulses	3375	100	100	100	100	100
8	Fruits & Veg.	1800	100	100	100	100	41
9	Groundnut	1575	100	100	100	100	100
10	Sugarcane	1125	100	100	100	100	0
11	Coconut	1125	100	100	100	100	0
Total		22500	97	99	100	100	52
Objective function value			21825	22275	22410	22136	11700

Table 7.2.8: Kabini Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	13719	100	100	100	100	882
2	Kh.Jowar	2287	100	100	100	100	443
3	Kh.Ragi	4573	100	100	100	100	414
4	Fodder	2287	100	100	0	100	0
5	Cotton	2287	100	100	0	100	0
6	Rabi Paddy	2287	100	100	100	100	458
7	Pulses	6859	100	100	300	100	4997
8	Fruits & Veg.	3658	100	100	160	100	414
9	Groundnut	3201	100	100	47	100	0
10	Sugarcane	2286	100	100	0	100	0
11	Coconut	2286	100	100	0	100	0
Total		45730	100	100	82	100	692
Objective function value			45730	45730	34499	45730	

Table 7.2.9: Taraka Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops: Without minimum food requirements	Annual benefits from crops: With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	5790	41	45	68	45	176
2	Kh.Jowar	965	100	100	100	100	44
3	Kh.Ragi	1930	100	100	100	100	103
4	Fodder	965	100	100	0	100	0
5	Cotton	965	100	82	0	82	0
6	Rabi Paddy	965	97	98	100	98	694
7	Pulses	2895	100	100	300	100	2082
8	Fruits & Veg.	1544	100	100	160	100	0
9	Groundnut	1351	100	72	47	72	0
10	Sugarcane	97	99	100	0	100	0
11	Coconut	965	71	100	0	100	0
Total		18432	92	91	80	91	282
Objective function value			16957	16773	14746	16773	51978

Table 7.2.10: Sagardoddakare Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops: Without minimum food requirements	Annual benefits from crops: With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	510	100	100	100	100	163
2	Kh.Jowar	85	100	100	600	100	82
3	Kh.Ragi	170	100	100	300	100	76
4	Fodder	85	100	100	0	100	0
5	Cotton	85	100	100	0	100	0
6	Rabi Paddy	85	100	100	600	100	85
7	Pulses	255	100	100	600	100	923
8	Fruits & Veg.	136	100	100	600	100	76
9	Groundnut	119	100	100	200	100	0
10	Sugarcane	85	100	100	0	100	0
11	Coconut	85	100	100	0	100	0
Total		1700	100	100	273	100	128
Objective function value			1700	1700	4641	1700	2176

Table 7.2.11 : Upper Nugu Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	12141	36	26	31	26	210
2	Kh.Jowar	2024	0	100	100	100	106
3	Kh.Ragi	4047	21	100	100	100	98
4	Fodder	2024	100	100	0	100	0
5	Cotton	2024	0	26	0	26	0
6	Rabi Paddy	2024	94	10	10	10	109
7	Pulses	6071	17	100	300	100	118
8	Fruits & Veg.	3238	5	100	160	100	98
9	Groundnut	2833	100	34	16	34	0
10	Sugarcane	2024	0	0	0	0	0
11	Coconut	2024	44	0	0	0	0
Total		40474	38	54	65	54	67
Objective function value			15380	21856	26308	21856	27118

Table 7.2.12 : Nugu Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	3158	100	100	100	100	229
2	Kh.Jowar	526	100	100	100	100	115
3	Kh.Ragi	1053	100	100	100	100	108
4	Fodder	526	100	100	0	100	0
5	Cotton	526	100	100	0	100	0
6	Rabi Paddy	526	100	100	100	100	119
7	Pulses	1579	100	100	300	100	129
8	Fruits & Veg.	842	100	100	160	100	108
9	Groundnut	737	100	100	47	100	0
10	Sugarcane	526	100	100	0	100	0
11	Coconut	526	100	100	0	100	0
Total		10526	100	100	82	100	73
Objective function value			10526	10526	8631	10526	7684

Table 7.2.13: Mettur Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	2732	100	100	100	100	139
2	Kh.Jowar	1821	0	0	4	0	280
3	Kh.Ragi	1821	100	100	100	100	130
4	Fodder	1821	100	100	100	100	0
5	Cotton	1821	100	100	0	100	0
6	Rabi Paddy	1821	100	100	100	100	289
7	Pulses	2732	100	100	150	100	245
8	Fruits & Veg.	911	100	100	0	100	526
9	Groundnut	911	100	100	33	100	0
10	Sugarcane	911	100	100	0	100	0
11	Coconut	911	100	100	0	100	0
Total		18213	91	91	53	91	146
Objective function value			16574	16574	9653	16529	26590

Table 7.2.14 : Lower Bhavani Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	11421	100	60	60	60	83
2	Kh.Jowar	19035	100	100	100	100	280
3	Kh.Ragi	3807	100	100	0	100	130
4	Fodder	3807	100	100	0	100	0
5	Cotton	7614	10	100	100	100	0
6	Rabi Paddy	7614	100	100	100	100	289
7	Pulses	11421	100	100	100	100	245
8	Fruits & Veg.	11421	100	100	100	100	526
9	Groundnut	11421	100	100	100	100	0
10	Sugarcane	3807	100	100	0	100	0
11	Coconut	3807	100	100	0	100	0
Total		95175	92	96	60	96	141
Objective function value			87561	91368	57105	91368	134197

Table 7.2.15 : Amaravathi Project - LP Model Results with Crop Considerations

Sl.No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Kh.Paddy	1214	100	100	100	100	176
2	Kh.Jowar	2024	100	100	100	100	53
3	Kh.Ragi	405	100	100	0	100	0
4	Fodder	405	100	100	0	100	0
5	Cotton	809	100	100	100	100	0
6	Rabi Paddy	809	100	100	100	100	132
7	Pulses	1214	100	100	100	100	35
8	Fruits & Veg.	1214	100	100	100	100	71
9	Groundnut	1214	100	100	100	100	294
10	Sugarcane	405	100	100	0	100	0
11	Coconut	405	100	100	0	100	0
Total		10118	100	100	64	100	69
Objective function value			10118	10118	6476	10118	6981

Table 7.2.16: Abstract - LP Model Results with Crop Considerations

Sl. No.	Name of Crop	Crop Area Proposed in project report	Cropping Intensity				
			Objective Function				
			Annual water utilization	Area to be irrigated annually	Annual food production	Annual benefits from crops	
						Without minimum food requirements	With minimum food requirements
		(Ha)	%	%	%	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Upper Cauvery Sub-basin						
1	Yagachi	25746	100	100	71	100	153
2	Hemavathi	265079	100	100	72	100	210
3	Harangi	53540	100	100	72	100	210
4	Cauvery	40550	100	99	80	100	196
5	Krishnarajsagar (KRS)	113601	100	100	72	100	210
	Kabini Sub-basin						
6	Banasurasagar	6436	137	147	164	135	225
7	Mananthvady	22500	97	99	86	100	52
8	Kabini	45730	100	100	82	100	692
9	Taraka	18432	92	91	80	91	282
10	Sagardoddakere	1700	100	100	273	100	128
11	Upper Nugu	40474	38	54	65	54	67
12	Nugu	10526	100	100	82	100	73
	Chinnar Sub-basin						
13	Mettur	18213	91	91	53	91	146
	Bhavani Sub-basin						
14	Lower Bhavani	95175	92	96	60	96	141
	Amaravathi Sub-basin						
15	Amaravathi	10118	100	100	64	100	69

Table 7.3.1: Parameters Used in Hydropower Energy Computations

Sl. No.	Name of Project	Dead Storage Level (m)	Gross Storage Level (m)	Dead Storage Capacity MCM	Gross Storage Capacity MCM	Tail Water Level /Av.Head (m)	Installed Capacity (MW)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Banasurasagar	754.86	772.10	23.75	166.86	734.90	231.00
2	Mananthvady	734.50	748.50	156.15	607.78	723.50	817.00
3	Kabini	685.50	696.16	99.00	552.00	17.50	98.00
4	Mettur	NA	240.79	62.02	2708.79	23.78	240.00

Note: Overall hydropower energy generation efficiency = 0.85.

Table 7.3.2: Hydropower Energy Computations for Banasurasagar Reservoir

Sl. No.	Month	Releases from Reservoir		Initial storage	Final storage	Average storage	Head	Power generated	Energy generated
		(MCM)	m3/Sec)	(MCM)	(MCM)	(MCM)	(m)	(MW)	(MWhr)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	1	4.22	1.60	16.58	45.25	187.07	306	52.9	38631.6
2	2	4.50	1.71	45.25	104.43	230.99	377	69.7	50893.9
3	3	4.40	1.68	104.43	107.85	262.29	428	77.5	56577.8
4	4	3.54	1.35	107.85	107.88	264.02	431	62.7	45739.4
5	5	0.51	0.20	107.88	124.42	272.30	445	9.4	6855.8
6	6	1.26	0.48	124.42	116.92	276.82	452	23.4	17047.5
7	7	2.36	0.90	116.92	90.86	260.04	425	41.2	30097.5
8	8	3.36	1.28	90.86	52.91	228.04	373	51.4	37550.3
9	9	3.06	1.16	52.91	17.99	191.60	313	39.3	28696.1
10	10	1.66	0.63	17.99	0.43	165.36	270	18.4	13454.5
11	11	0.49	0.19	0.43	5.12	158.92	260	5.2	3811.1
12	12	0.30	0.11	5.12	16.58	167.00	273	3.3	2437.9
								Annual	331793.5

Table 7.3.3: Hydropower Energy Computations for Mananthvady Reservoir

Sl. No.	Month	Releases from Reservoir		Initial storage	Final storage	Average storage	Head	Power generated	Energy generated
		(MCM)	m3/Sec)	(MCM)	(MCM)	(MCM)	(m)	(MW)	(MWhr)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	1	0.87	0.33	35.00	102.026	92.26	28.3	1.01	739.45
2	2	0.90	0.34	102.03	274.356	211.94	64.9	2.41	1760.77
3	3	29.32	11.16	274.36	232.389	277.12	84.9	102.26	74646.92
4	4	0.87	0.33	232.39	226.161	253.03	77.5	2.78	2027.90
5	5	0.90	0.34	226.16	297.535	285.60	87.5	3.25	2372.70
6	6	0.87	0.33	297.53	313.107	329.07	101	3.61	2637.38
7	7	78.45	29.85	313.11	198.226	279.42	85.6	275.85	201371.18
8	8	0.90	0.34	198.23	143.282	194.50	59.6	2.21	1615.91
9	9	0.82	0.31	143.28	96.32	143.55	44	1.48	1080.34
10	10	83.79	31.88	96.32	83.79	113.80	34.9	119.99	87592.14
11	11	0.87	0.33	83.79	20.43	75.86	23.2	0.83	607.97
12	12	0.90	0.34	20.43	35.00	51.46	15.8	0.59	427.54
								Annual	376880.21

Table 7.3.4: Hydropower Energy Computations for Kabini Reservoir

Sl. No.	Month	Releases from Reservoir		Initial storage	Final storage	Average storage	Head	Power generated	Energy generated
		(MCM)	m3/Sec)	(MCM)	(MCM)	(MCM)	(m)	(MW)	(MWhr)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	1	28.11296	10.70	144.75	310.395	326.57	17.55	20.27	14797.71
2	2	161.8819	61.60	310.39	206.469	357.43	19.21	127.76	93261.47
3	3	316.7635	120.53	206.47	113.1	258.78	13.91	180.99	132124.71
4	4	272.2151	103.58	113.1	97.2665	204.18	10.97	122.72	89586.52
5	5	460.0645	175.06	97.266	171.368	233.32	12.54	237.00	173011.80
6	6	49.70735	18.91	171.37	453	411.18	22.10	45.13	32943.30
7	7	88.12823	33.53	453	395.834	523.42	28.13	101.85	74348.72
8	8	140.1941	53.35	395.83	177.211	385.52	20.72	119.33	87114.39
9	9	111.5126	42.43	177.21	93.21	234.21	12.59	57.67	42095.97
10	10	63.88646	24.31	93.21	71.36	181.29	9.74	25.57	18667.29
11	11	23.1902	8.82	71.36	68.5891	168.97	9.08	8.65	6315.91
12	12	16.8036	6.39	68.589	144.747	205.67	11.05	7.63	5570.32
									769838.12

Table 7.3.5: Hydropower Energy Computations for Mettur Reservoir

Sl. No.	Month	Releases from Reservoir		Initial storage	Final storage	Average storage	Head	Power generated	Energy generated
		(MCM)	m3/Sec)	(MCM)	(MCM)	(MCM)	(m)	(MW)	(MWhr)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	1	43.94	16.72	1226.42	1628.64	1489.55	25.6	46.15	33688.20
2	2	53.55	20.38	1628.64	789.59	1271.13	21.8	48.00	35039.33
3	3	48.80	18.57	789.59	325.12	619.373	10.6	21.31	15557.40
4	4	32.84	12.50	325.12	421.39	435.275	7.47	10.08	7357.60
5	5	18.81	7.16	421.39	280.25	412.838	7.09	5.48	3997.58
6	6	17.69	6.73	280.25	409.07	406.677	6.98	5.07	3702.90
7	7	23.53	8.95	409.07	467.96	500.536	8.59	8.30	6061.88
8	8	33.25	12.65	467.96	779.20	685.6	11.8	16.08	11734.77
9	9	39.54	15.04	779.20	1012.39	957.817	16.4	26.70	19492.43
10	10	44.72	17.02	1012.39	1078.27	1107.35	19	34.92	25491.45
11	11	26.55	10.10	1078.27	1158.57	1180.44	20.3	22.10	16130.25
12	12	26.96	10.26	1158.57	1226.42	1254.51	21.5	23.85	17407.51

Chapter – 8

ANALYSIS OF LINEAR PROGRAMMING MODEL RESULTS

8.1 INTRODUCTION

The objective of this research work was to develop a linear programming (LP) model which can be used for planning the development measures of a real life large size transboundary river basin, i.e., for Cauvery river basin, a major river basin in India. The details of the study area are discussed in Chapter 3. Before planning for intra-basin water transfers among the sub-basins lying within a major river basin, water balance of each sub-basin is carried out, with the purpose of identifying water surplus and water deficit sub-basins. In Chapter 4, therefore, the monthly water balance studies on an annual basis, for all the sixteen sub-basins in Cauvery river basin and Cauvery basin as a whole, for the projected population in the Cauvery basin for the scenario 2050 AD were carried out. The water balance studies are done for, with and without the considerations of the ground water availability in the basins. In the water balance study of each sub-basin, the basin was considered as one entity, which lacked the consideration of the influence of the effects of the locations of the various projects involved and the aerial distribution of the runoff in the basin, on the basin's water balance. In order to see the influence of these factors, the LP technique was applied. Therefore, a LP model was developed and applied to the Cauvery river basin. The model can be applied to any river basin planning problem, and is described in Chapter 5. For analysis the 75%, 50%, 90% and 100% water year dependable flows were used. The necessary data needed for the LP model has been computed in

Chapter 6. The computed results of LP model are presented in Chapter 7. The analysis of the results is presented in this chapter.

The LP model is basically related to the conjunctive water use development in the river basin. The amount of the ground water resources available is fixed, and was taken as the same in all the model runs. For considering the surface water availability as a resource in the model, firstly, the model was run for 75% water year dependable flow, representing a normal water year for the Cauvery river basin as a whole, with consideration of various water exports from the Mettur reservoir to the down-stream sub-basins below Mettur, then, it was run for the two water shortage years, i.e., the 90% (a water deficit year), and the 100% (a critical water deficit year) water year dependable flows and one water surplus year, i.e., the 50%(a water surplus year) water year dependable flow.

The annual water export quantity to be released from the Mettur reservoir to the sub-basins lying in the downstream reaches of the Cauvery river below Mettur was considered for the following cases: (i) for an amount equal to the interim award of Cauvery Water Dispute Tribunal (CWDTIA), i.e., for 5800 MCM; (ii) for 4200 MCM; (iii) for 6200 MCM; and (iv) for 7200 MCM, 7800 MCM, 6900 MCM and 6700 MCM for the four flows, respectively.

Five objective functions were considered for analyzing various options, mainly related to the irrigation development. The first of them was to maximize, the annual water utilizations from irrigation, and water supply (i.e., domestic and industrial), from major projects, and was subjected to the various constraints on the system related to the availability of surface and ground waters; intra-basin exports; intra-basin imports; regenerations from irrigation, domestic and industrial uses;

hydropower; and water needs for environmental purposes; excluding the constraints related to the crops. For this objective function, irrigation was considered as lumped at each major project (reservoir), i.e., in terms of the contribution of surface water in the volume of annual irrigation water required to be diverted from each reservoir, as the decision variable in the model. The next two objective functions were to maximize the annual irrigation water use, and to maximize the irrigated crop areas, respectively; with the crop areas as the decision variables in the model for both the objective functions. In the remaining two objective functions the objective was to maximize the total annual net benefits from crops, to maximize the agricultural food production in the basin, respectively. These last four objective functions were subjected to the constraints related to crops only, i.e. 5.3.6, 5.3.7, 5.3.8, and 5.3.9.

The last objective function was also subjected to the constraints of minimum food needs in the basin, i.e., 5.3.10.1, 5.3.10.2, 5.3.10.3, and 5.3.10.4.

The results of LP model for maximization of water utilization for the Cauvery river basin as a whole are given in Tables 7.1(a) to 7.1(d), Tables 7.2(a) to 7.2(d), Tables 7.3(a) to 7.3(d), and Tables 7.4(a) to 7.4(d), for 75%, 50%, 90%, and 100% water year dependable flows, respectively.

8.2 ANALYSIS OF LP MODEL RESULTS FOR LUMPED IRRIGATION AND WATER SUPPLY FROM MAJOR PROJECTS

8.2.1 General

The LP model was run for maximization of water utilization for the Cauvery basin as a whole considering the objective function given by equation 5.2.1-I. The results obtained from the model computations are first analyzed thoroughly, keeping in view the objectives of the problem. An adequate analysis helps in the proper decision making process, before the decisions are actually implemented in practice.

The detailed analysis of the LP model results is done (i) at the individual major project/site level, (ii) at all the sixteen sub-basins level and (iii) for the Cauvery river basin as a whole; for the 75% water year dependable flow. But, the analysis for the flows of other dependabilities is also briefly discussed. Similarly, the 5800 MCM export of water from Mettur reservoir to the sub-basins below Mettur is of main concern, and thus, the detailed analysis gives more emphasis to this aspect.

In the text below, the 'upstream' water demands at the upstream of a major project are many times referred to as 'at the medium and minor projects'; similarly, the 'downstream' water demands at the downstream of the major project are meant for 'at the major project'. This is in reference to the "upstream" and the "downstream" of a major project, i.e., a major reservoir.

8.2.2 Analysis at the Individual Major Project/Site Level

The analysis is done at the individual; major project or site level and, at sub-basin level; for the 75% water year dependable flow, with various export quantities from the Mettur reservoir to the sub-basins below Mettur.

In general, it is observed that for the 50%, 75%, 90% and 100% water year dependable flows, the upstream and downstream annual demands for water supply, i.e., at all the medium and minor projects, and major projects, respectively, are met satisfactorily but the upstream annual demands for irrigation at the medium and minor projects, and the downstream annual demands for irrigation at the major projects, even in the 50% water year dependable flow are not met satisfactorily at some of the projects.

The projectwise graphs of the percentage deficits in meeting various annual water demands in respect to the annual water supply and irrigation at the major, medium and minor projects above Mettur, with the annual water export from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows is presented in Figures 8.3.1 to 8.3.6.

8.2.2.1 Major Projects in Upper Cauvery sub-basin Above Mettur

The results show that at the major projects 1, 2, 3, 4 and 5, i.e., at the reservoirs Yagachi, Hemavathi, Harangi, Cauvery and Krishnarajsagar (KRS), the upstream annual demands for irrigation and water supply at their medium and minor projects are met satisfactorily and the downstream annual water supply demands at these major projects are also met satisfactorily, but the downstream annual irrigation demands at these major projects, except at KRS, are not met satisfactorily. The annual deficits in meeting the downstream annual irrigation demands at the major projects Yagachi, Hemavathi, Harangi, and Cauvery are 49%, 88%, 8%, and 80%, respectively.

8.2.2.2 Major Projects in Kabini sub-basin above Mettur

In the case of major projects 6, 7, 8, 9, 10, 11 and 12, i.e., at the reservoirs Banasursagar, Mananthvady, Kabini, Taraka, Sagardoddakere, Upper Nugu and Nugu, the downstream annual water supply demands at these major projects and the annual upstream water supply demands at their medium and minor projects are met satisfactorily, and the upstream annual irrigation demands at their medium and minor projects are also met satisfactorily, but the downstream annual irrigation demands at these major projects, except Kabini and Sagardoddakere, are not met satisfactorily.

The annual deficits in meeting the downstream annual irrigation demands at the major projects Banasursagar, Mananthvady, Taraka, Upper Nugu and Nugu are 86% 14%, 44%, 83% and 18%, respectively.

8.2.2.3 Major Project in Chinnar sub-basin above Mettur

In the case of Mettur, i.e., major project 13, all the upstream annual water demands at the major project and all the upstream annual water demands at the medium and minor projects are met satisfactorily.

8.2.2.3 Major Projects in Bhavani, and Amaravathi sub-basins below Mettur

In the case of Bhavani and Amaravathi reservoirs, i.e., major project, 14 and 15, the upstream annual water supply demands at the medium and minor projects, and the downstream annual water supply demands at the major projects are met satisfactorily and the upstream annual irrigation demands at the medium and minor projects are also met satisfactorily, but the downstream annual irrigation demands at the major projects are not met satisfactorily. The annual deficits in meeting the downstream annual irrigation demands at Bhavani and Amaravathi are 15% and 21%, respectively.

8.2.3 Analysis at the Sub-Basin Level

For each water year dependable flow, the graphical presentation of the trade offs between the annual total of all the water demands met at various projects and remaining areas in a sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for two cases, i.e., for the projects above and for the projects below Mettur are presented in Figures 8.1.1 to 8.1.5.

The percentage deficits in meeting the total of annual water demand of a given purpose in a sub-basin, i.e., the deviations from the annual total of target demands of the given purpose, for the various water exports from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows are presented in Figures 8.2.1 to 8.2.9.

The variation in annual irrigation and / or water supply from major, medium and minor projects vs. various percent water year dependable flows in various sub-basins are given in Figures 8.4.1 to 8.4.9.

The demands for upstream water supply at the medium and minor projects are completely met during all the water year dependable flows.

8.2.3.1 Upper Cauvery sub-basin

In the case of Upper Cauvery sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply and for irrigation at the medium and minor projects are met satisfactorily, and the downstream annual demands for water supply at the major projects are also met satisfactorily. But the downstream annual demands for irrigation at the major projects are not met satisfactorily. The annual total of the deficits in the downstream annual irrigation at various major projects in the sub-basin, which are short of water, is found to be 26%, 23%, 54%, and 58% for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.41 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The percentage deficits in meeting the total annual water demands of a given purpose in Upper Cauvery sub-basin, i.e., the deviations from the annual total of target demands of the given purpose, at the medium and minor projects and at the major projects, for the various water exports from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows are presented in Figures 8.2.1(a) and 8.2.1(b) respectively.

The variation in annual irrigation from medium and minor projects vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.1(a). The variation in annual irrigation from major projects vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.1(b).

8.2.3.2 Kabini sub-basin

In the case of Kabini sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply and for irrigation at the medium and minor projects are met satisfactorily accept for 100% water year dependable flow, the upstream annual water demands for irrigation at the medium and minor projects, the annual total of deficit 57% is found out. The downstream annual demands for water supply at the major projects are also met satisfactorily. The downstream annual demands for irrigation at the major projects are met satisfactorily for 50% and 75% water year dependable flows. But the downstream annual demands for irrigation at the major projects for 90% and 100% water year dependable flows are not met satisfactorily. The annual total of the deficits in the downstream annual irrigation at various major projects in the sub-basin, which are short of water, is found to be 44%, and 66% for the 90% and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.73 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The percentage deficits in meeting the total annual water demands of a given purpose in Kabini sub-basin, i.e., the deviations from the annual total of target demands of the given purpose, at the medium and minor projects and at the major projects, for the various water exports from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows are presented in Figures 8.2.2(a) and 8.2s.2(b), respectively.

The variation in annual irrigation from medium and minor projects vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.2(a). The variation in annual irrigation from major projects vs. various water year dependable flows in the sub-basin is given in Figure 8.4.2(b).

8.2.3.3 Shimsha sub-basin

In the case of Shimsha sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply and for irrigation at the medium and minor projects are not met satisfactorily. The annual total of the deficits in the upstream annual water demands for water supply and for irrigation at the medium and minor projects, which are short of water, is found to be (for water supply 51%, 51%, 51%, and 51%) and (for irrigation 68%, 68%, 84%, and 84%) for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.35 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

8.2.3.4 Arkavathi sub-basin

In the case of Arkavathi sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply at the medium and minor projects are met satisfactorily, but the upstream annual demands for irrigation at the medium and minor projects are not met satisfactorily. There is no any major project in this sub-basin. The annual total of the deficits in the upstream annual irrigation at various medium and minor projects in the sub-basin, which are short of water, is found to be 89%, 89%, 91%, and 92% for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.30 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The percentage deficits in meeting the total annual water demands of a given purpose in Arkavathi sub-basin, i.e., the deviations from the annual total of target demands of the given purpose, at the major projects and at the medium and minor, and major projects, for the various water exports from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows are presented in Figures 8.2.3(a) and 8.2.3(b), respectively.

The variation in annual water supply from major projects vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.3(a). The variation in annual total water supply from major, medium and minor projects vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.3(b).

8.2.3.5 Middle Cauvery sub-basin

In the case of Middle Cauvery sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply at the medium and minor projects are met satisfactorily. The upstream annual demands for irrigation at the medium and minor projects are met satisfactorily for 50% water year dependable flows. But the upstream annual demands for irrigation at the medium and minor projects are not met satisfactorily for 75%, 90% and 100% water year dependable flows. The annual total of the deficits in the upstream annual irrigation at various major projects in the sub-basin, which are short of water, is found to be 6%, 6%, and 6% for the 75%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.77 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The percentage deficits in meeting the total annual water demands of a given purpose in Middle Cauvery sub-basin, i.e., the deviations from the annual total of target demands of the given purpose, at the medium and minor projects and at the major projects, for the various water exports from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows are presented in Figures 8.2.4(a) and 8.2.4(b), respectively.

The variation in annual total irrigation from major, medium and minor projects vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.4.

8.2.3.6 Suvarnavathi sub-basin

In the case of Suvarnavathi sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply and for irrigation at the medium and minor projects are met satisfactorily. But the upstream annual demands for irrigation at the medium and minor projects are not met satisfactorily. The annual total of the deficits in the upstream annual irrigation at various medium and minor projects in the sub-basin, which are short of water, is found to be 90%, 88%, 94%, and 94% for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.20 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The percentage deficits in meeting the total annual water demands of a given purpose in Suvarnavathi sub-basin, i.e., the deviations from the annual total of target demands of the given purpose, at the medium and minor projects, for the various water exports from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows are presented in Figures 8.2.5(a) and 8.2.5(b), respectively.

8.2.3.7 Palar sub-basin

In the case of Palar sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply at the medium and minor projects are met satisfactorily. But the upstream annual demands for irrigation at the medium and minor projects are not met satisfactorily. The annual total of the deficits in the upstream annual irrigation at various medium and minor projects in the sub-basin, which are short of water, is found to be 54%, 10%, 57%, and 62% for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.60 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

8.2.3.8 Chinnar sub-basin

In the case of Chinnar sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply and for irrigation at the medium and minor projects are met satisfactorily. The annual water utilization factor computed for this sub-basin is 1.00 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The variation in annual total irrigation from major, medium and minor projects vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.5.

8.2.3.9 Bhavani sub-basin

In the case of Bhavani sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply and for irrigation at the medium and minor projects are met satisfactorily accept for 100% water year dependable flow, where the deficit is of 12% is found out for irrigation; and the downstream annual water demands for water supply and irrigation at the major projects are also met satisfactorily, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.52 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

8.2.3.10 Noyil sub-basin

In the case of Noyil sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply and for irrigation at the medium and minor projects are not met satisfactorily. The annual total of the deficits in the upstream annual water supply and irrigation at various medium and minor projects in the sub-basin, which are short of water, is found to be (for water supply 65%, 65%, 65%, and 65%) and (for irrigation 97%, 97%, 97%, and 97%) for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.19 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The variation in annual total water supply from major project vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.6(a).

8.2.3.11 Amaravathi sub-basin

In the case of Amaravathi sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream and downstream annual water demands for water supply at the medium and minor, and major projects are met satisfactorily. But the upstream and downstream annual demands for irrigation at the medium and minor projects and major projects, respectively, are not met satisfactorily. The annual total of the deficits in the upstream and downstream annual irrigation at various medium and minor, and major projects, respectively, in the sub-basin, which are short of water, is found to be (for medium and minor project 69%, 68%, 77%, and 78%) and (for major projects 3%, 24%, 24% and 84%) for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.62 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The percentage deficits in meeting the total annual water demands of a given purpose in Amaravathi sub-basin, i.e., the deviations from the annual total of target demands of the given purpose, at the medium and minor projects and at the major projects, for the various water exports from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows are presented in Figures 8.2.6(a), 8.2.6(b), and 8.2.6(c), respectively.

The variation in annual irrigation from medium and minor projects vs. various water year dependable flows in the sub-basin is given in Figure 8.4.7(a). The variation in annual irrigation from major projects vs. various water year dependable flows in the sub-basin is given in Figure 8.4.7(b). The variation in annual irrigation from major, medium and minor projects vs. various water year dependable flows in the sub-basin is given in Figure 8.4.7(c).

8.2.3.12 Tirumanimuttar sub-basin

In the case of Tirumanimuttar sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply at the medium and minor projects are met satisfactorily. But the upstream annual demands for irrigation at the medium and minor projects are not met satisfactorily. The annual total of the deficits in the upstream annual irrigation at various medium and minor projects in the sub-basin, which are short of water, is found to be 91%, 89%, 93%, and 948% for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.36 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The percentage deficits in meeting the total annual water demands of a given purpose in Tirumanimuttar sub-basin, i.e., the deviations from the annual total of target demands of the given purpose, at the medium and minor projects and at the major projects, for the various water exports from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows are presented in Figures 8.2.7(a), 8.2.7(b) and 8.2.7(c), respectively.

The variation in annual total irrigation from major, medium and minor projects vs. various percent water year dependable flows in the sub-basin is given in Figures 8.4.8(a). The variation in annual total water supply from major project vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.8(b). The variation in annual total water supply from major, medium and minor projects vs. various percent water year dependable flows in the sub-basin is given in Figure 8.4.8(c).

8.2.3.13 Ponnanai Ar sub-basin

In the case of Ponnanai Ar sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply at the medium and minor projects are met satisfactorily. But the upstream annual demands for irrigation at the medium and minor projects are not met satisfactorily. The annual total of the deficits in the upstream annual irrigation at various medium and minor projects in the sub-basin, which are short of water, is found to be 55%, 54%, 56%, and 57% for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.52 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

The percentage deficits in meeting the total annual water demands of a given purpose in Ponnanai Ar sub-basin, i.e., the deviations from the annual total of target demands of the given purpose, at the medium and minor projects and major projects, for the various water exports from Mettur reservoir to the sub-basins below Mettur, for different water year dependable flows are presented in Figure 8.2.8.

The variation in annual irrigation from major, medium and minor projects vs.. various percent water year dependable flows in the sub-basin is given in Figure 8.4.9.

8.2.3.14 Upper Coleroon sub-basin

In the case of Upper Coleroon sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply at the medium and minor projects are met satisfactorily. But the upstream annual demands for irrigation at the medium and minor projects are not met satisfactorily. The annual total of the deficits in the upstream annual irrigation at various medium and minor projects in the sub-basin, which are short of water, is found to be 26%, 23%, 27%, and 28% for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.63 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

8.2.3.15 Lower Coleroon sub-basin

In the case of Lower Coleroon sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply at the medium and minor projects are met satisfactorily. But the upstream annual demands for irrigation at the medium and minor projects are not met satisfactorily. The annual total of the deficits in the upstream annual irrigation at various major projects in the sub-basin, which are short of water, is found to be 46%, 43%, 48%, and 49% for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.50 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

8.2.3.16 Cauvery Delta sub-basin

In the case of Cauvery Delta sub-basin, the LP model results show that when water is exported from Mettur reservoir, to the sub-basins below Mettur (export equal to 5800 MCM) and to the out side the Cauvery basin; for all the water year dependable flows, the upstream annual water demands for water supply at the medium and minor projects are met satisfactorily. But the upstream annual demands for irrigation at the medium and minor projects are not met satisfactorily. The annual total of the deficits in the downstream annual irrigation at various major projects in the sub-basin, which are short of water, is found to be 63%, 62%, 64%, and 65% for the 75%, 50%, 90%, and 100% water year dependable flows, respectively, for the export of water from Mettur reservoir to the sub-basins below Mettur is as per the CWDTIA.The annual water utilization factor computed for this sub-basin is 0.40 for the 75% water year dependable flow, and for other flow conditions the values are estimated and given in Table 8.1.

The trade-offs between the annual total of all the water demands met at various projects and remaining areas in the sub-basin, with the annual water exports from Mettur reservoir to the sub-basins below Mettur, for various water year dependable flows, for the upstream annual demands at the medium and minor projects, and for the downstream annual demands at the major projects are given in Figures 8.1.1 to 8.1.5, respectively.

8.3 ANALYSIS OF LP MODEL RESULTS WITH CROP CONSIDERATIONS

8.3.1 General

The LP model was run for the objective functions given by equations 5.2.1-II, 5.2.2, 5.2.3 and 5.2.4, with crops being considered as the decision variables in the model, and the results were obtained for all the objectives for analysis, only for the 75% annual dependable flow. The model runs were made at the individual project/site level, i.e., for all the 15 major projects in the Cauvery river system. The surface water contribution as diversions for irrigation from a reservoir, were made available from the LP model results in Section 8.2. Similarly, the ground water contributions towards irrigation were also obtained from the results in Section 8.2. The model was run for monthly time periods on an annual basis. The results are given in Table 7.2.1 to Table 7.2.15.

8.3.2 Analysis at the Individual Project/Site Level

8.3.2.1 Major Projects in Upper Cauvery sub-basin above Mettur

The results show that at the major projects 1,2,3,4 and 5, i.e., at the reservoirs Yagachi, Hemavathi, Harangi, Cauvery and Krishnarajsagar (KRS), the annual water diversions made available for irrigation from each reservoir and the annual ground water available, is sufficient to meet the irrigation water needs for the crop areas proposed in the project report, in order to maximize the objective functions for (i) maximization of area to be irrigated, (ii) maximization of annual irrigation water utilization and (iii) maximization of the total annual returns from the crops in the respective sub-basins. But in order to maximize the objective function for annual food production from various crops, to meet the minimum food requirements of the agricultural population in the command areas of the respective major projects, these available annual water diversions and the ground water resource is not sufficient. From the model results in Table 7.2.1, it is seen that, this deficiency in water availability in meeting the irrigation water requirements of the crops at Yagachi, resulted in crop areas for the pulses and oilseed are 13% and 42%, of crop areas mentioned in the project report and 53% for oilseeds of the minimum crop areas needed for the minimum annual food production, respectively.

In case of Hemavathi (Table 7.2.2), the deficiency in water availability in meeting the irrigation water requirements of the crops for the pulses, oilseeds and vegetables are 43%, 100% and 100%, respectively. In case of the Harangi, Cauvery and KRS projects, the irrigation water demands for the cereal crops are met satisfactorily, but the irrigation water demands for pulses and oil seeds are not met at all.

8.3.2.2 Major Projects in Kabini sub-basin above Mettur

In case of the sites 6, 7, 8, 9, 10, 11 and 12, i.e., at the reservoirs Banasursagar, Mananthvady, Kabini, Taraka, Sagardoddakere, Upper Nugu and Nugu, the annual demands for irrigation projects for the proposed crop areas for the objective functions for (i) maximization of area to be irrigated, (ii) maximization of annual water utilization and (iii) maximization of net benefits from the crops proposed in the respective sub-basins are met satisfactorily. But the annual water demands for the crop area for the objective function of maximization of food production to meet the minimum food requirements of the agricultural population in the command areas of the respective major projects are not met satisfactorily. In the objective function of maximization of food production to meet the minimum food requirements of the agricultural population in the command areas of the respective major projects in case of the sites 7, 9 and 11, i.e., at the reservoirs Mananthvady, Taraka and Nugu the irrigation annual water demands are not met satisfactorily. In case of Mananthvady project the annual irrigation requirements satisfied for the crops are 0%, 0%, 26%, 2%, 24%, and 2% for Kharif Paddy, Kharif Jowar, Ragi, pulses, fruits and vegetables, and groundnut, respectively. In case of Upper Nugu the annual irrigation demands satisfied for Kharif Paddy, Rabi Paddy and groundnut are 31%, 10% and 16% respectively. The annual irrigation demands incase of pulses and fruit and vegetables are 300% and 160% respectively.

8.3.2.3 Major Projects in Chinnar sub-basin above Mettur

In case of the Mettur reservoir, i.e., major project 13, the annual demands for irrigation projects for the proposed crop areas for the objective functions for (i) maximization of area to be irrigated, (ii) maximization of annual water utilization and (iii) maximization of net benefits from the crops proposed in the respective sub-basins are met satisfactorily. The annual irrigation demands for the cereal crops are met satisfactorily. In case of Mettur the irrigation demand for minimum food requirement case the pulses of 150% area can be irrigated, for oil crops the demand is satisfied 33%.

8.3.2.4 Major Projects in Bhavani, and Amaravathi sub-basins below Mettur

In case of the Bhavani and Amaravathi reservoirs, i.e., major projects 14 and 15, the annual demands for irrigation projects for the proposed crop areas for the objective functions for (i) maximization of area to be irrigated, (ii) maximization of annual water utilization and (iii) maximization of net benefits from the crops proposed in the respective sub-basins are met satisfactorily. The annual irrigation demands for the cereal crops are met satisfactorily. In case of lower Bhavani the Kharif Paddy the irrigation of 60% is possible.

Table 8.1 : Computed Annual Water Utilization Factors from LP Model Results Under Different Scenario for 75% Water Year Dependable Flow

Sl.No.	Name of Sub-Basins	Exports from Mettur Reservoir	utilization factor-with					
			sw	sw+imp	sw+imp+swr	g.w.	gw+gwr	sw+imp+swr+gw+gwr
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Upper Cauvery	4200	0.40	0.40	1.00	1.00	0.83	0.41
2	Upper Cauvery	5800	0.40	0.40	1.00	1.00	0.83	0.41
3	Upper Cauvery	6200	0.36	0.36	1.00	1.00	0.83	0.38
4	Upper Cauvery	7200	0.35	0.35	1.00	1.00	0.83	0.37
5	Kabini	4200	0.91	0.82	0.92	0.94	0.79	0.74
6	Kabini	5800	0.90	0.82	0.92	0.94	0.79	0.73
7	Kabini	6200	0.89	0.81	0.92	0.94	0.79	0.72
8	Kabini	7200	0.89	0.81	0.92	0.94	0.79	0.72
9	Shimsha	4200	1.00	0.29	0.31	1.00	0.81	0.35
10	Shimsha	5800	1.00	0.28	0.31	1.00	0.81	0.35
11	Shimsha	6200	1.00	0.28	0.31	1.00	0.81	0.34
12	Shimsha	7200	1.00	0.27	0.31	1.00	0.81	0.34
13	Arkavathi	4200	0.81	0.34	0.53	1.00	0.61	0.33
14	Arkavathi	5800	0.71	0.29	0.51	1.00	0.61	0.30
15	Arkavathi	6200	0.68	0.28	0.51	1.00	0.61	0.30
16	Arkavathi	7200	0.67	0.28	0.51	1.00	0.61	0.30
17	Middle C.	4200	6.67	1.00	0.30	1.00	0.84	0.96
18	Middle C.	5800	5.16	0.89	0.28	1.00	0.84	0.77
19	Middle C.	6200	4.85	0.84	0.28	1.00	0.84	0.74
20	Middle C.	7200	4.55	0.78	0.28	1.00	0.84	0.70
21	Suvarnavathi	4200	1.00	0.13	0.16	1.00	0.71	0.20
22	Suvarnavathi	5800	1.00	0.13	0.16	1.00	0.71	0.20
23	Suvarnavathi	6200	1.00	0.13	0.16	1.00	0.71	0.20
24	Suvarnavathi	7200	1.00	0.13	0.16	1.00	0.71	0.20
25	Palar	4200	0.51	0.51	1.00	0.95	0.76	0.60
26	Palar	5800	0.51	0.51	1.00	0.95	0.76	0.60
27	Palar	6200	0.55	0.55	1.00	0.95	0.76	0.61
28	Palar	7200	0.55	0.55	1.00	0.95	0.76	0.61
29	Chinnar	4200	1.00	1.00	1.00	0.90	0.73	1.03
30	Chinnar	5800	1.00	1.00	1.00	0.90	0.73	1.02
31	Chinnar	6200	1.00	1.00	1.00	0.90	0.73	1.06
32	Chinnar	7200	1.00	1.00	1.00	0.90	0.73	1.05
33	Bhavani	4200	0.59	0.59	0.99	0.95	0.74	0.52
34	Bhavani	5800	0.59	0.58	0.99	1.00	0.78	0.52
35	Bhavani	6200	0.56	0.56	0.99	1.00	0.78	0.51
36	Bhavani	7200	0.62	0.61	0.99	1.00	0.78	0.53
37	Noyil	4200	0.58	0.20	0.42	0.60	0.48	0.19
38	Noyil	5800	0.58	0.20	0.42	0.60	0.48	0.19
39	Noyil	6200	0.75	0.25	0.45	0.60	0.48	0.23
40	Noyil	7200	0.75	0.25	0.45	0.60	0.48	0.23
41	Amaravathi	4200	1.31	0.86	0.74	0.81	0.65	0.64
42	Amaravathi	5800	1.26	0.83	0.74	0.78	0.62	0.62
43	Amaravathi	6200	1.12	0.73	0.74	0.78	0.62	0.57
44	Amaravathi	7200	1.12	0.73	0.73	0.78	0.62	0.57
45	Tirumanimuttar	4200	1.30	0.35	0.41	1.00	0.58	0.33
46	Tirumanimuttar	5800	1.50	0.40	0.42	1.00	0.58	0.36
47	Tirumanimuttar	6200	1.43	0.38	0.41	1.00	0.58	0.35

Table 8.1 (Contd...)

Sl.No.	Name of Sub-Basins	Exports from Mettur Reservoir	utilization factor-with					
			sw	sw+imp	sw+imp+swr	g.w.	gw+gwr	sw+imp+swr+gw+gwr
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
48	Tirumanimuttar	7200	1.66	0.45	0.43	1.00	0.58	0.38
49	Ponnanai Ar	4200	2.01	0.58	0.48	0.94	0.81	0.51
50	Ponnanai Ar	5800	2.05	0.59	0.48	0.94	0.81	0.52
51	Ponnanai Ar	6200	3.49	1.01	0.57	0.94	0.81	0.64
52	Ponnanai Ar	7200	3.54	1.03	0.57	0.94	0.81	0.65
53	Upper Coleroon	4200	1.46	0.74	0.59	0.85	0.72	0.63
54	Upper Coleroon	5800	1.46	0.74	0.59	0.85	0.72	0.63
55	Upper Coleroon	6200	1.50	0.76	0.60	0.85	0.72	0.63
56	Upper Coleroon	7200	1.50	0.76	0.60	0.85	0.72	0.63
57	Lower Coleroon	4200	3.06	0.53	0.27	0.93	0.82	0.50
58	Lower Coleroon	5800	3.06	0.53	0.27	0.93	0.82	0.50
59	Lower Coleroon	6200	3.18	0.55	0.28	0.93	0.82	0.51
60	Lower Coleroon	7200	3.18	0.55	0.28	0.93	0.82	0.51
61	Cauvery Delta	4200	3.94	0.43	0.19	1.00	0.57	0.39
62	Cauvery Delta	5800	4.04	0.44	0.19	1.00	0.57	0.40
63	Cauvery Delta	6200	4.07	0.44	0.18	1.00	0.57	0.41
64	Cauvery Delta	7200	4.26	0.46	0.18	1.00	0.57	0.43

Note: (1) sw = Surface water; sw + imp = Surface water + imports.
sw + imp + swr = Surface water + imports + regenerations from surface water use;
g.w. = Ground water
gw+gwr = Ground water + regenerations from ground water use
sw+imp+swr+gw+gwr = Surface water + imports + regenerations from surface water use + ground water + regenerations from ground water use

(2) The utilization factors calculated from LP model, where, if the utilization factor is less than one, the surplus water is available; however, when the utilization factor is equal to one, it means the demands are completely met with the following interpretations:

(i) the available water is less than the demands, and (ii) the available water is more than the demands and a part of available water is being diverted optimally to downstream sub-basins. This shows the impact of storages and locations on water utilization. This is because, the entire river system is considered as one, unlike in water balance studies where each sub-basin was considered independently.

The annual water utilization factor is defined as the ratio of the amount of water utilized and total quantity of water available from surface water and ground water.

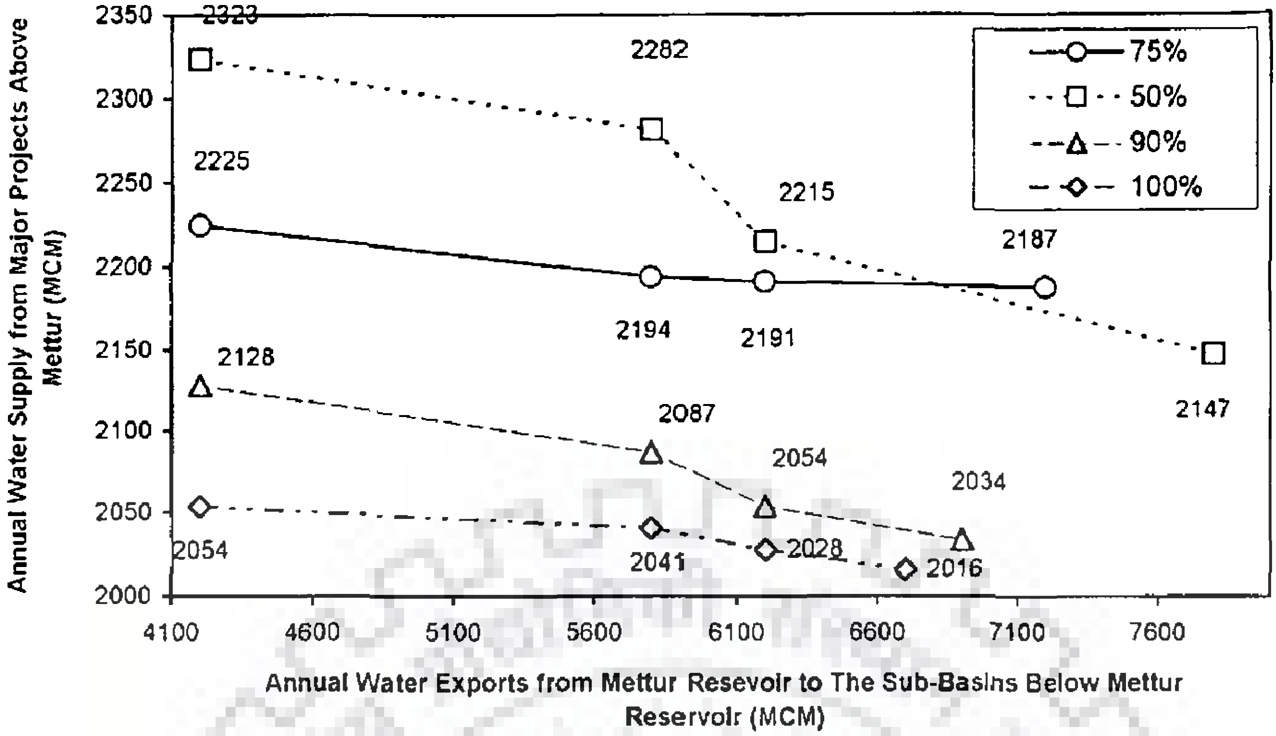

Figure 8.1.1(a): Trade Off Between Annual Water Supply from Major Projects Above Mettur and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

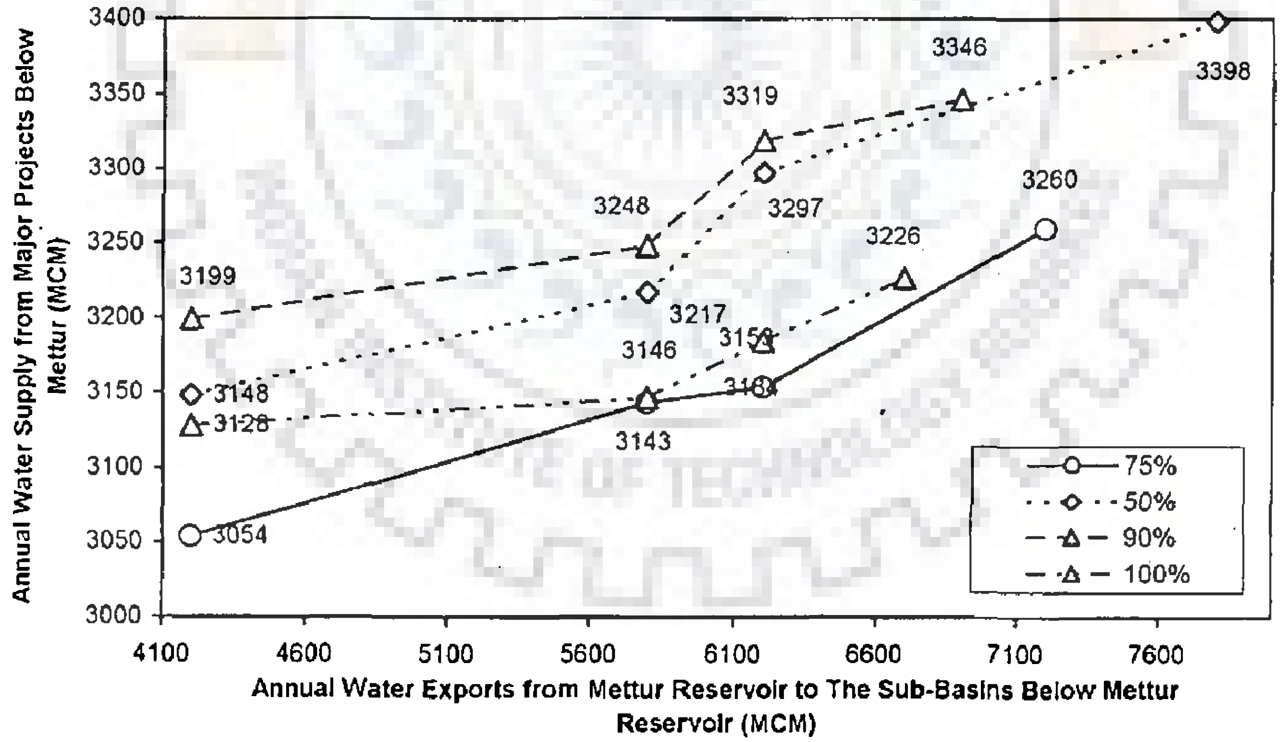

Figure 8.1.1(b): Trade Off Between Annual Water Supply from Major Projects Below Mettur and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

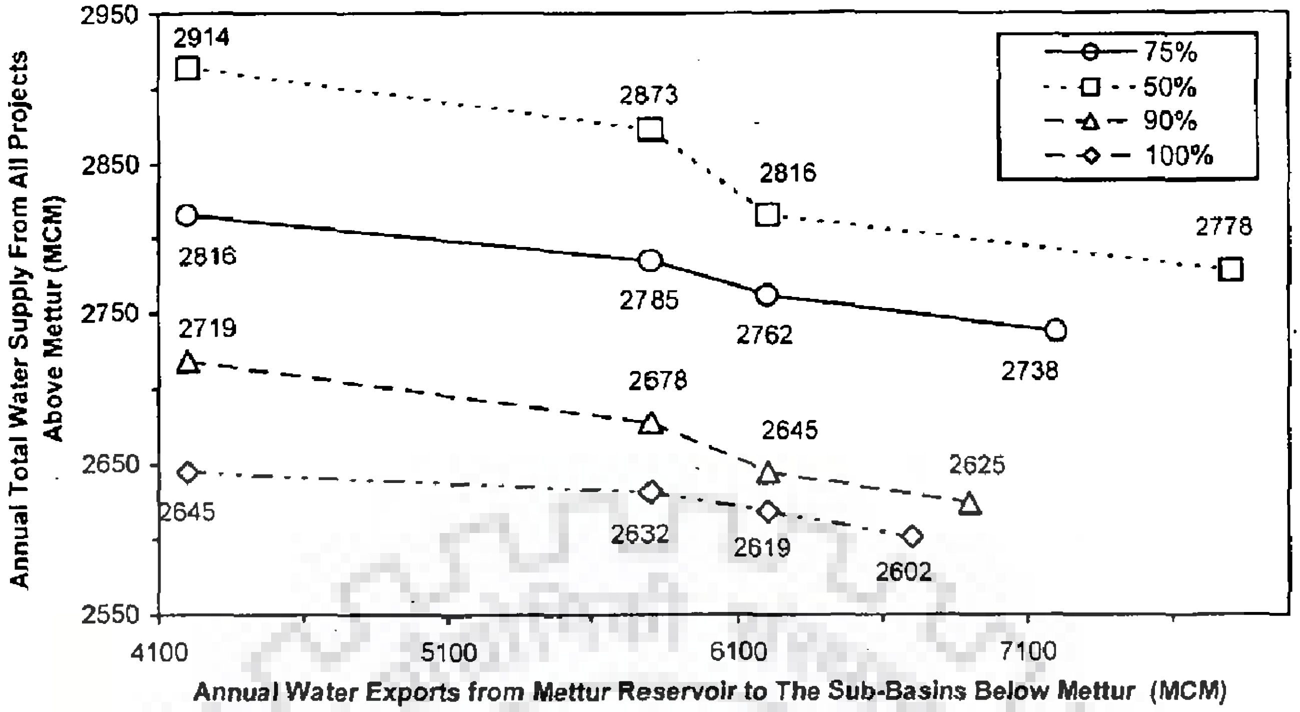

Figure 8.1.2(a): Trade Off Between Annual Total Water Supply Above Mettur and Above Mettur Reservoir and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

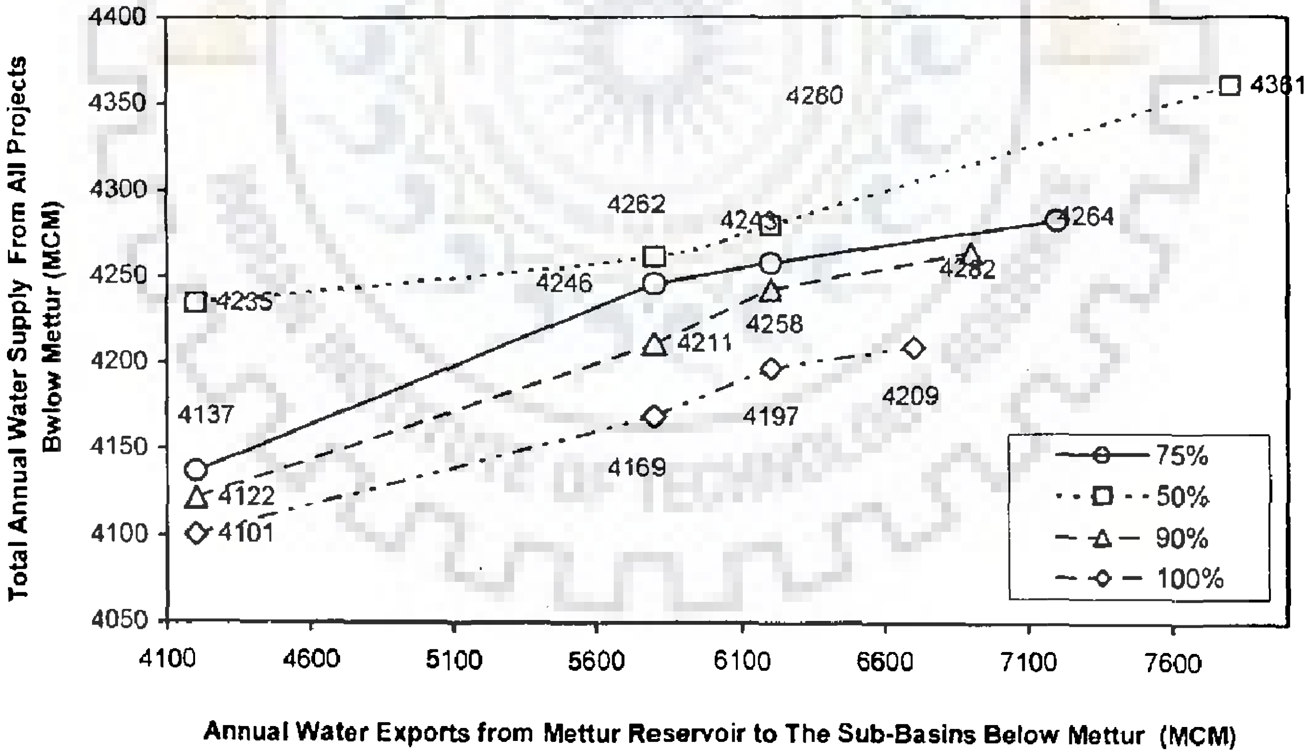

Figure 8.1.2(b): Trade Off Between Total Annual Water Supply Below Mettur and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

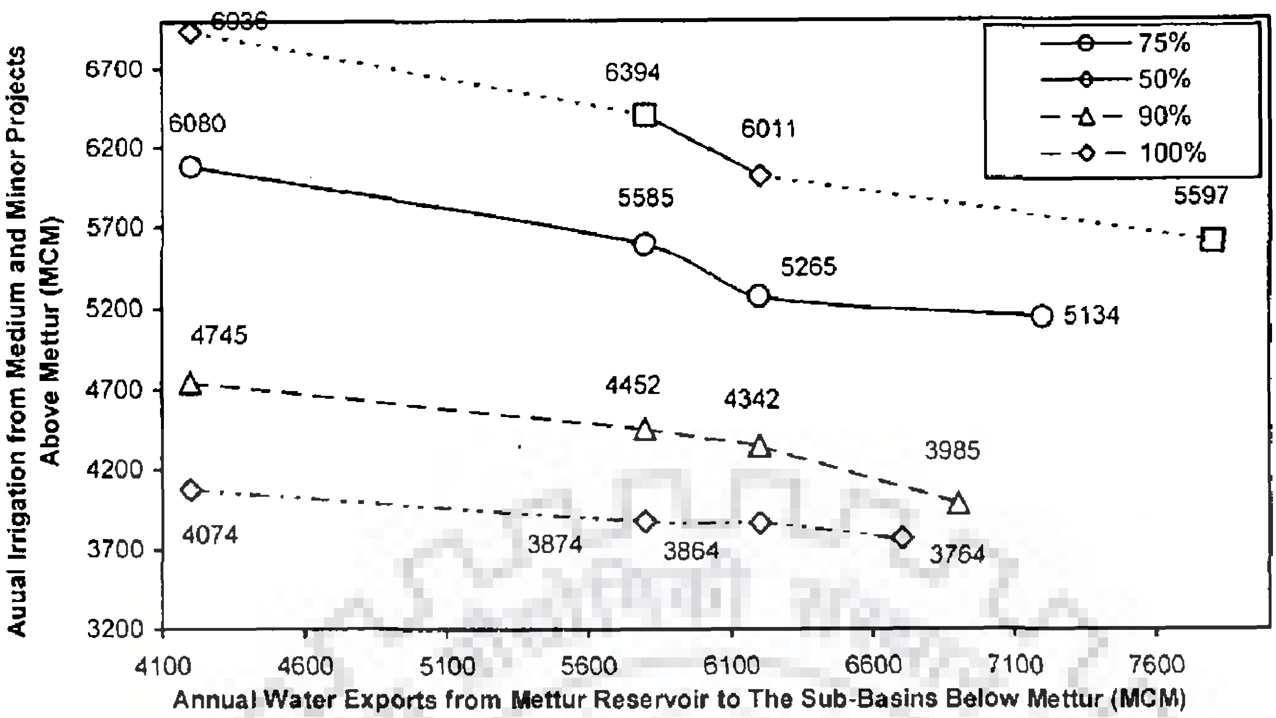

Figure 8.1.3(a): Trade Off Between Annual Irrigation from Medium and Minor Projects Above Mettur and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

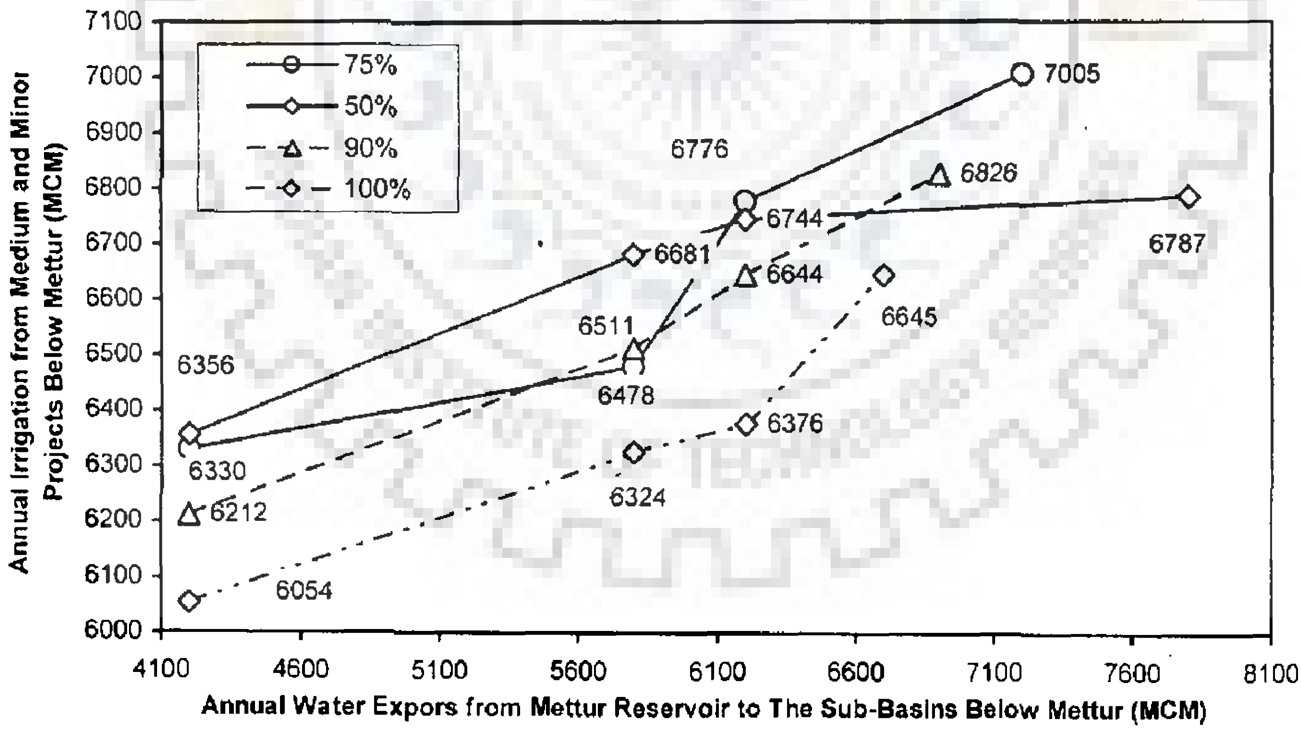

Figure 8.1.3(b): Trade Off Between Annual Irrigation from Medium and Minor Projects Below Mettur and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

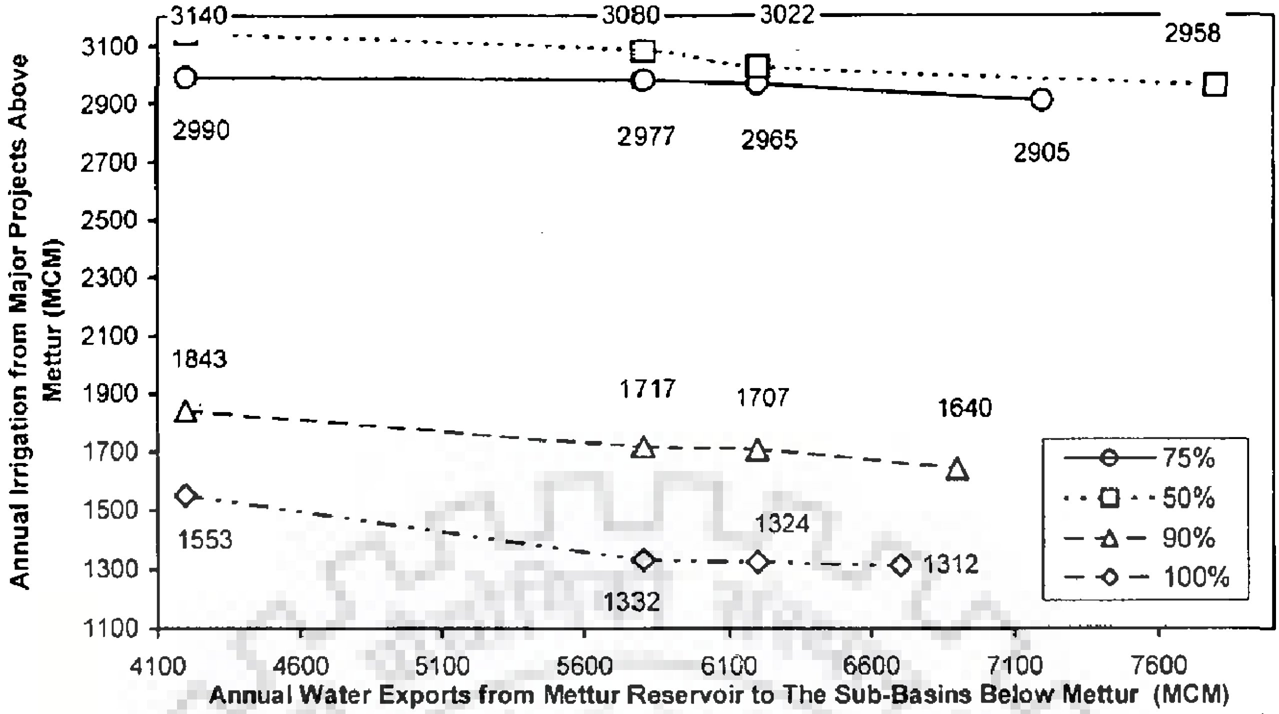

Figure 8.1.4(a): Trade Off Between Annual Irrigation from Major Projects Above Mettur and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

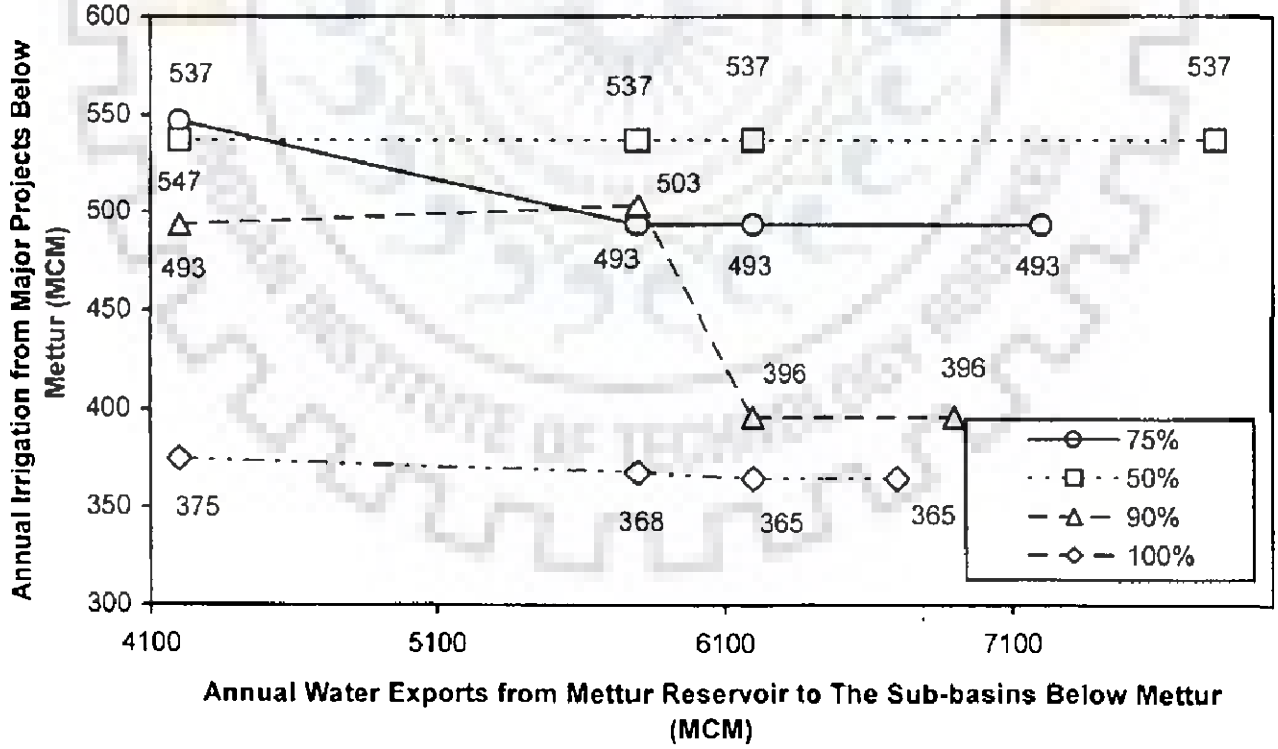

Figure 8.1.4(b): Trade Off Between Annual Irrigation from Major Projects Below Mettur and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

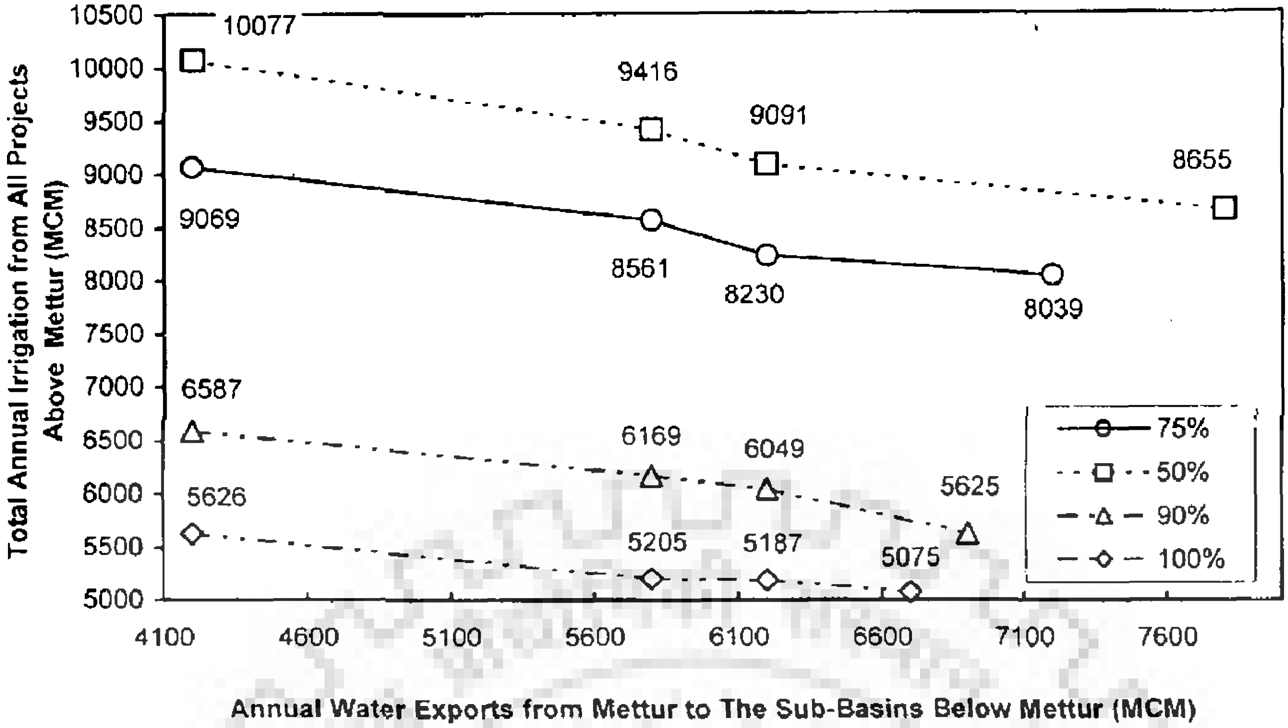

Figure 8.1.5(a): Trade Off Between Annual Total Irrigation Above Mettur and and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

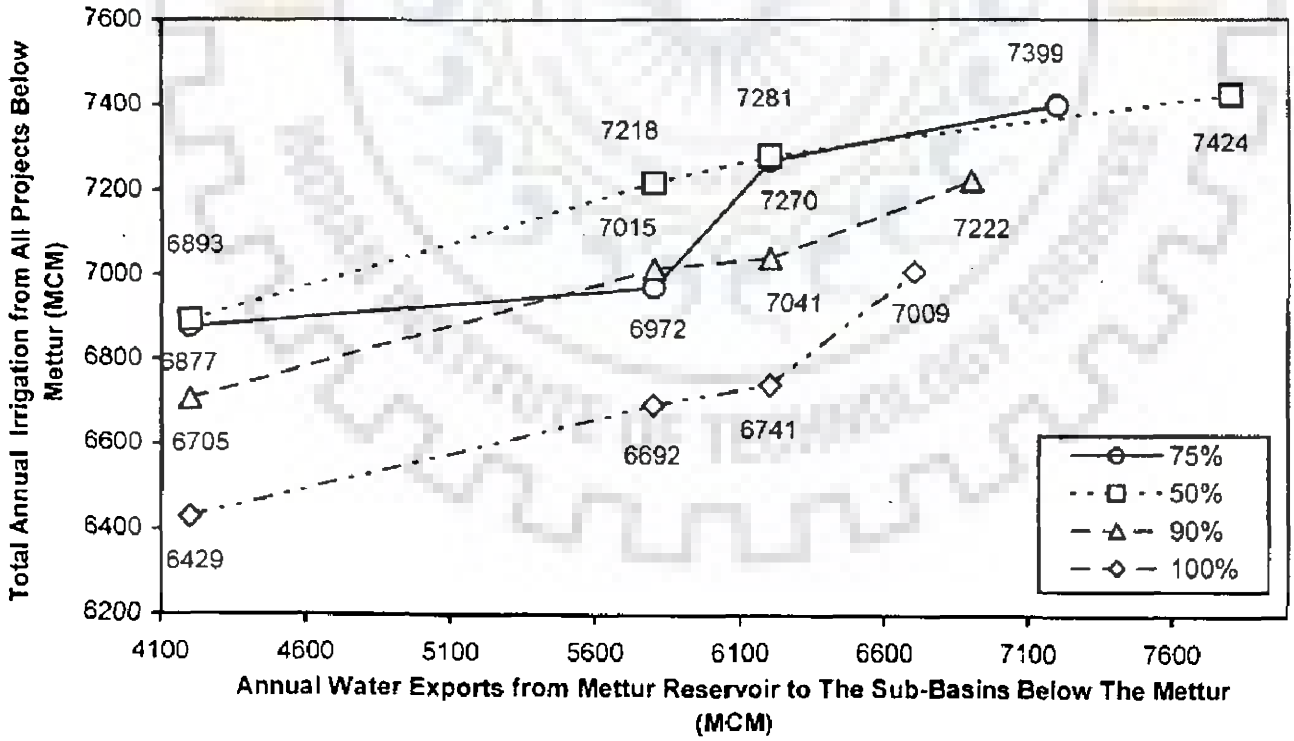

Figure 8.1.5(b): Trade Off Between Annual Total Irrigation Below Mettur and and Annual Water Exports from Mettur Reservoir to the Sub Basins Below Mettur for Different Water Year Dependable Flows

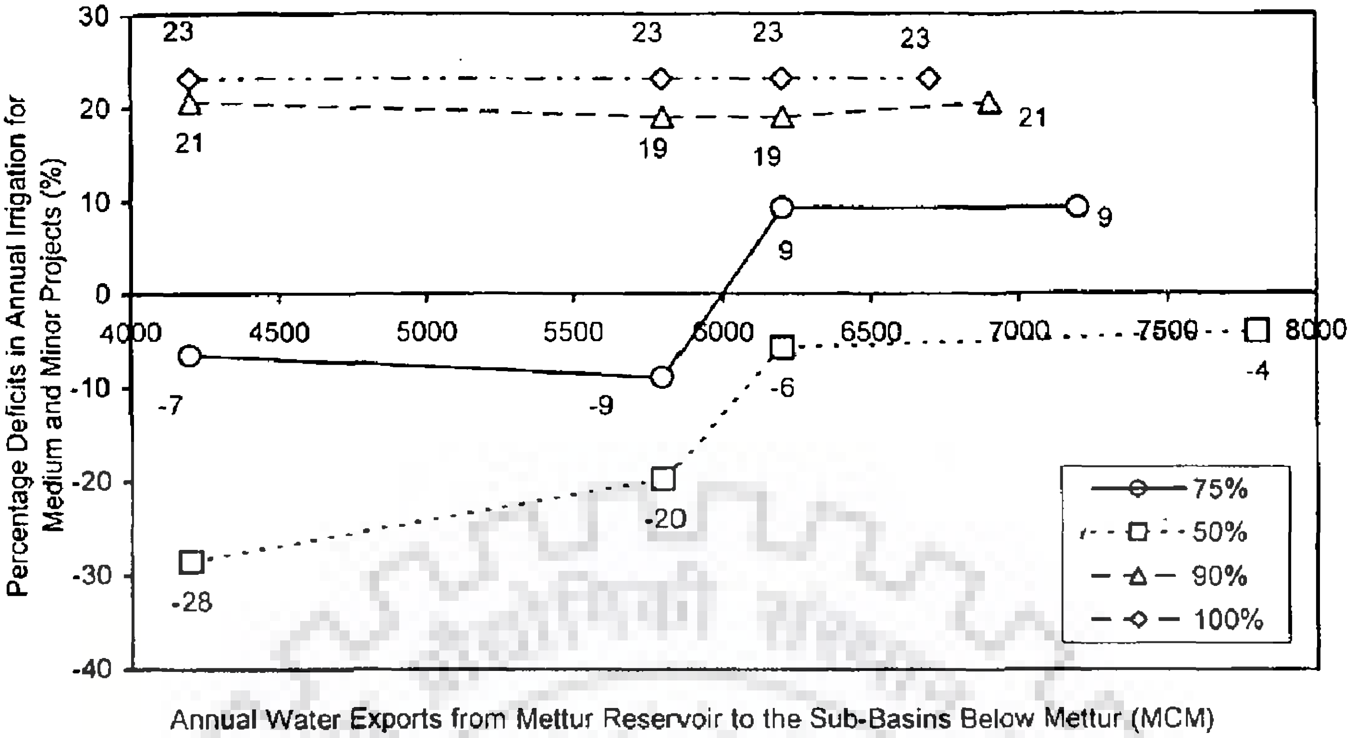

Figure 8.2.1(a): Percentage Deficit in Annual Irrigation for Medium and Minor Projects in Upper Cauvery Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

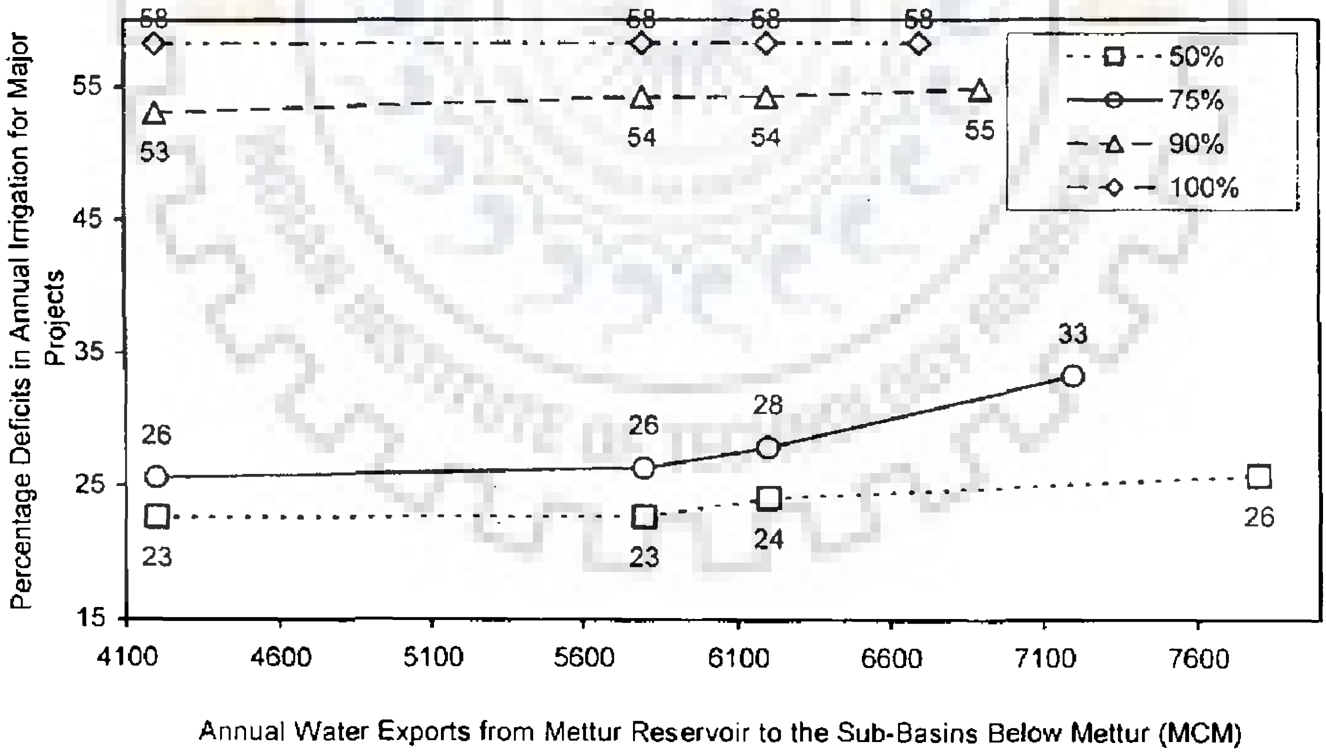

Figure 8.2.1(b): Percentage Deficit in Annual Irrigation for Major Projects in Upper Cauvery Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

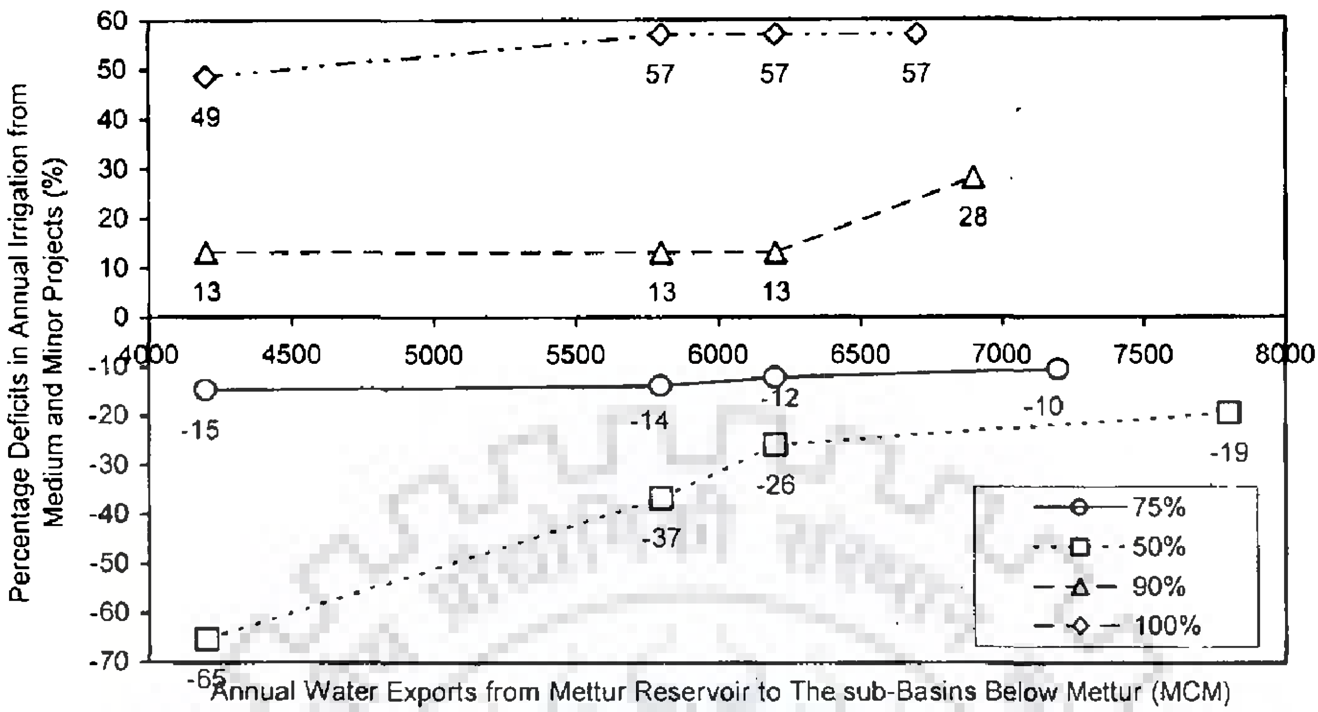

Figure 8.2.2(a): Percentage Deficits in Annual Irrigation for Medium and Minor Projects in Kabini Sub-Basin vs. Annual Water Exports to the Sub-Basins Below Mettur (MCM)

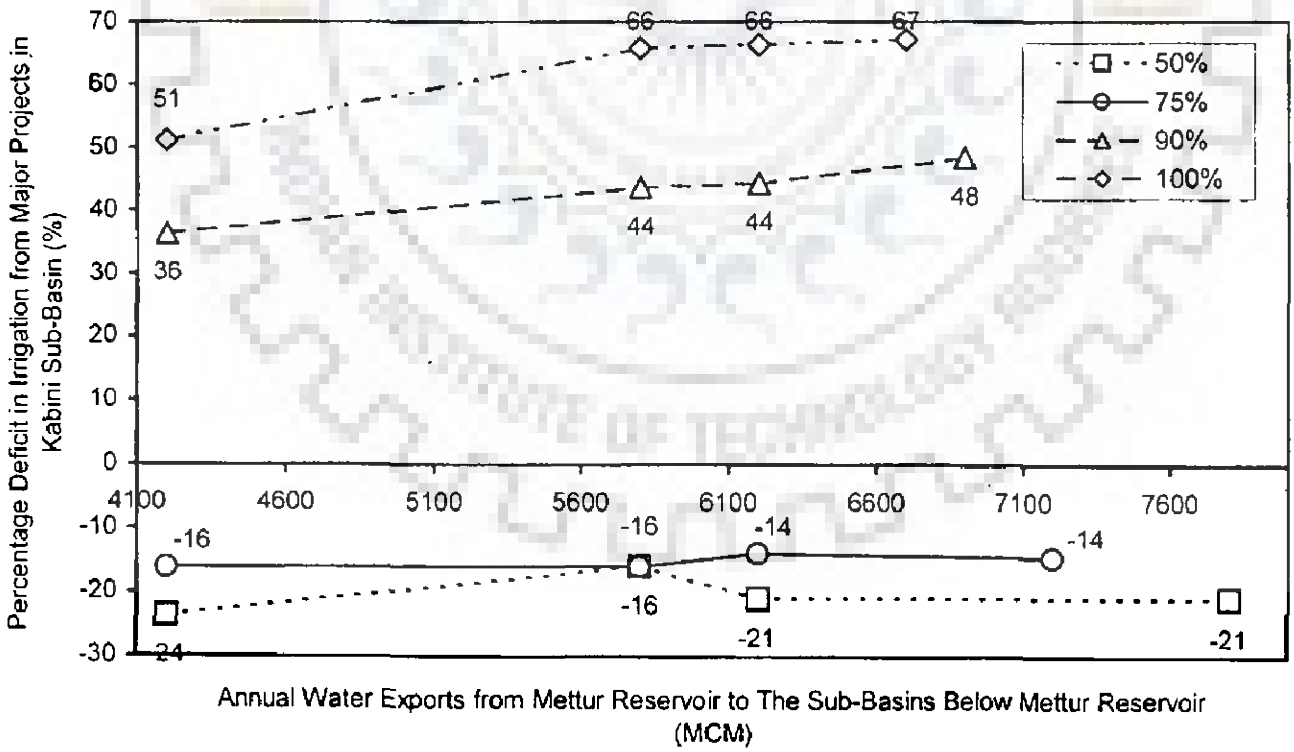

Figure 8.2.2(b): Percentage Deficits in Annual Irrigation for Major Irrigation Projects in Kabini Sub-Basin vs. Annual Water Exports to the Sub-Basins Below Mettur (MCM)

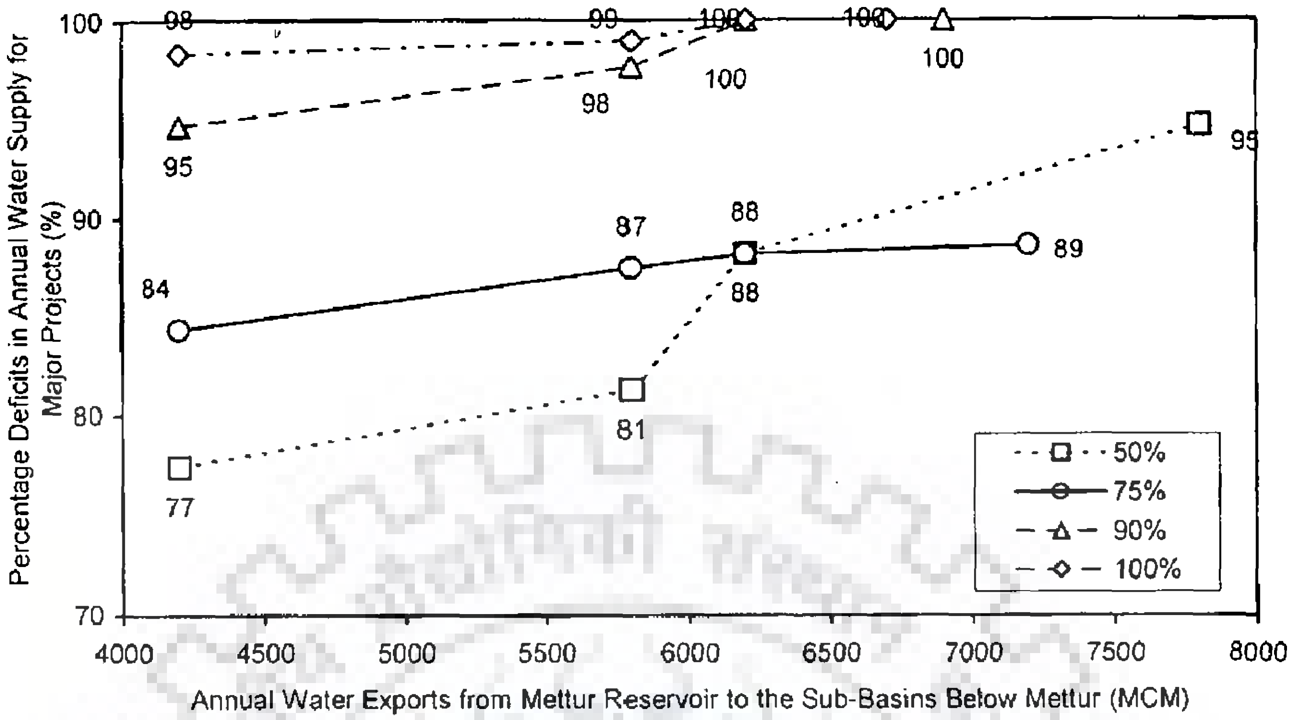

Figure 8.2.3(a): Percentage Deficit in Annual Water Supply for Major Projects in Arkavathi Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

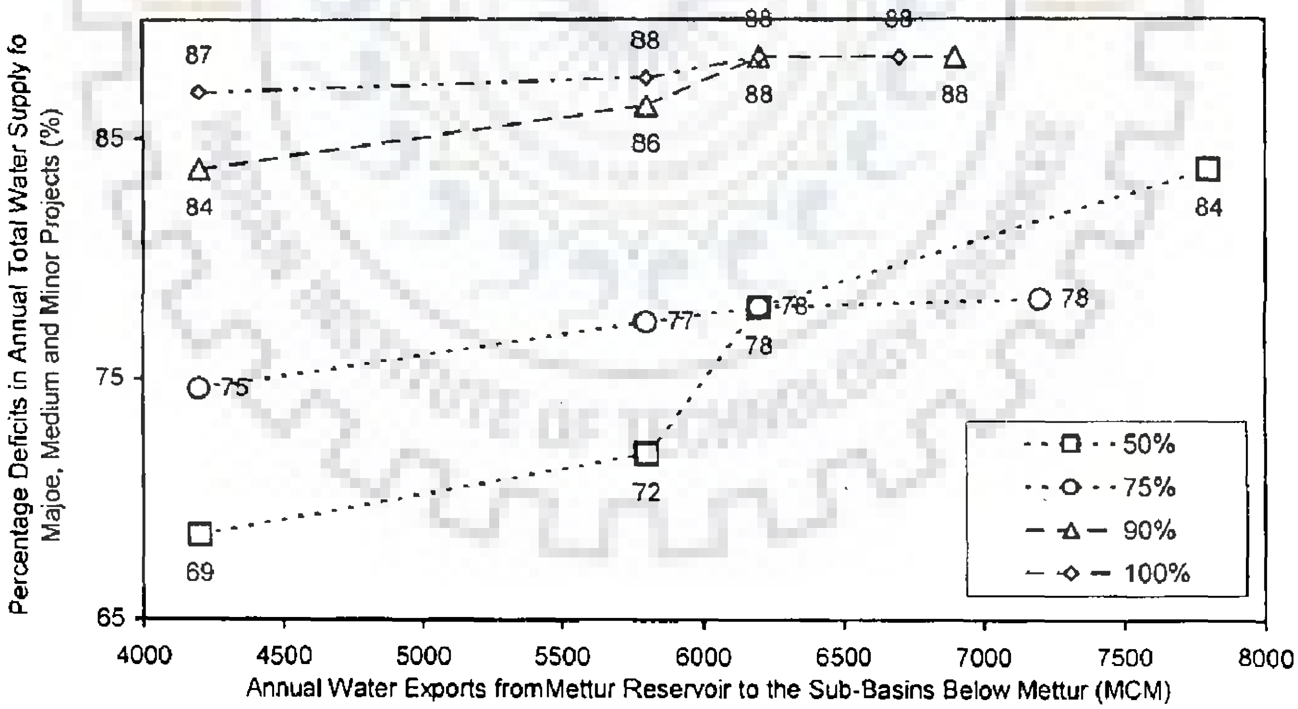

Figure 8.2.3(b): Percentage Deficit in Annual Water Supply for Major,Medium and Minor Projects in Arkavathi Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

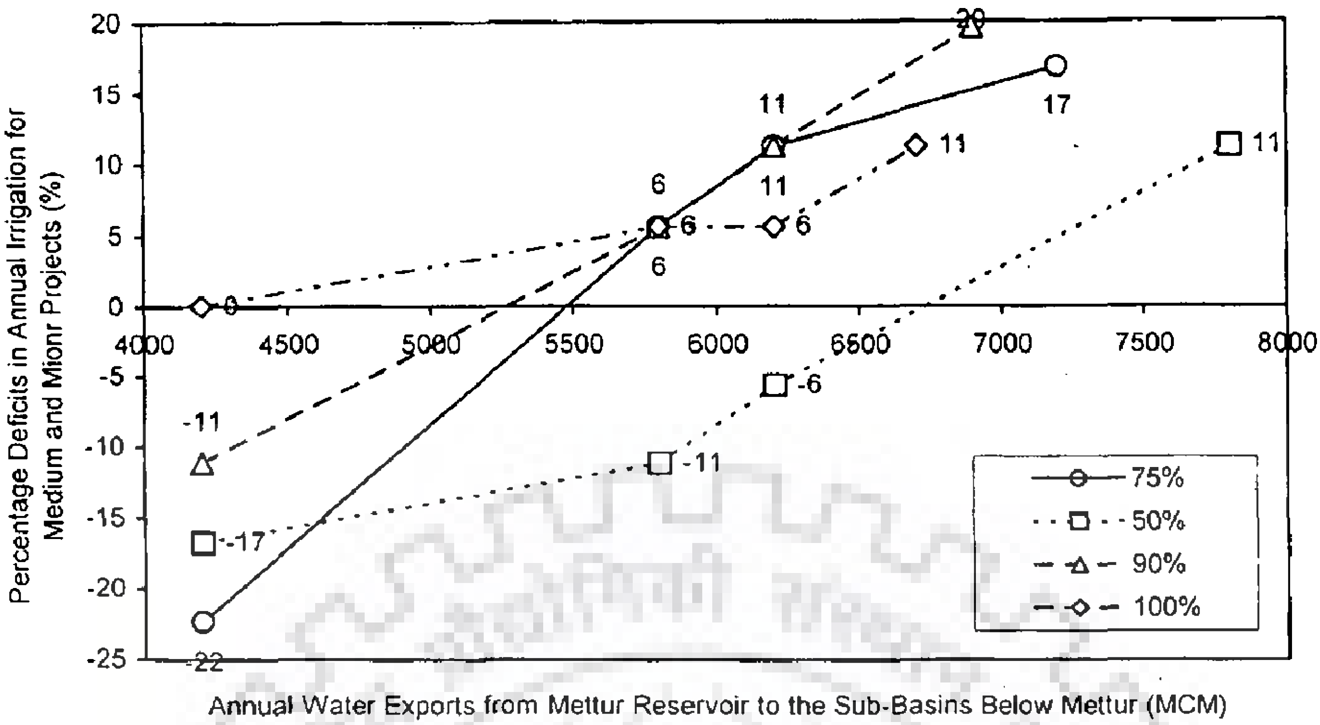

Figure 8.2.4(a): Percentage Deficit in Annual Irrigation for Medium and Minor Projects in Middle Cauvery Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

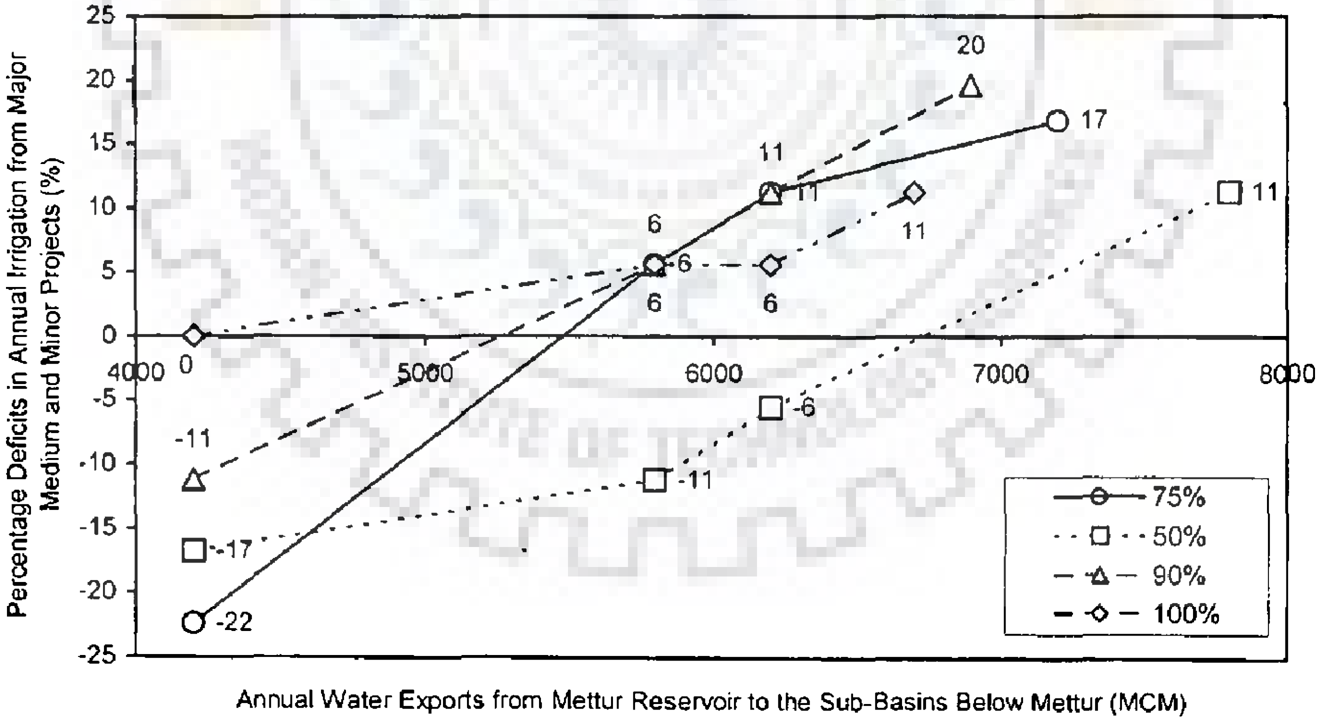

Figure 8.2.4(b): Percentage Deficit in Annual Irrigation for Major,Medium and Minor Projects in Middle Cauvery Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

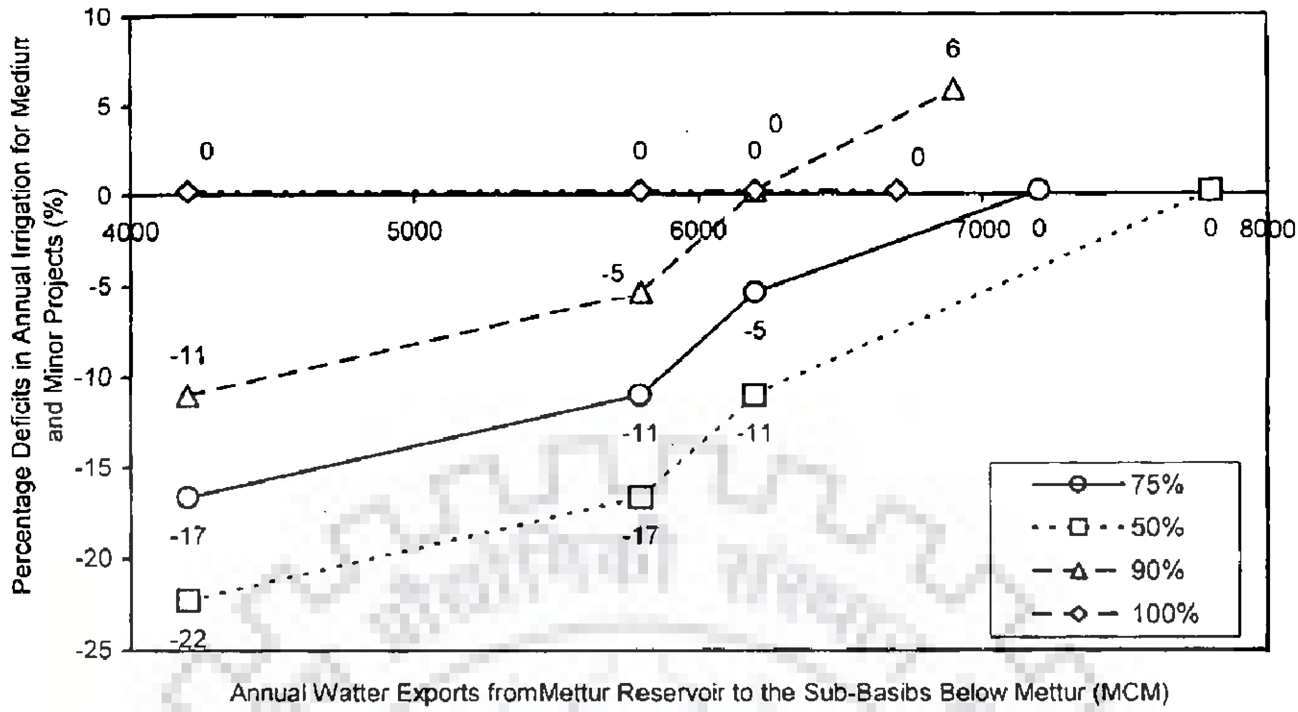

Figure 8.2.5(a): Percentage Deficit in Annual Irrigation for Medium and Minor Projects in Chinnar Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

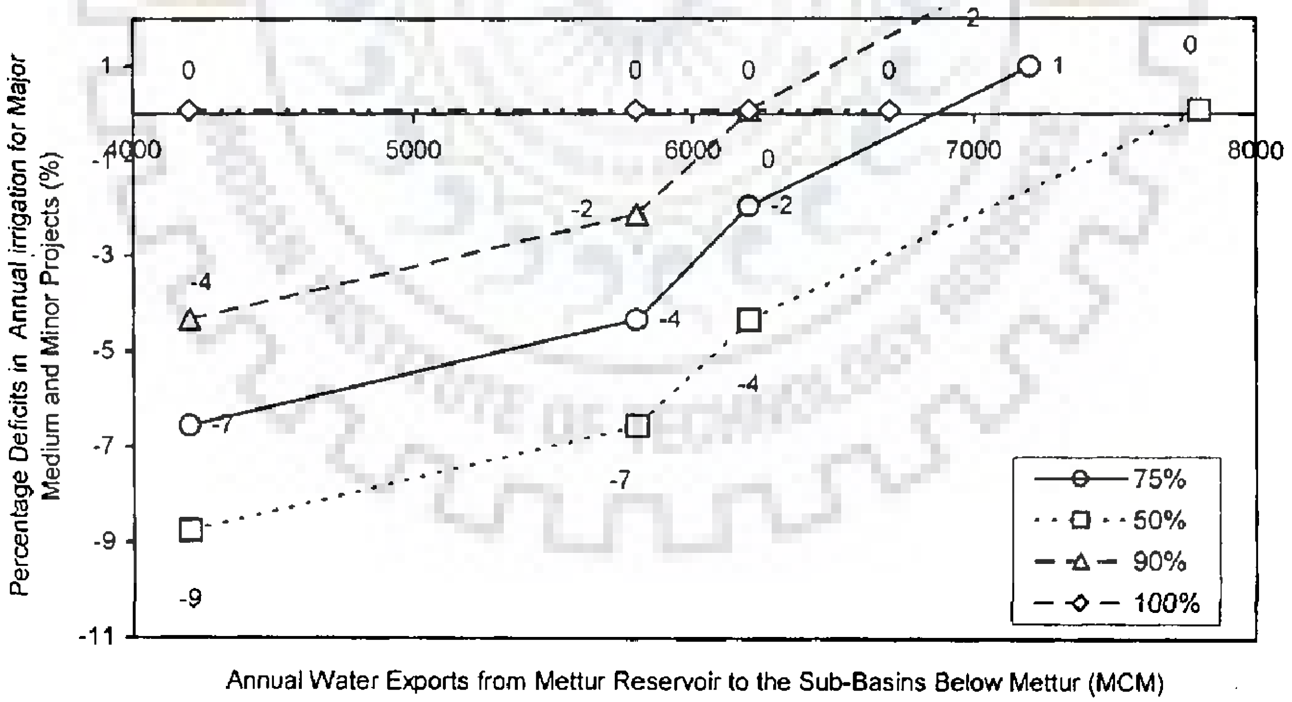

Figure 8.2.5(b): Percentage Deficit in Annual Irrigation for Major Projects in Chinnar Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

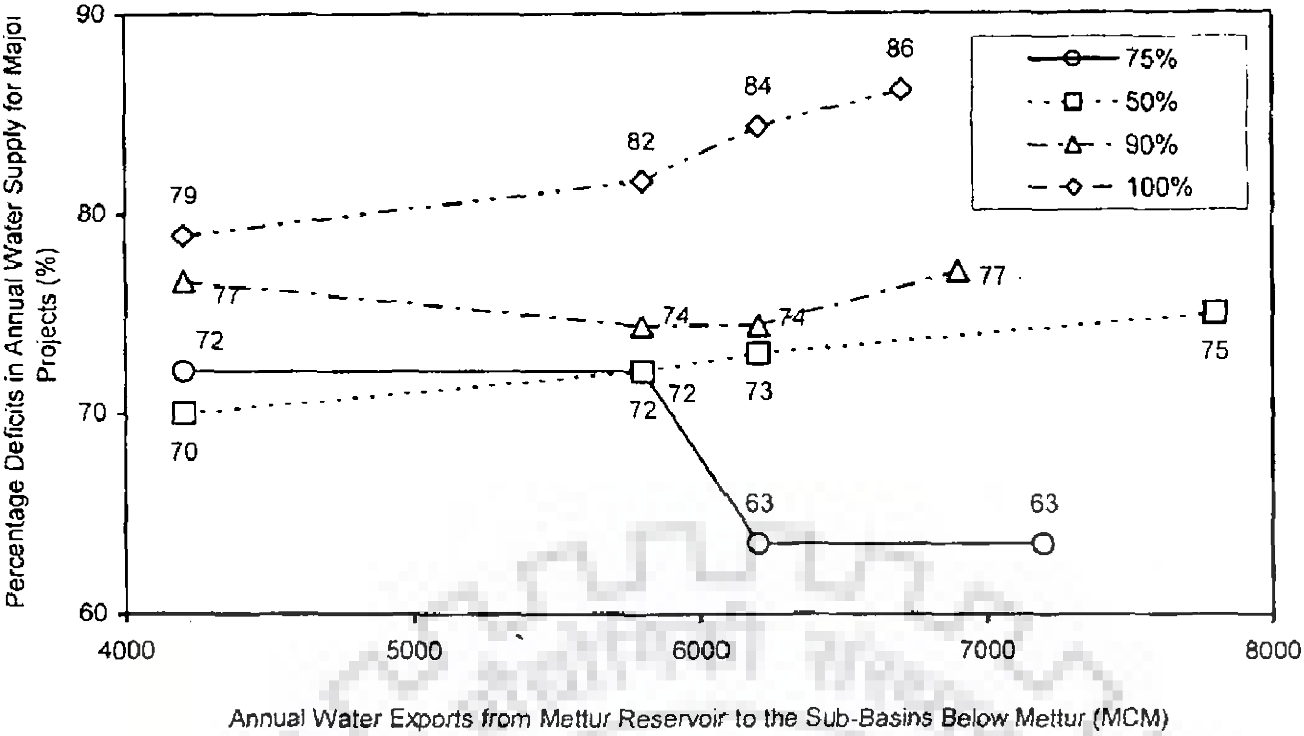

Figure 8.2.6(a): Percentage Deficit in Annual Water Supply for Medium and Minor Projects in Suvarnavathi Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

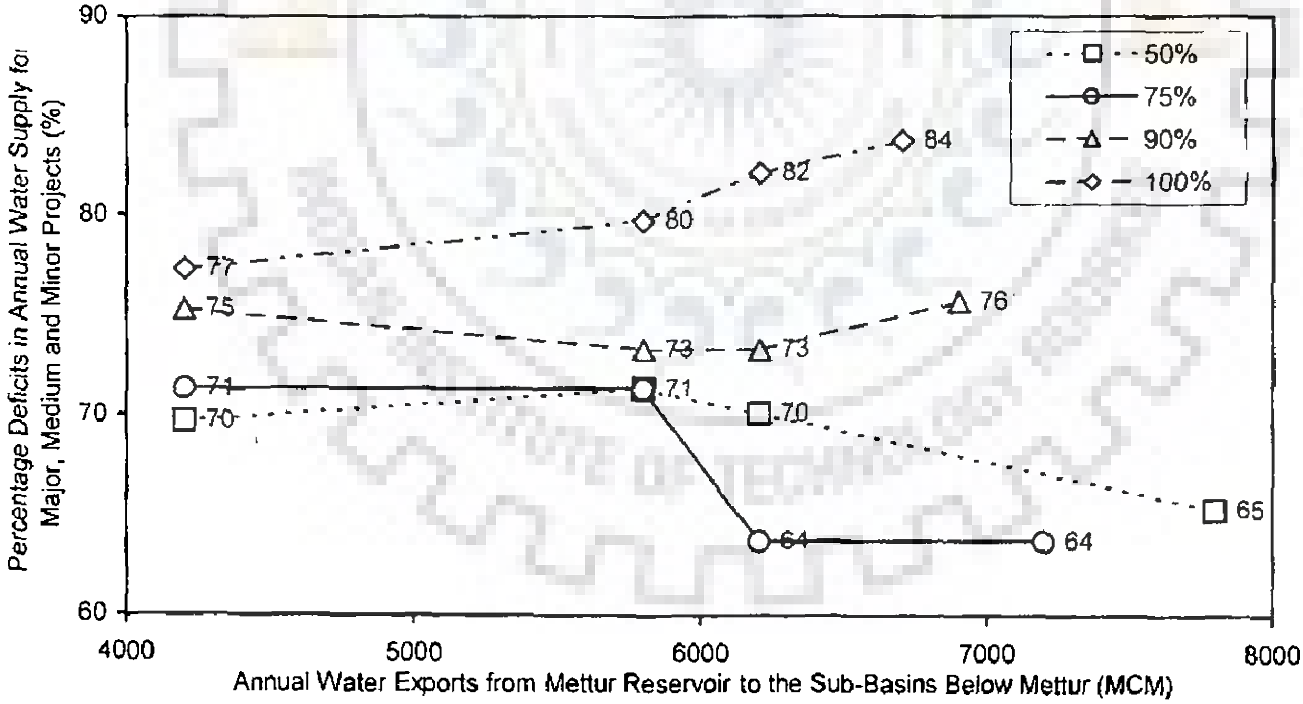

Figure 8.2.6(b): Percentage Deficit in Annual Water Supply for Major,Medium and Minor Projects in Suvarnavathi Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

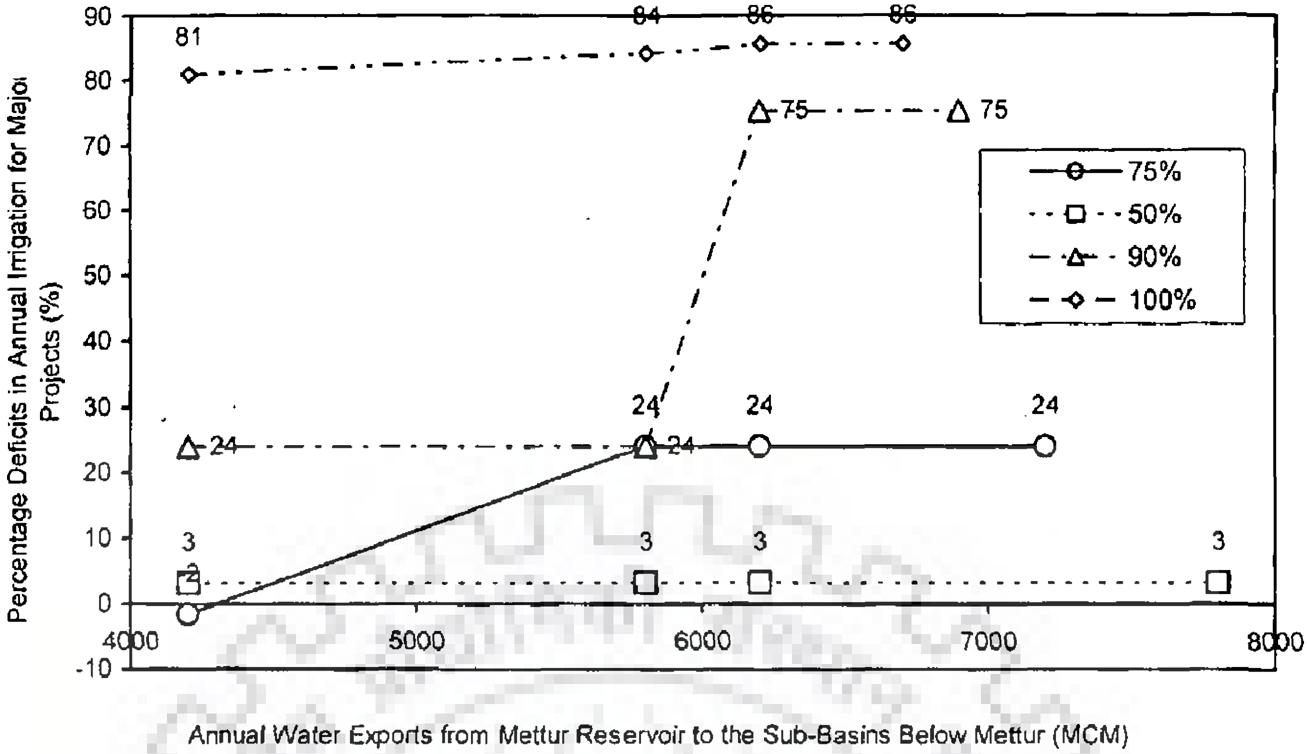

Figure 8.2.7(a): Percentage Deficit in Annual Irrigation for Major Projects in Amaravathi Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

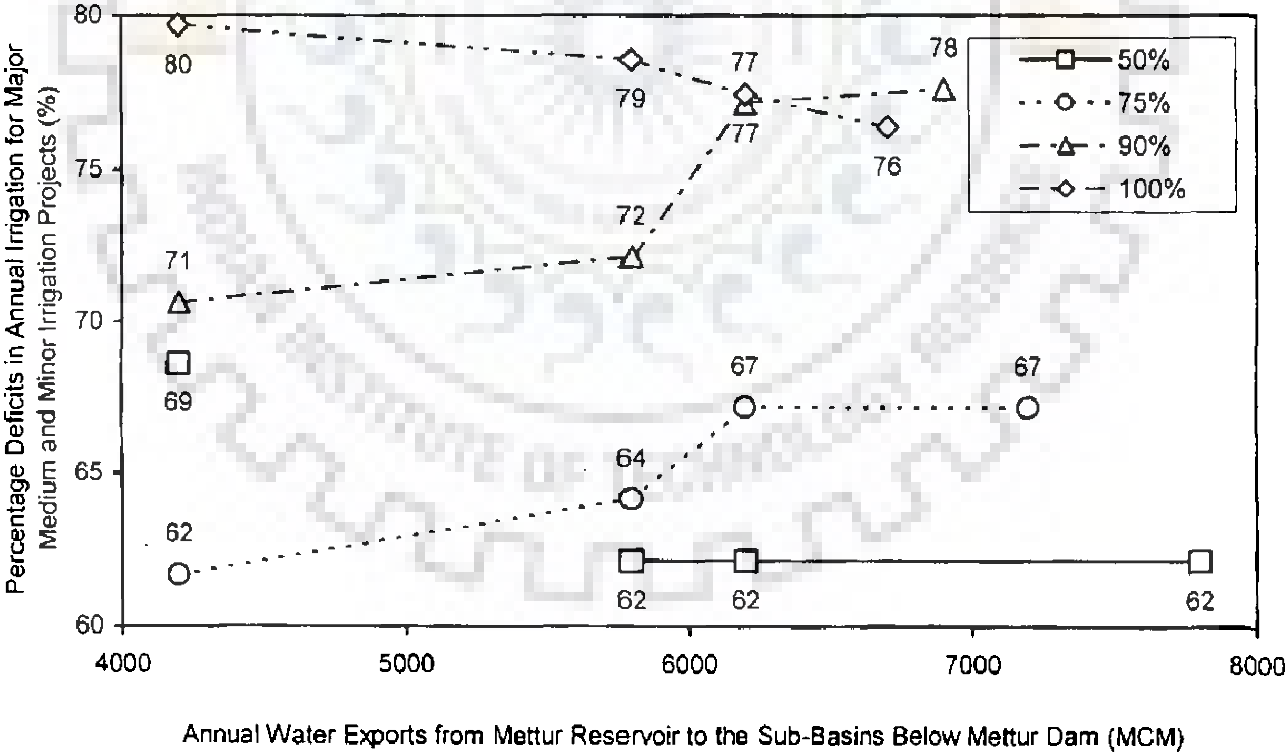

Figure 8.2.7(b): Percentage Deficit in Annual Irrigation for Major, Medium and Minor Irrigation Projects in Amravathi Sub-Basin vs. Annual Water Exports from Mettur Reservoirto the Sub-Basins Below Mettur (MCM)

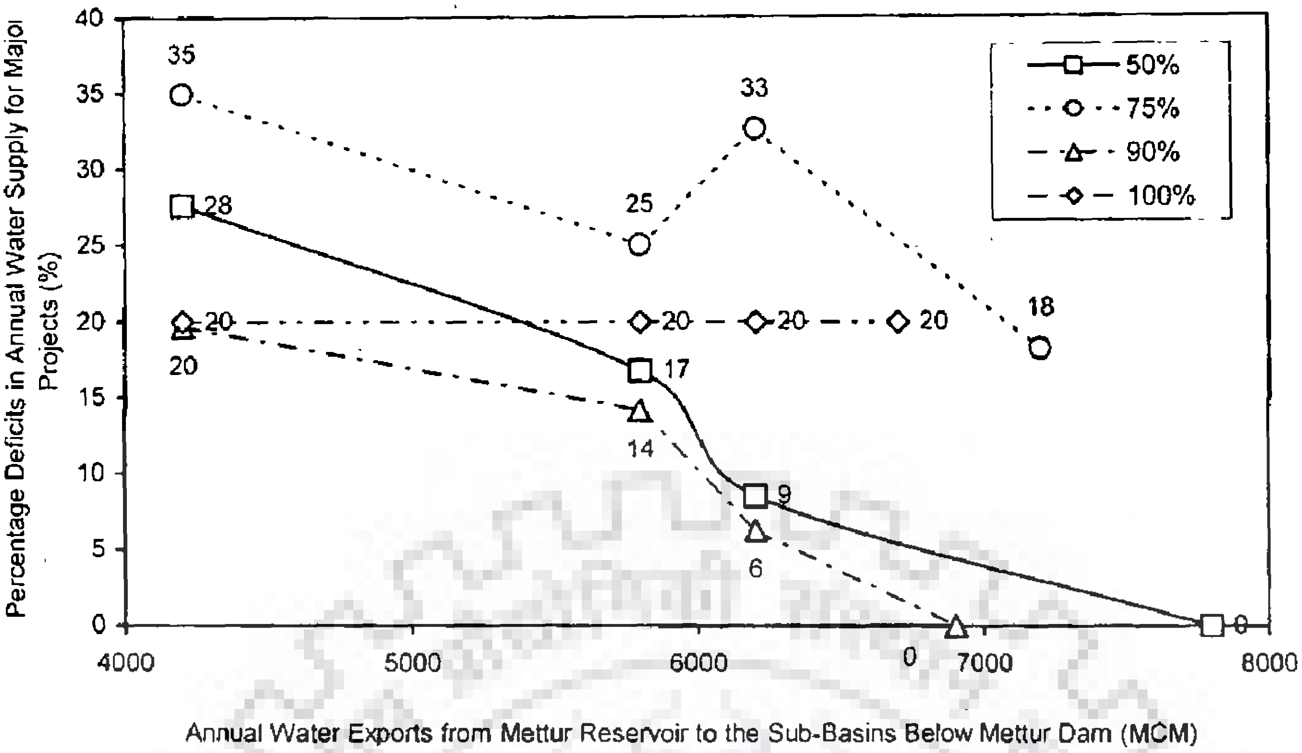

Figure 8.2.8(a): Percentage Deficit in Annual Water Supply for Major Projects in Tirumanimuttar Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

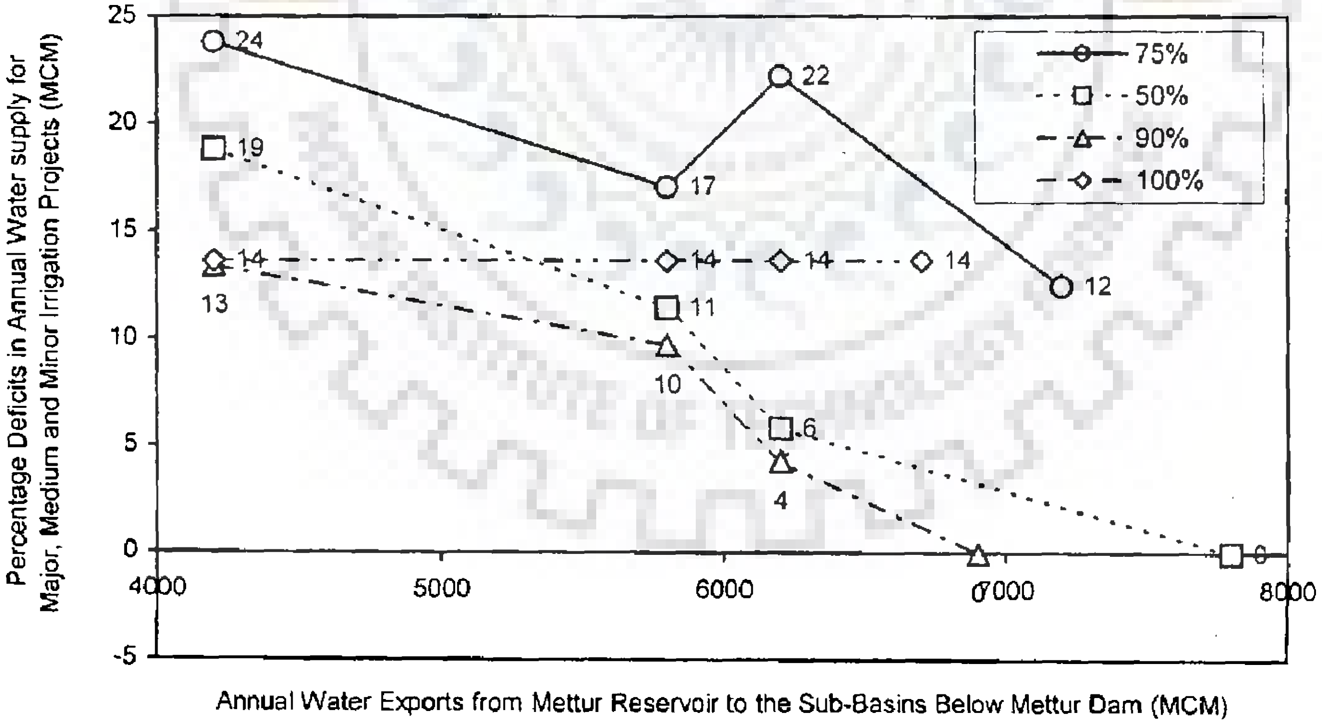

Figure 8.2.8(b): Percentage Deficit in Annual Water Supply for Major, Medium and Minor Projects in Tirumanimuttar Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

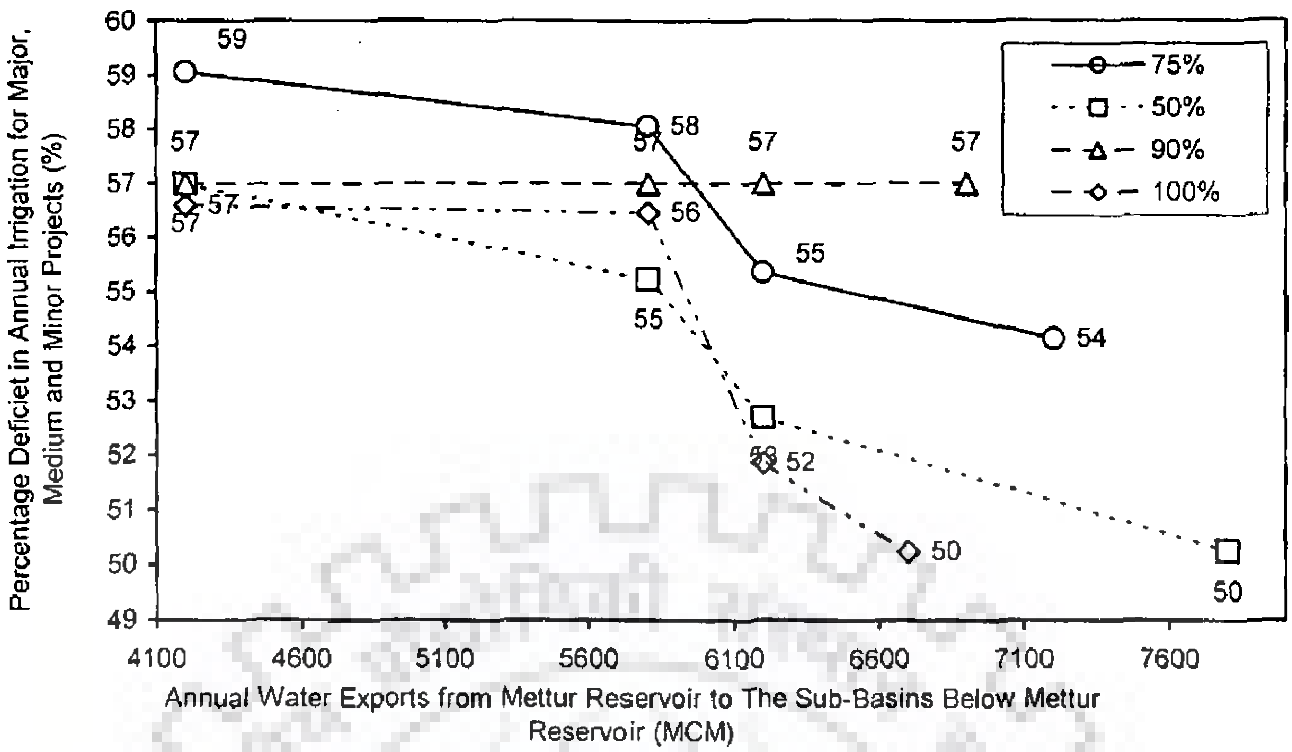

Figure 8.2.9: Percentage Deficit in Annual Irrigation for Major, Medium and Minor Projects in Ponnana Ar Sub-Basin vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur (MCM)

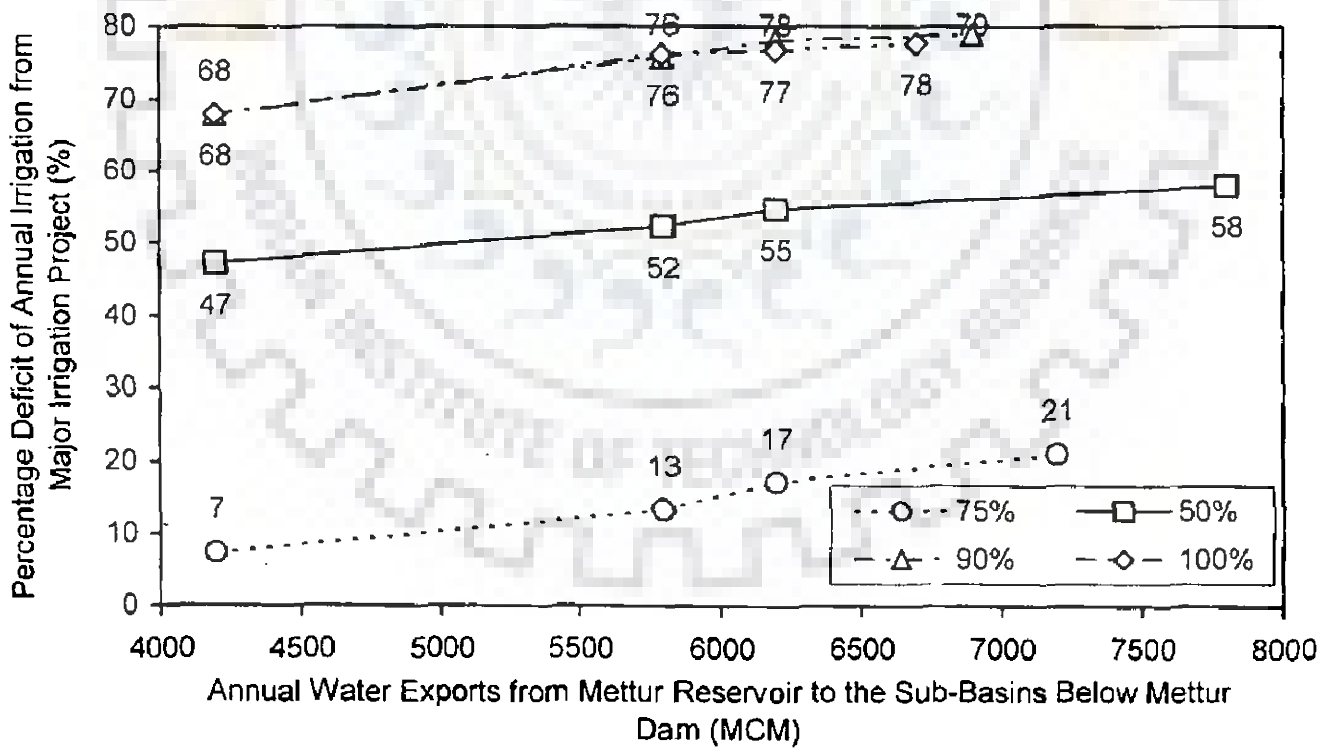

Figure 8.3.1: Graph Between Percentage Deficit of Annual Irrigation vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur for Harangi Project

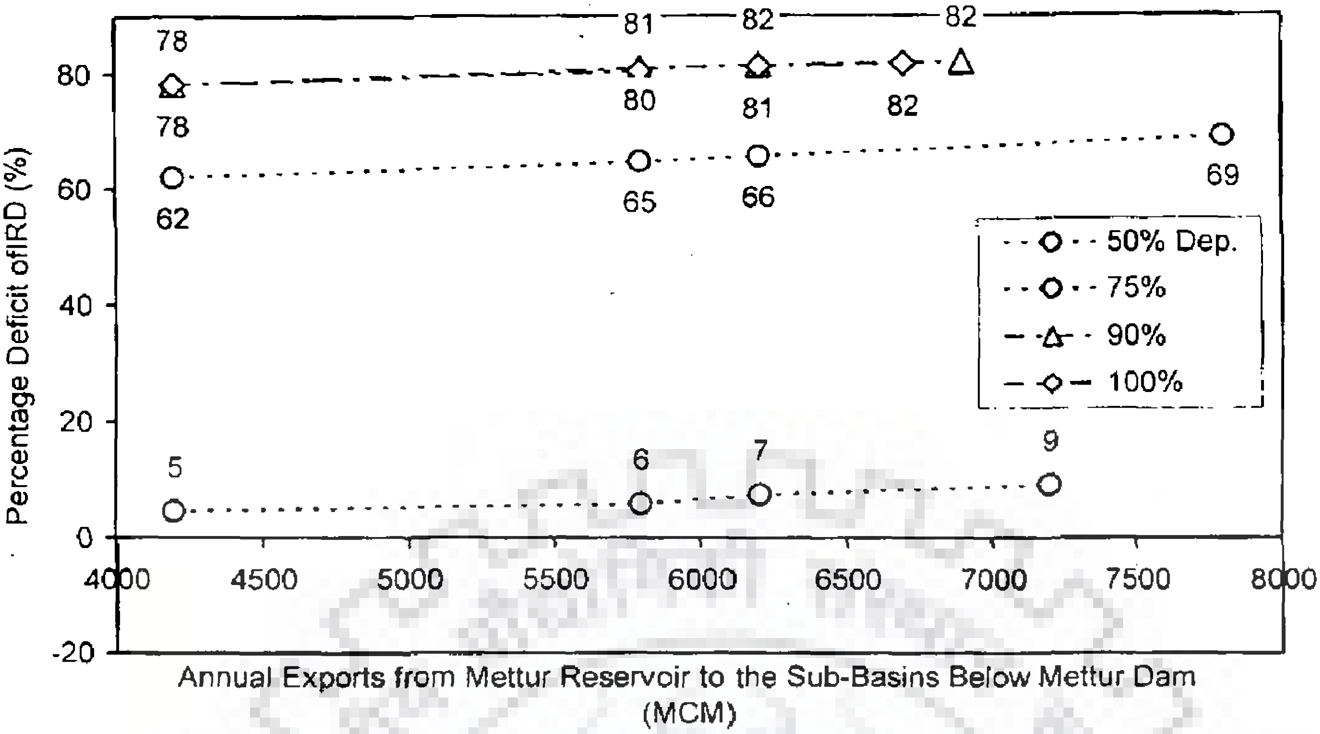

Figure 8.3.2: **Graph Between Percentage Deficit of Annual Irrigation vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur for Cauvery Project**

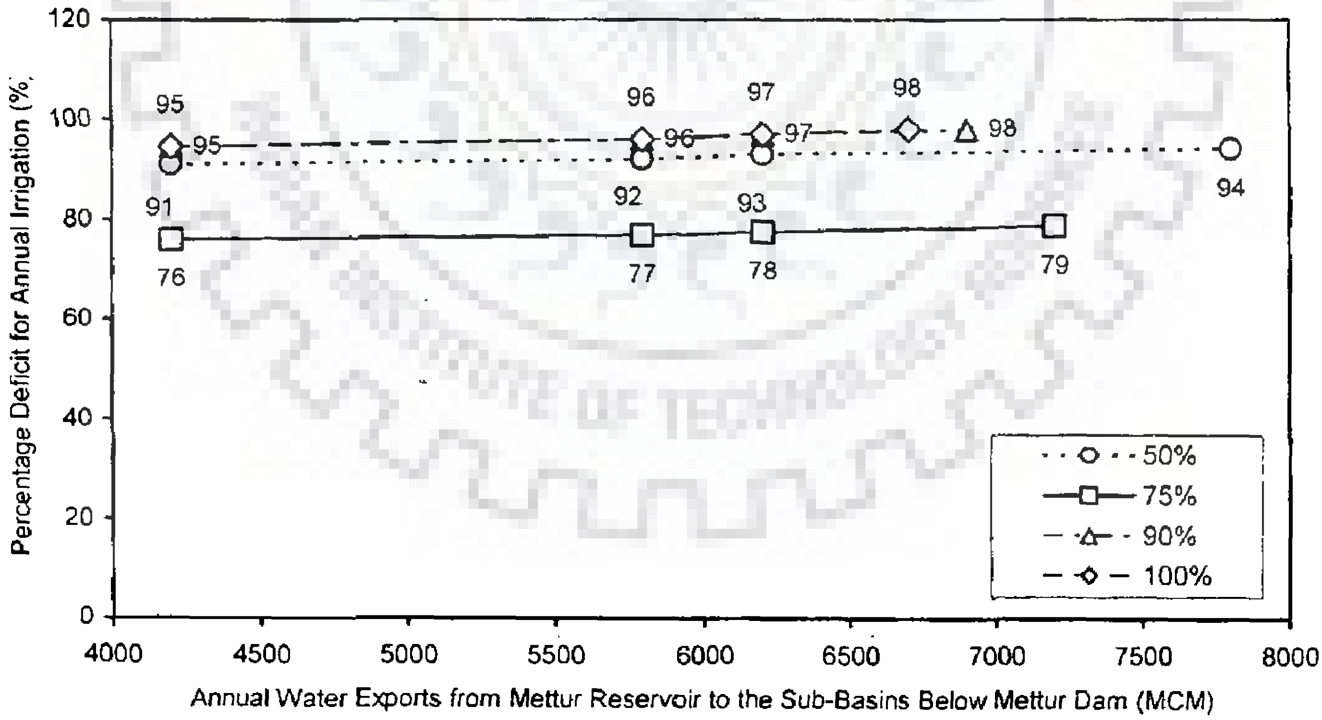

Figure 8.3.3: **Graph Between Percentage Deficit of Annual Irrigation vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur for Banasurasagar Project**

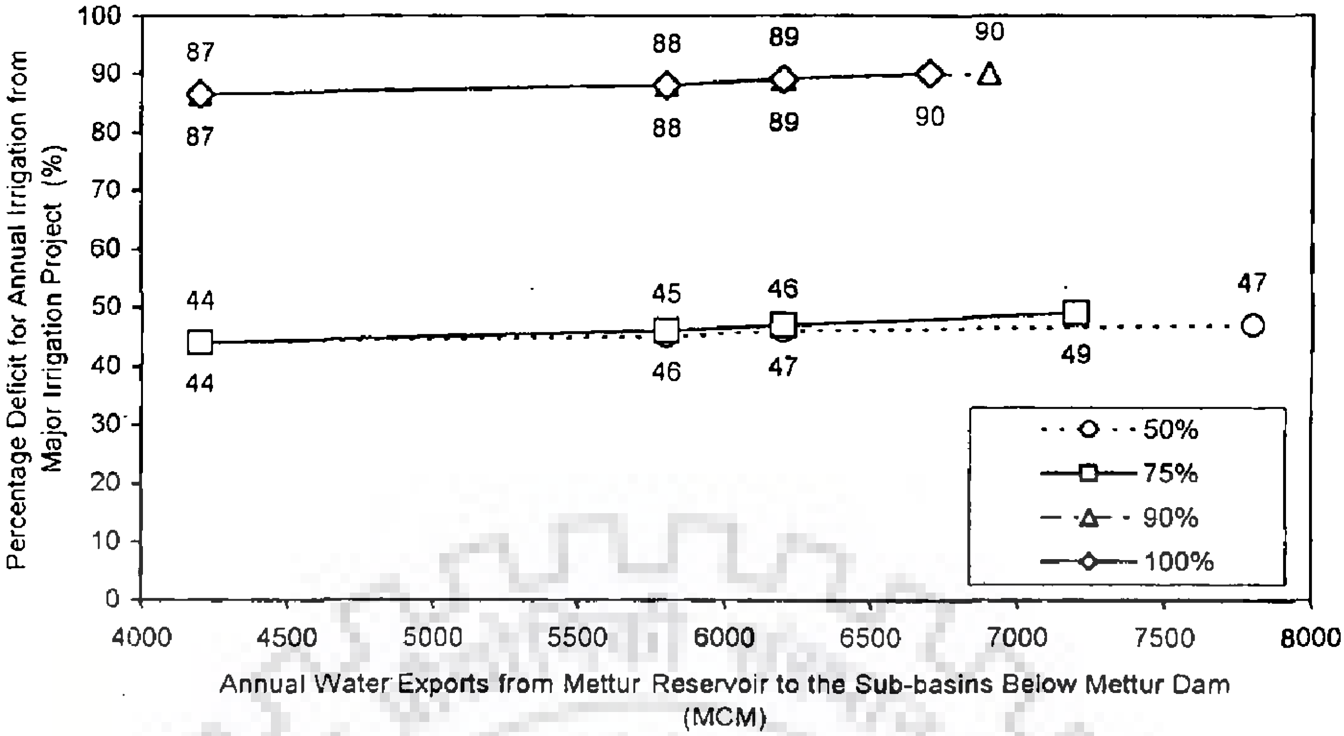

Figure 8.3.4: **Graph Between Percentage Deficit of Annual Irrigation vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur for Taraka Project**

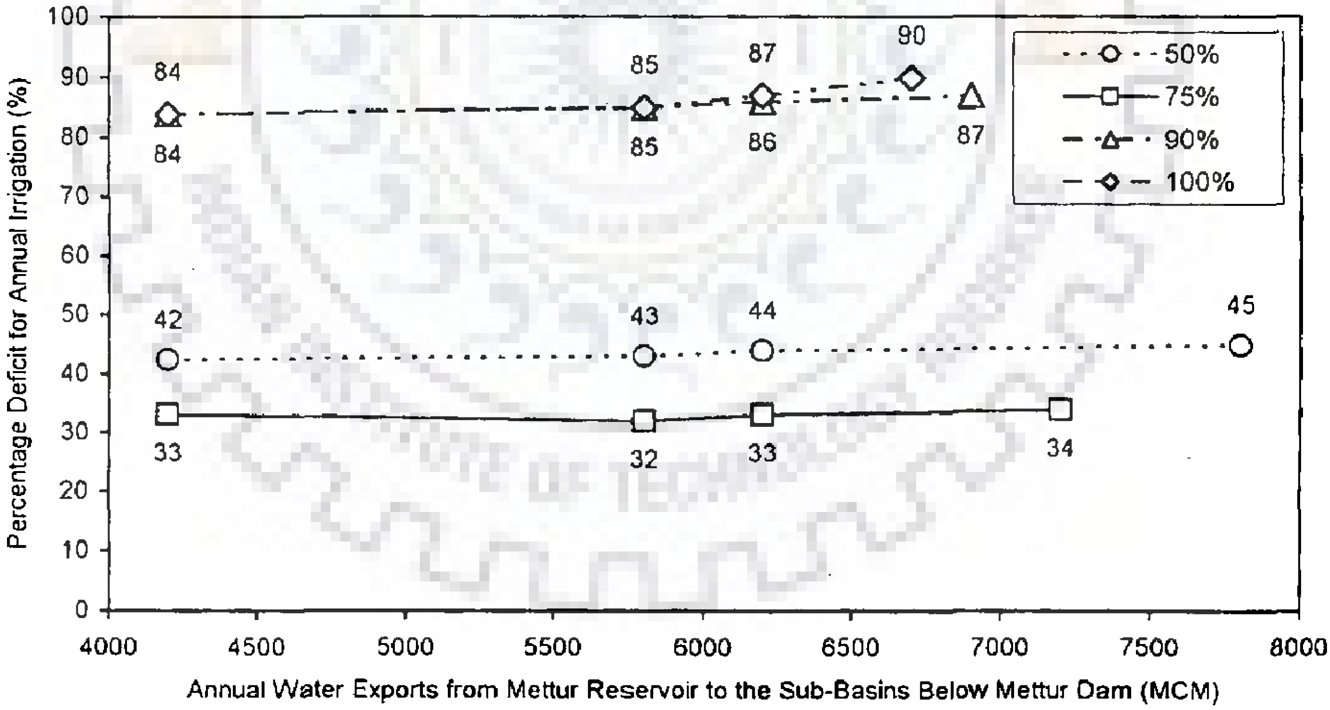

Figure 8.3.5 : **Graph Between Percentage Deficit of Annual Irrigation vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur for Upper Nugu Project**

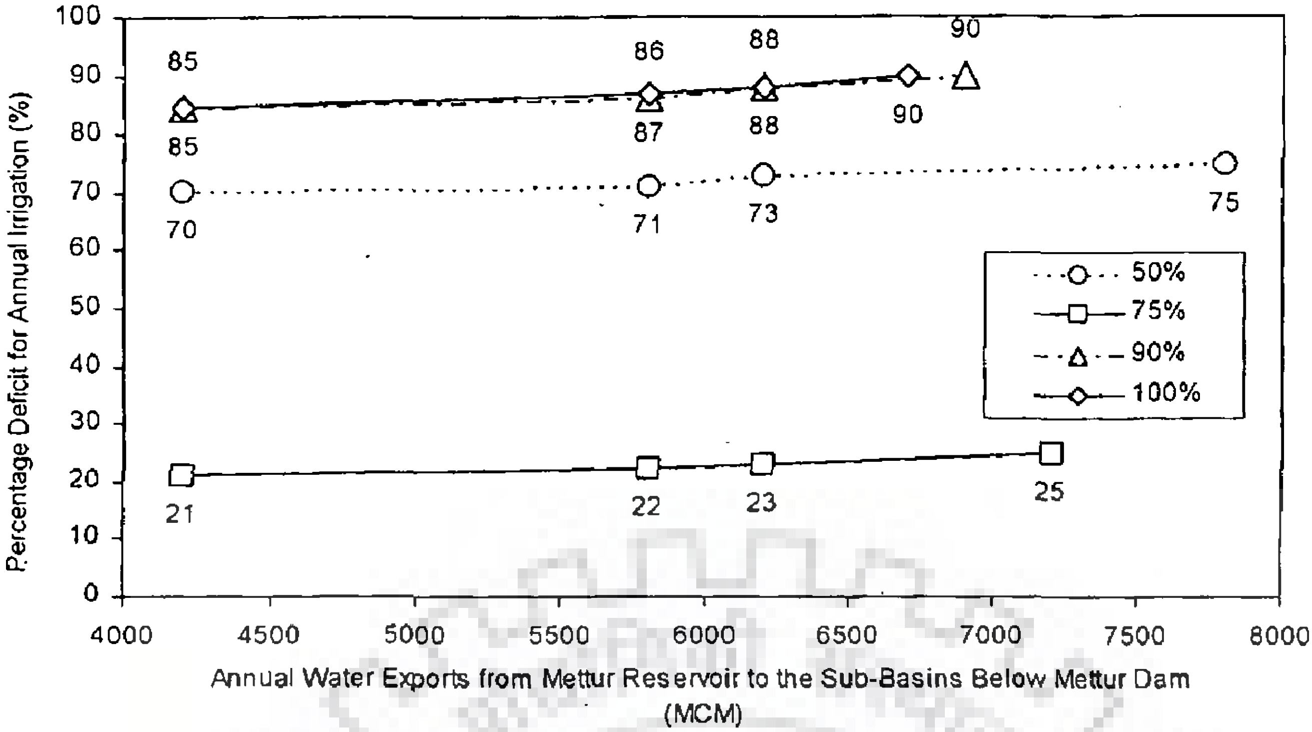

Figure 8.3.6: **Graph Between Percentage Deficit of Annual Irrigation vs. Annual Water Exports from Mettur Reservoir to the Sub-Basins Below Mettur for Amaravathi Project**

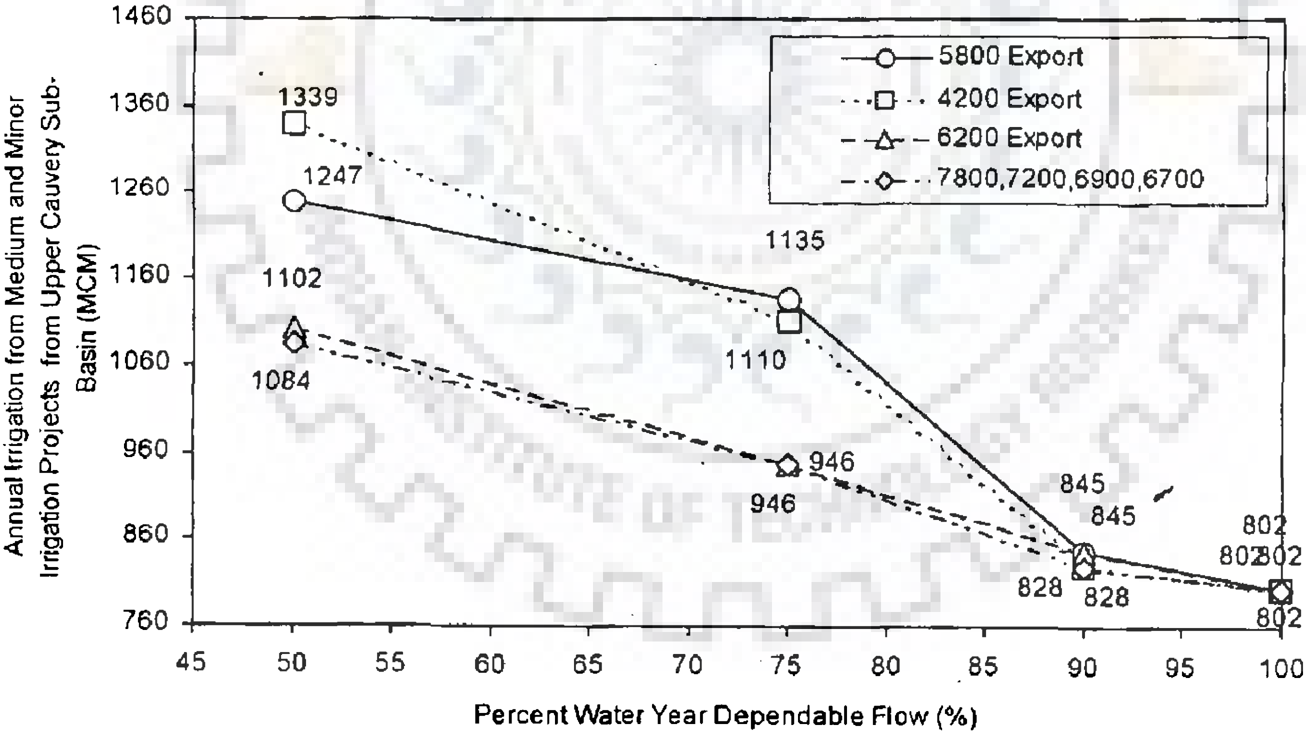

Figure 8.4.1(a): **Variation in Annual Irrigation from Medium and Minor Projects vs. Various Percent Water Year Dependable Flows in Upper Cauvery Sub-Basin**

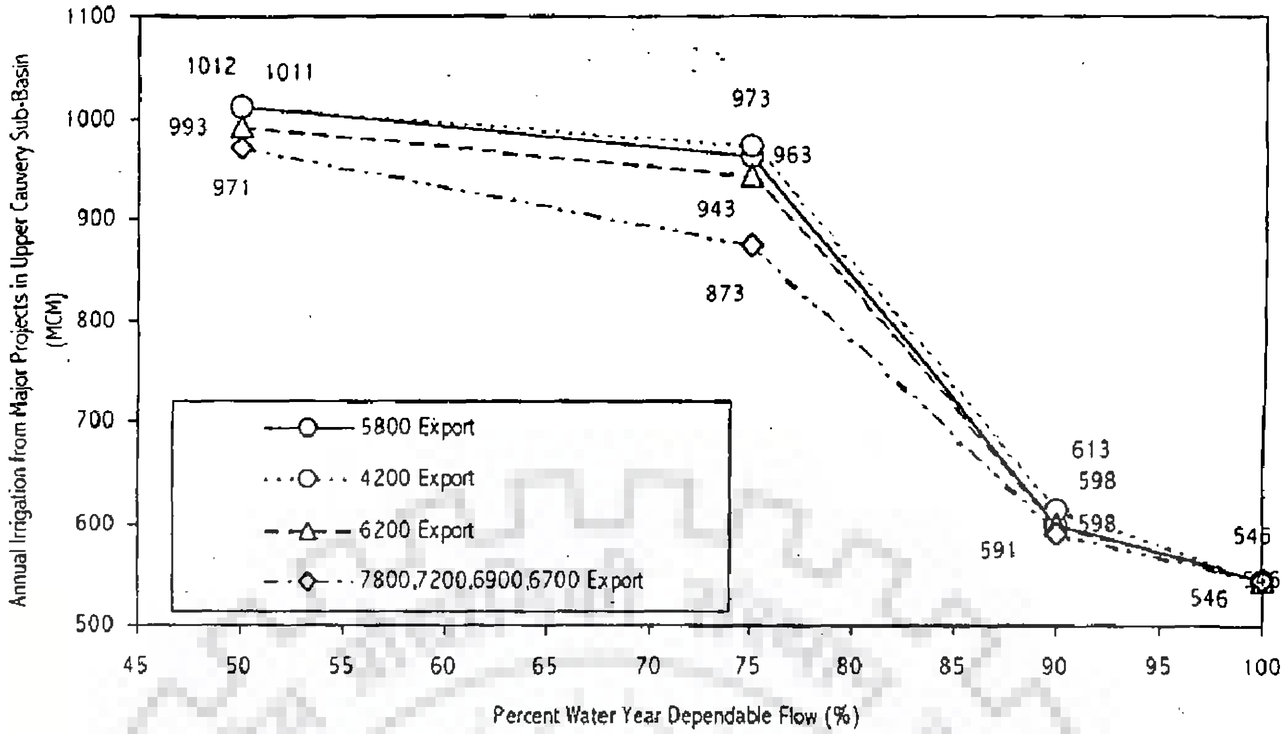

Figure 8.4.1(b): **Variation in Annual Irrigation from Major Projects vs. Various Percent Water Year Dependable Flows in Upper Cauvery Sub-Basin**

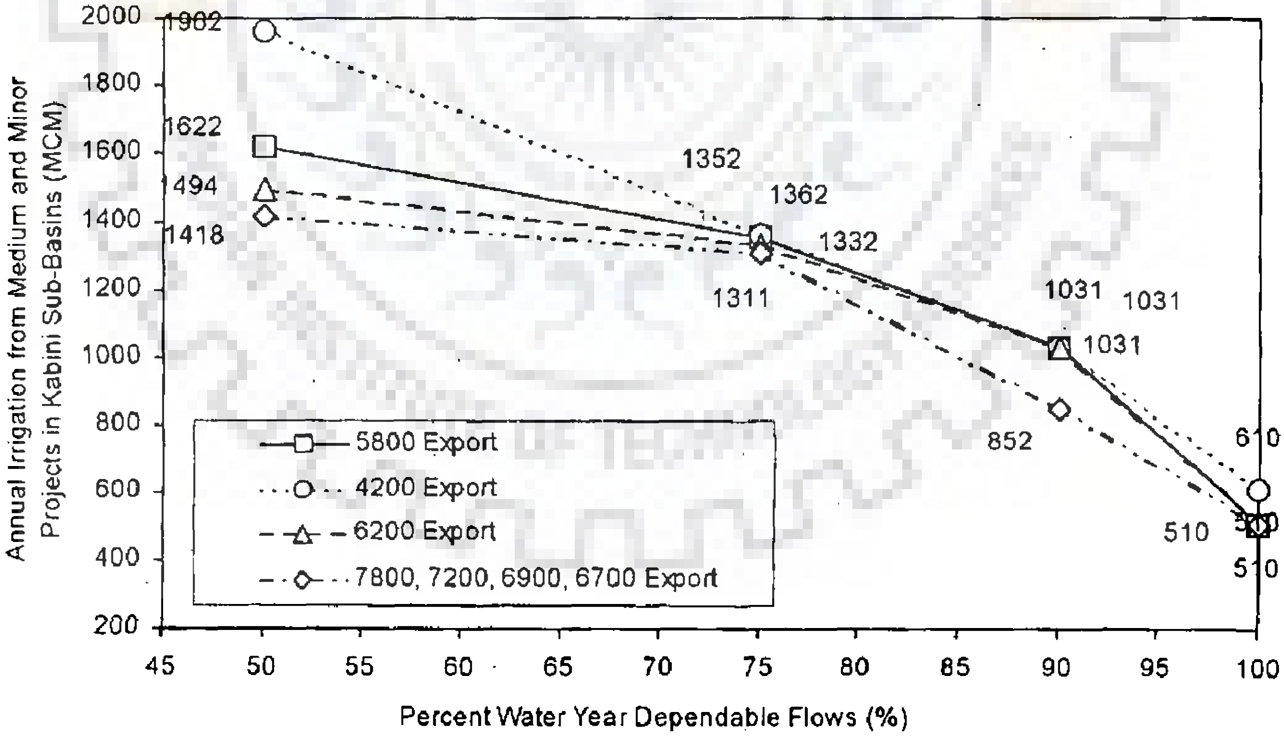

Figure 8.4.2(a): **Variation in Annual Irrigation from Medium and Minor Projects Vs. Various Percent Water Year Dependable Flows in Kabini Sub-Basin**

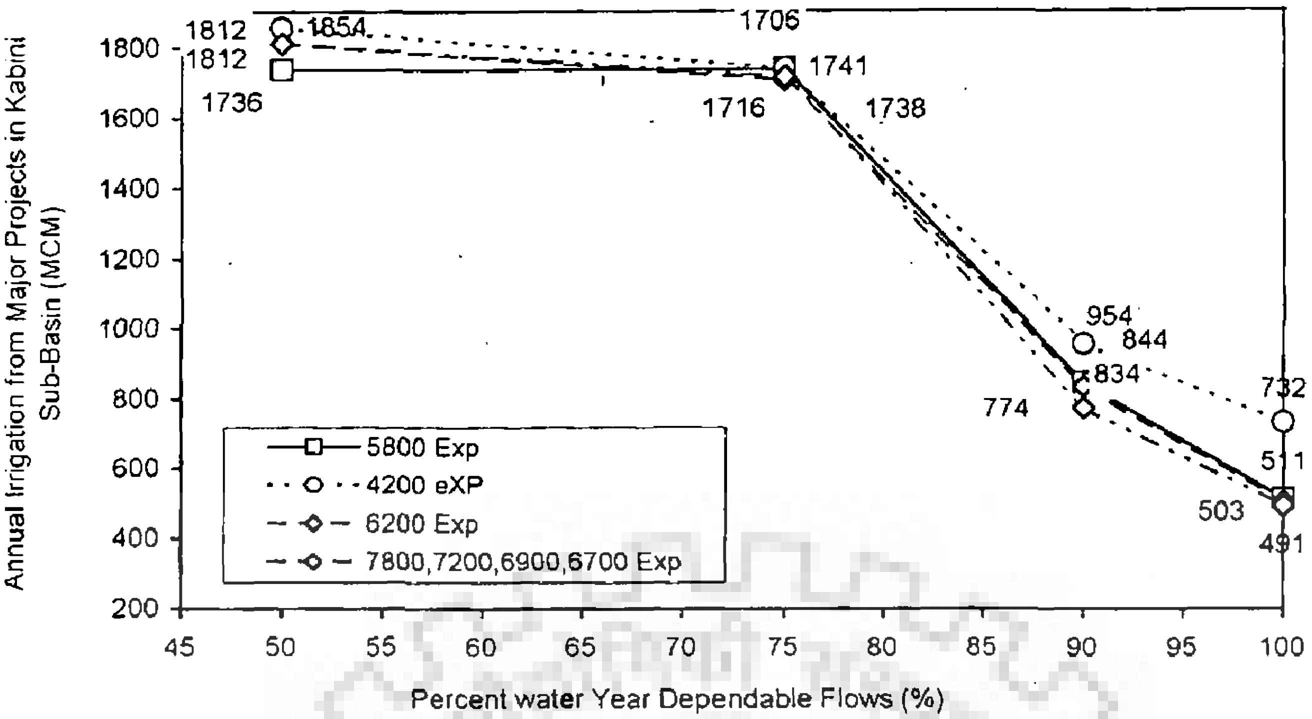

Figure 8.4.2(b): **Variation in Annual Irrigation from Major Projects Vs. Various Percent Water Year Dependable Flows in Kabini Sub-Basin**

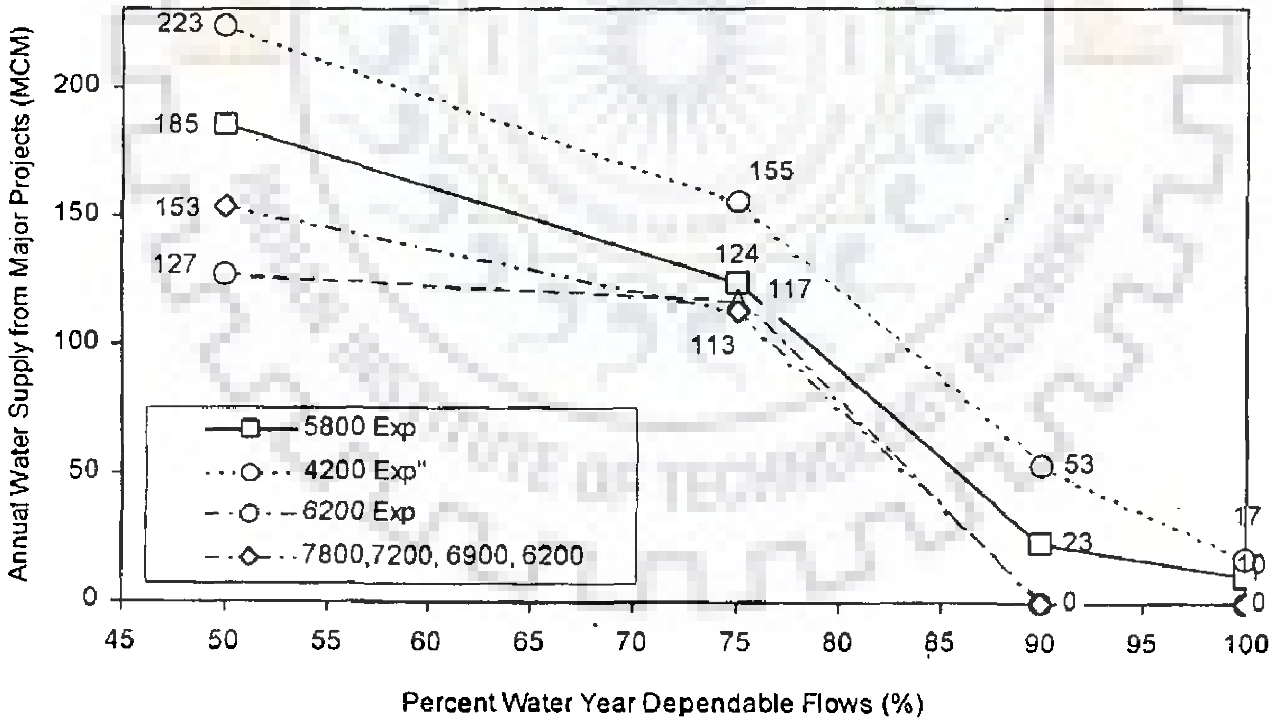

Fig. 8.4.3(a): **Variation in Annual water supply from Major Projects Vs. Various Percent Water Year Dependable Flows in Arkavathi Sub-Basin**

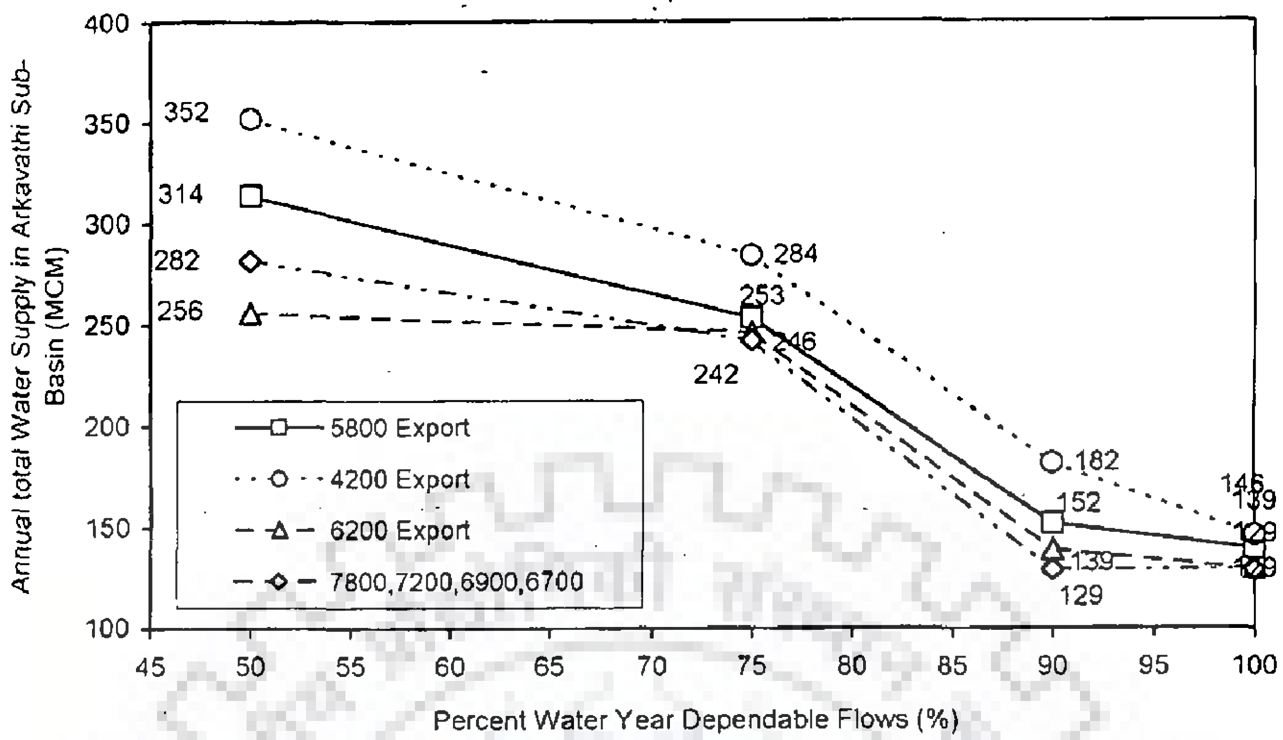

Figure 8.4.3(b): Variation in Annual Total Water Supply from Major, Medium and Minor Projects Vs. Various Percent Water Year Dependable Flows in Arkavathi Sub-Basin

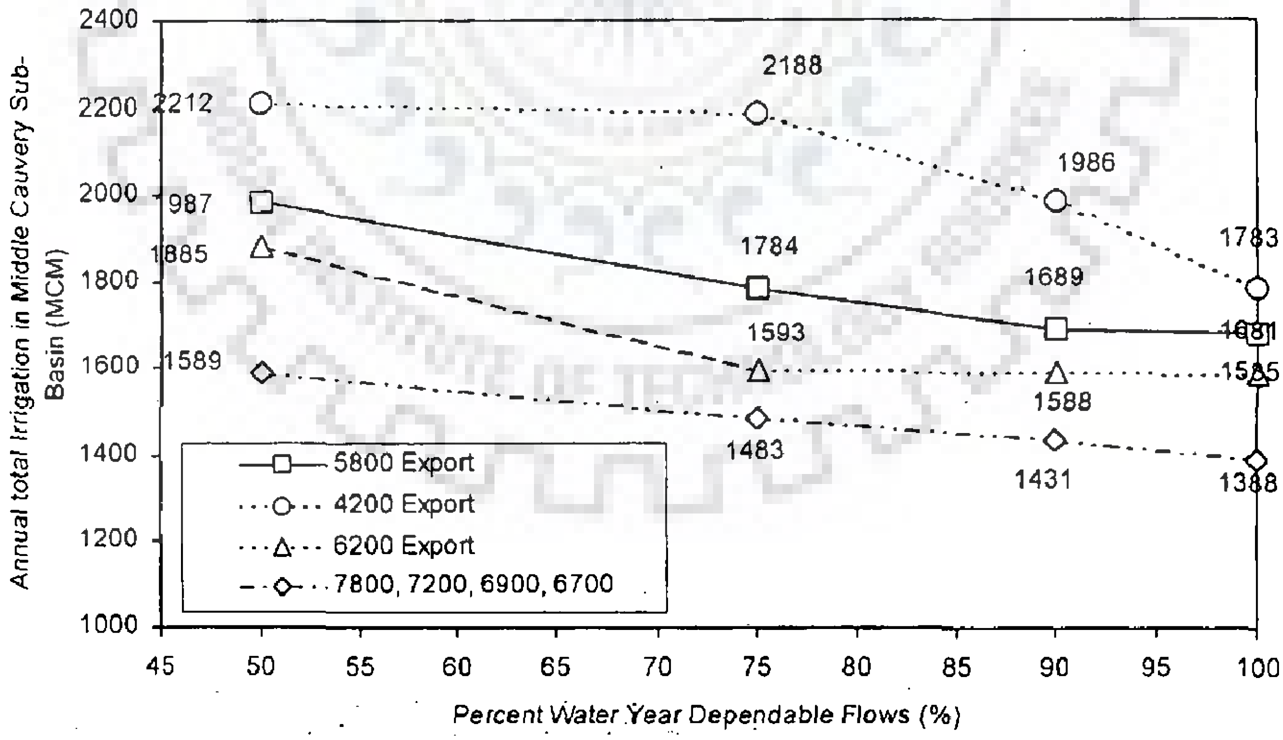

Figure 8.4.4: Variation in Annual Total Irrigation from Major, Medium and Minor Projects Vs. Various Percent Water Year Dependable Flows in Middle Cauvery Sub-Basin

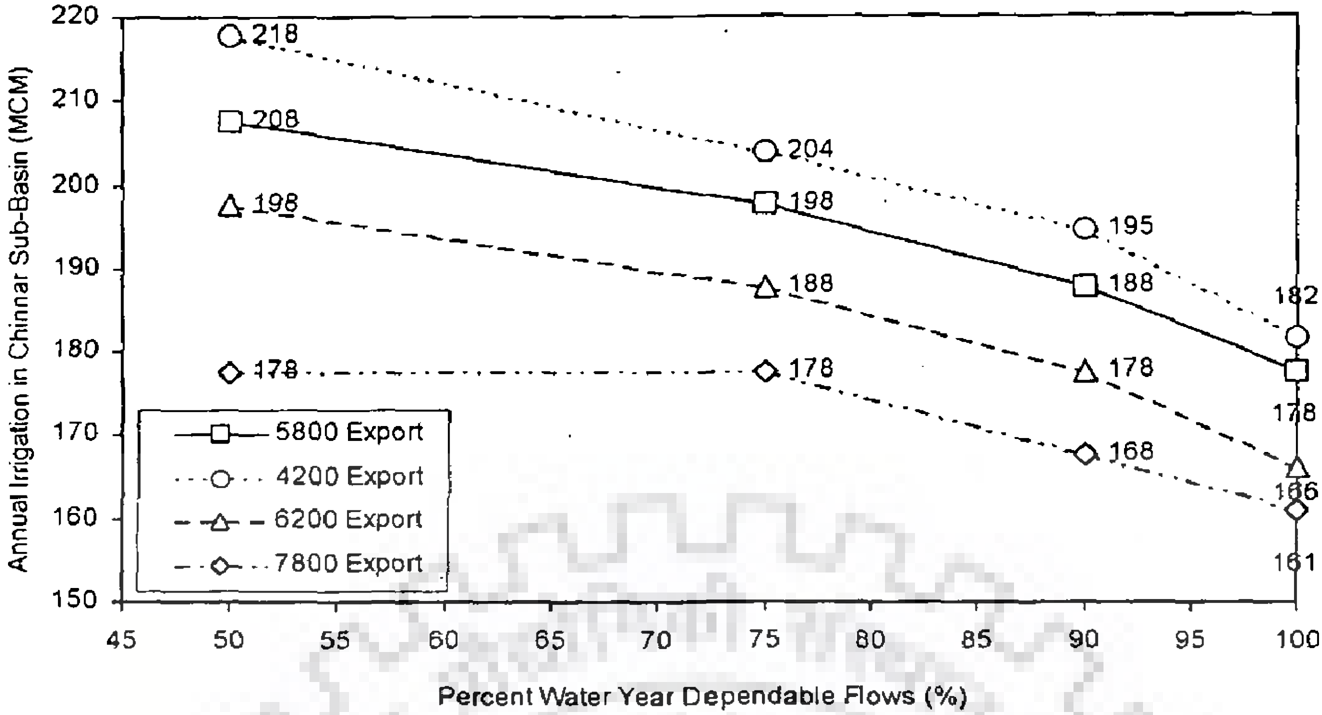

Figure 8.4.5: Variation in Annual Total Irrigation from Major, Medium and Minor Projects vs. Various Percent Water Year Dependable Flows in Chinnar Sub-Basin

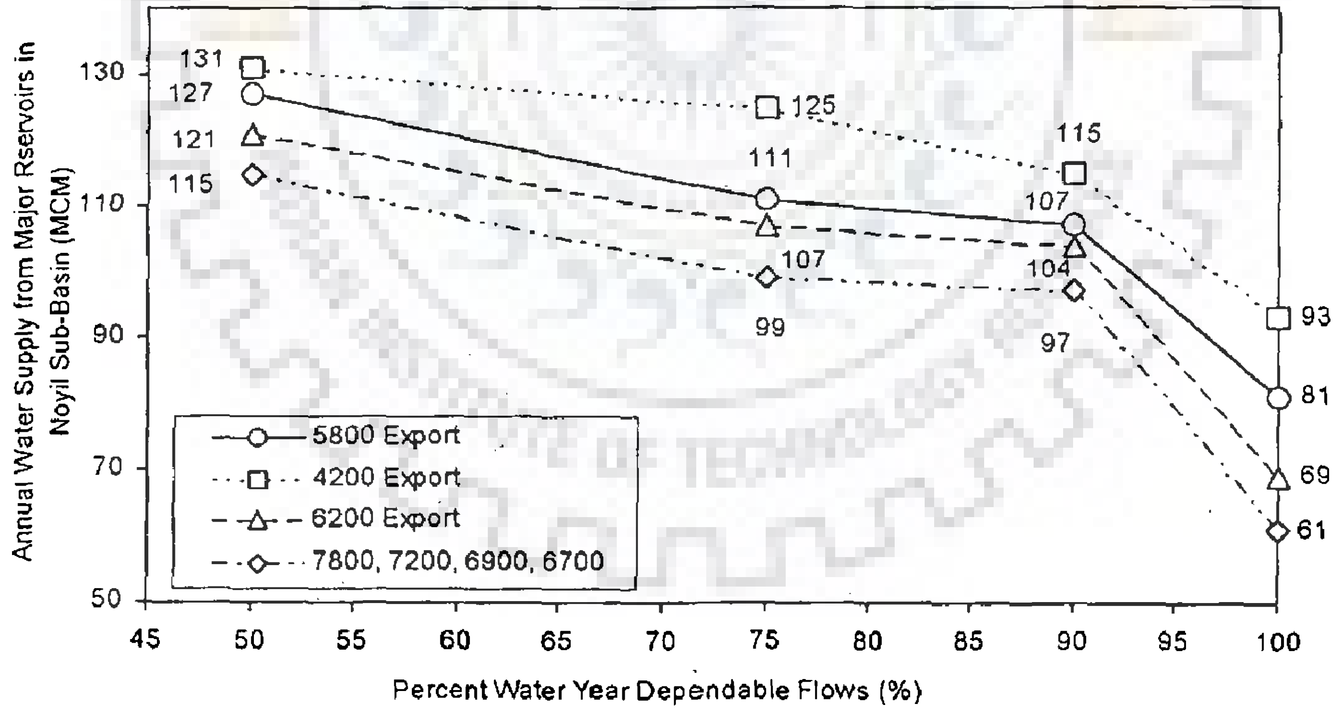

Figure 8.4.6(a): Variation in Annual Total Water Supply from Major Projects with respect to Various Percent Water Year Dependable Flows in Noyil Sub-Basin

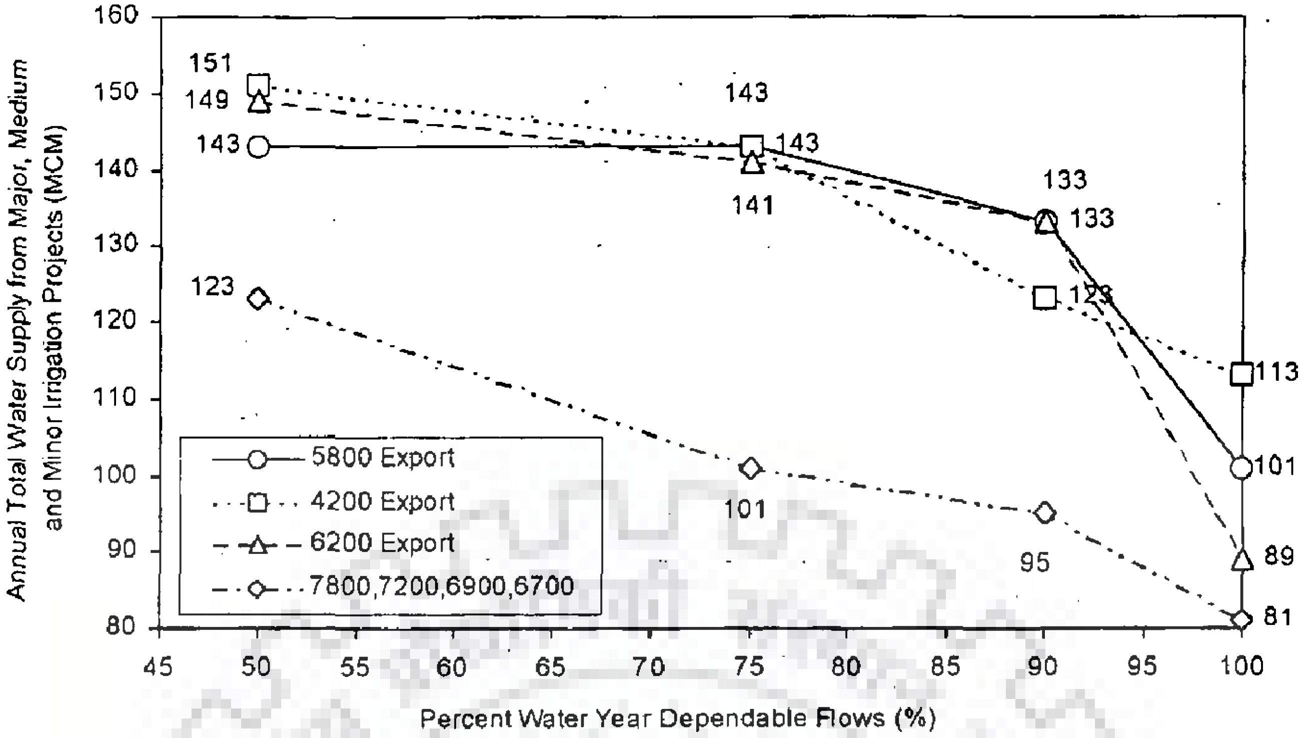

Figure 8.4.6(b): **Variation in Annual Total Water Supply from Major, Medium and Minor Projects vs. Various Percent Water Year Dependable Flows in Noyil Sub-Basin**

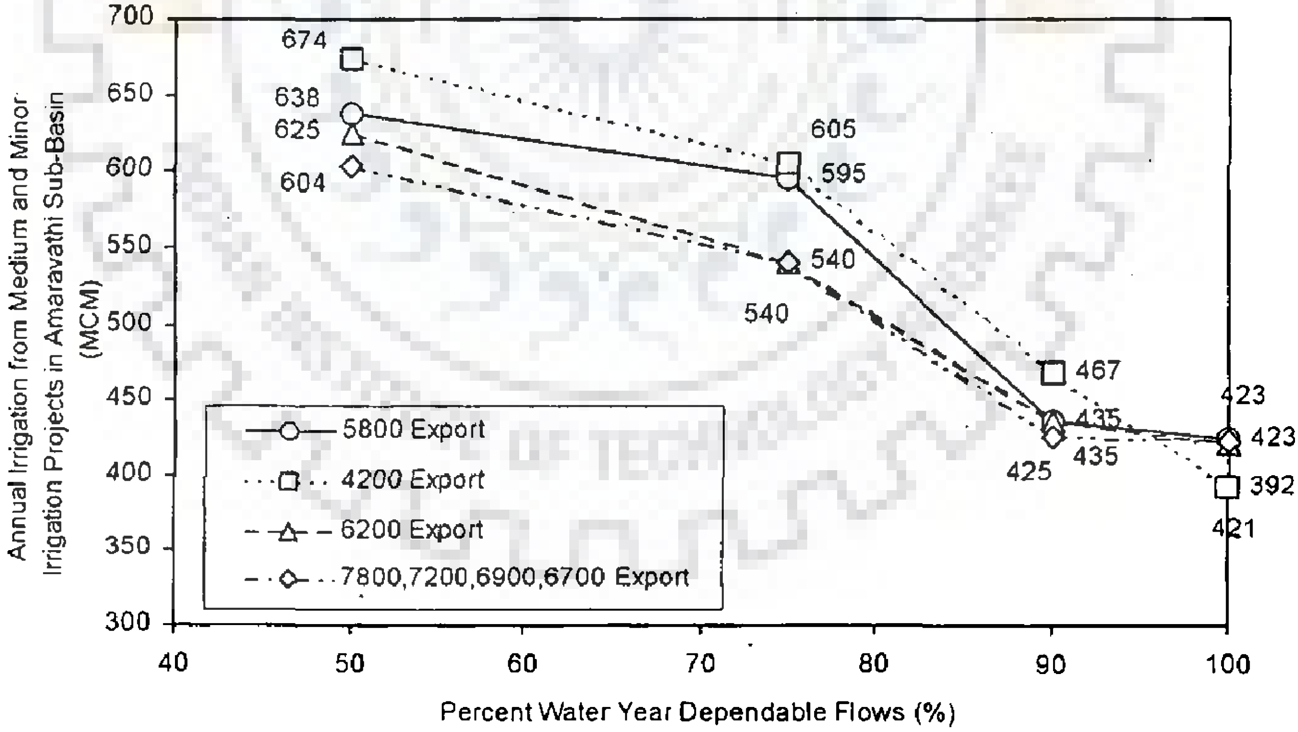

Figure 8.4.7(a): **Variation in Annual Irrigation from Medium and Minor Projects vs. Various Percent Water Year Dependable Flows in Amaravathi Sub-Basin**

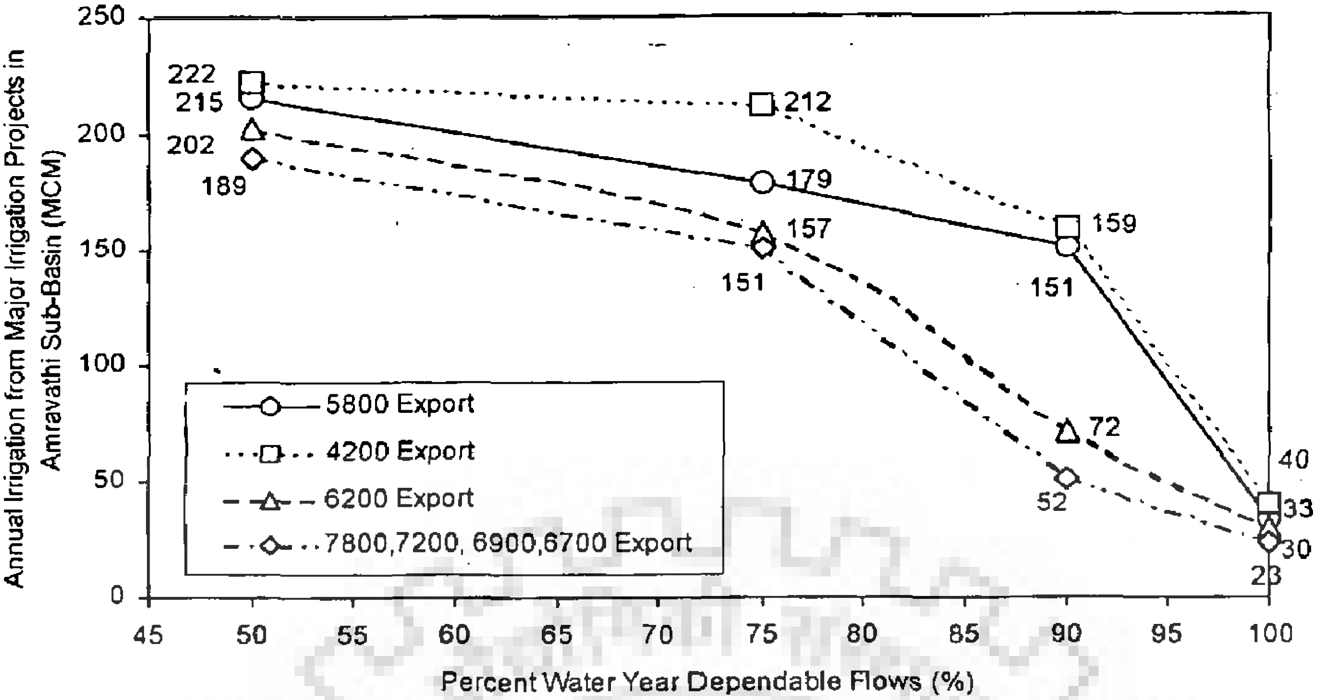

Figure 8.4.7(b): Variation in Annual Irrigation from Major Projects vs. Various Percent Water Year Dependable Flows in Amaravathi Sub-Basin

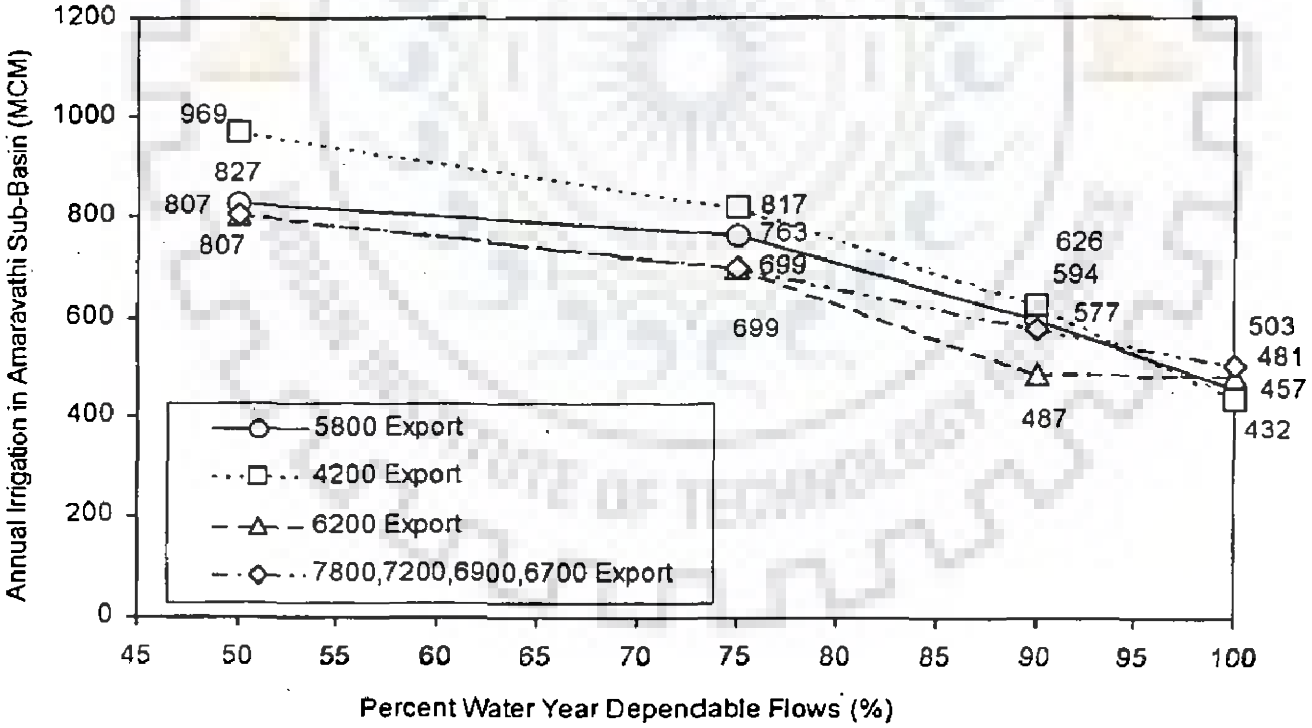

Figure 8.4.7(c): Variation in Annual Irrigation from Major, Medium and Minor Projects vs. Various Percent Water Year Dependable Flows in Amaravathi Sub-Basin

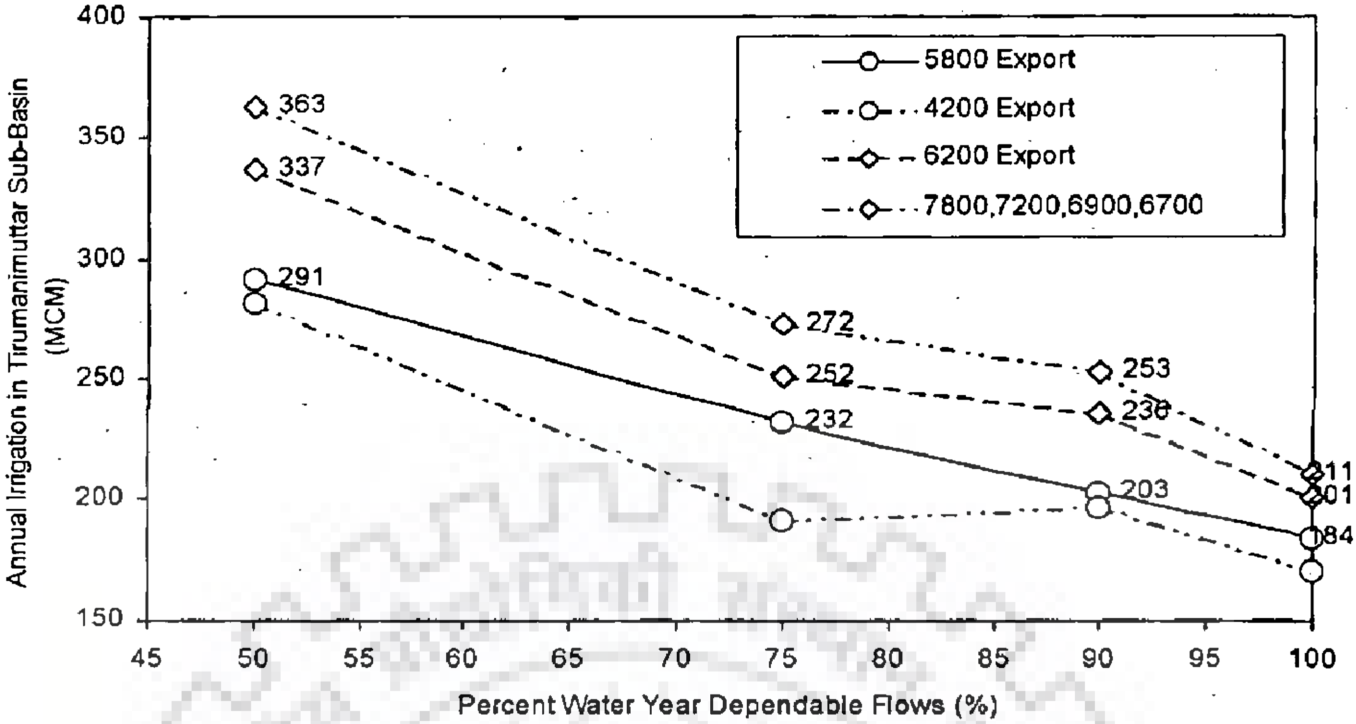

Fig. 8.4.8(a): **Variation in Annual Total Irrigation from Major, Medium and Minor Projects with Respect to Various Percent Water Year Dependable Flows in Tirumanimuttar Sub-Basin**

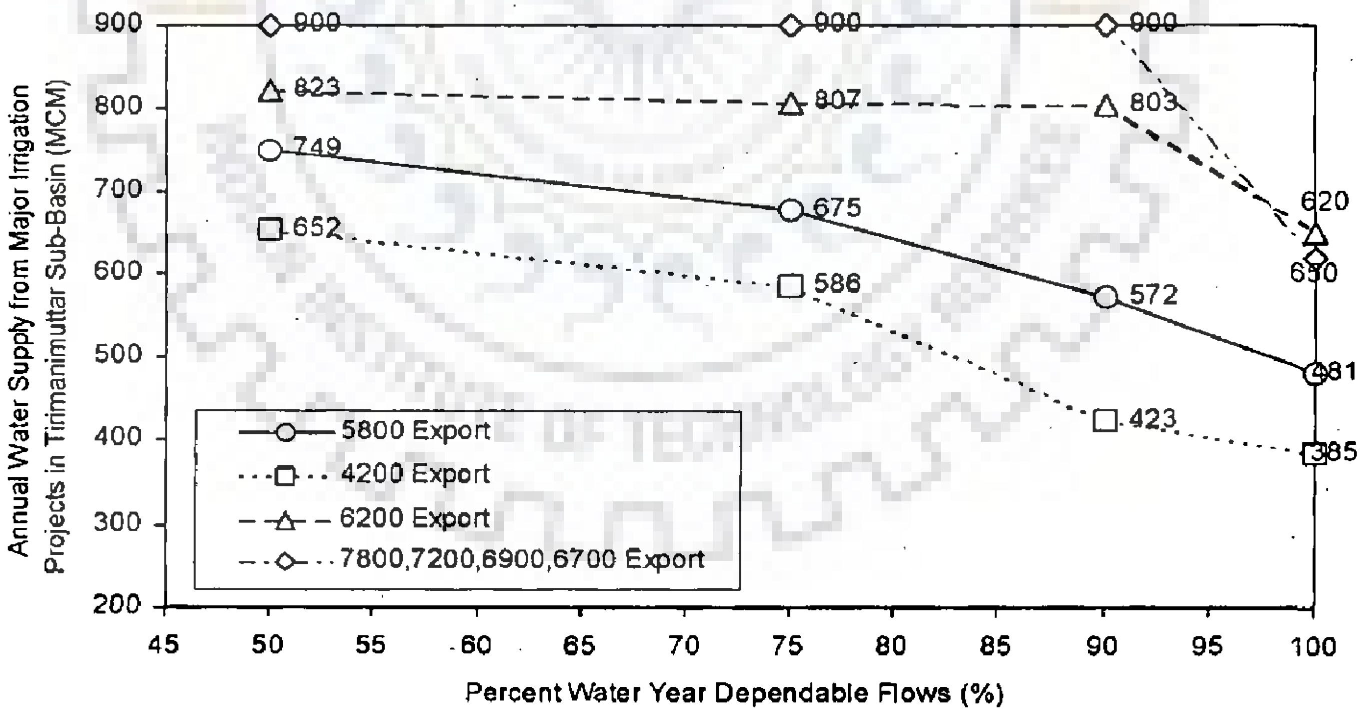

Fig. 8.4.8(b): **Variation in Annual Total Water Supply from Major, Projects with Respect to Various Percent Water Year Dependable Flows in Tirumanimuttar Sub-Basin**

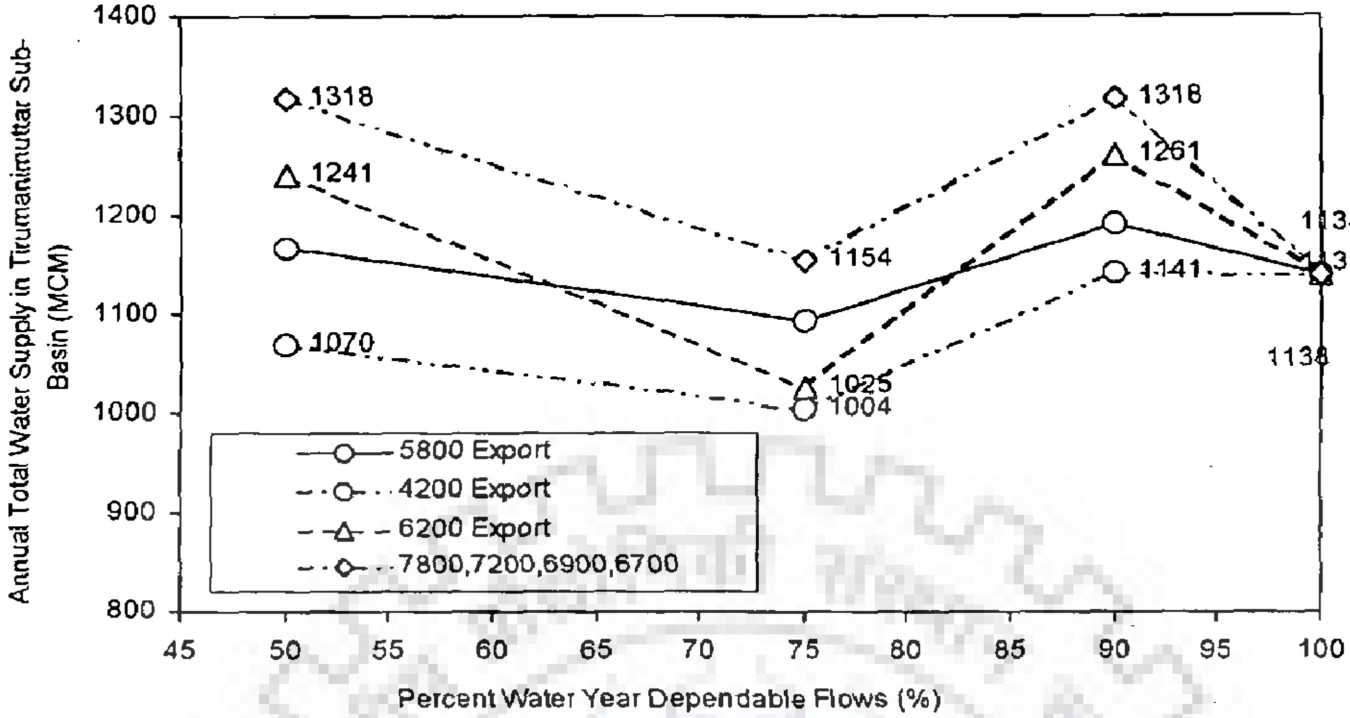

Fig. 8.4.8(c): **Variation in Annual Total Water Supply from Major, Medium and Minor Projects vs. Various Percent Water Year Dependable Flows in Tirumanimuttar Sub-Basin**

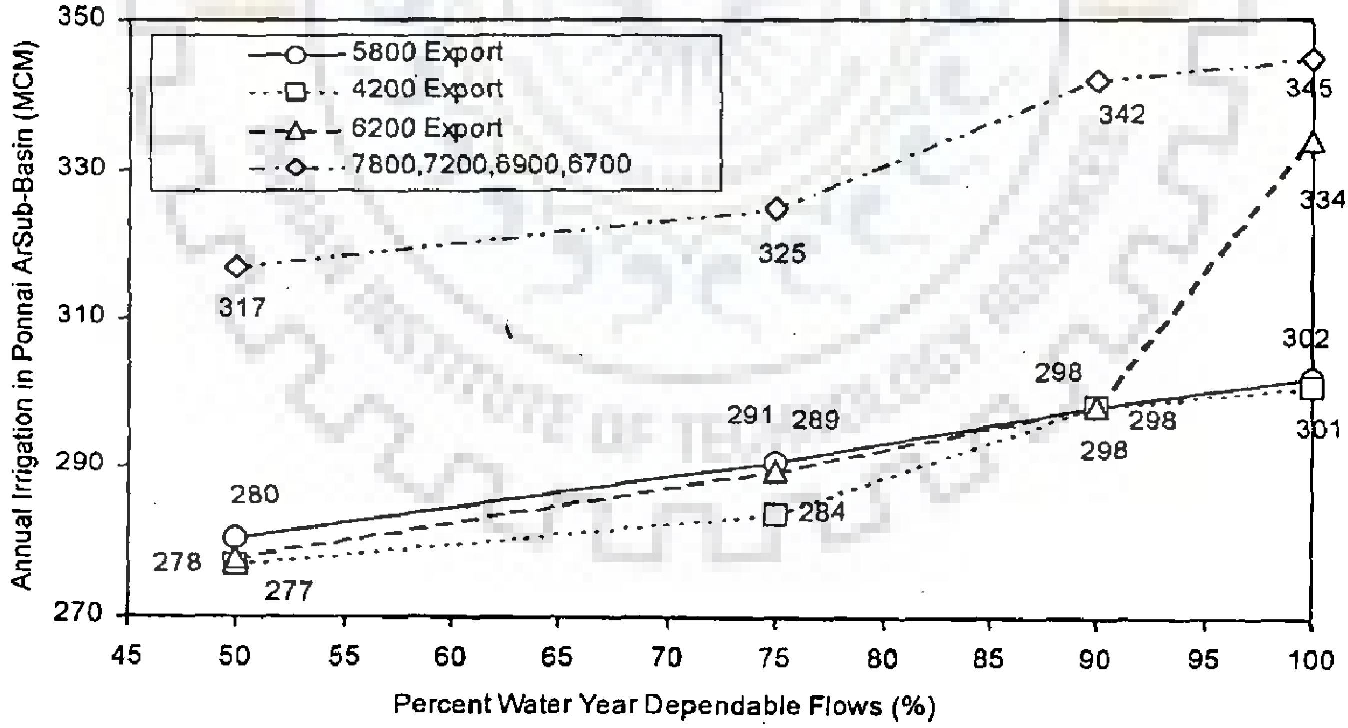

Fig. 8.4.9: **Variation in Annual Irrigation from Major, Medium and Minor Projects vs. Various Percent Water Year Dependable Flows in Ponnana Ar Sub-Basin**

SUMMARY OF FINDINGS AND CONCLUSIONS

9.1 INTRODUCTION

The present study was carried out with an overall objective of comprehensive analysis for optimal water utilization, with intra-basin and inter-basin water transfers considerations for an interstate Cauvery river system, in respect to the interim award of Cauvery Water Dispute Tribunal (CWDTIA) to release at the Mettur reservoir 5800 MCM (205 Million Cubic Feet) of water, which is the contribution from the upper riparian Karnataka state to the lower riparian Tamilnadu state. The river system was presented in Chapter 3. It was very important to assess the surface and ground waters available and its utilization, in the basin on monthly basis. Therefore, this study may be of great importance from actual field application point of view. The details of the studies are sequentially presented in the previous chapters. The presentation in this chapter begins with an overall view of the studies carried out. The subsequent section comprises of the summary of findings of the different aspects of the work accomplished. Finally, conclusions drawn from the overall study are presented in this chapter. Some suggestions are made at the end of this chapter to outline the scope for further related studies.

9.2 AN OVERALL VIEW OF THE PROBLEM

The Cauvery is an inter state river in South India originating in the state of Karnataka and flowing through the states of Karnataka, Kerala, Tamilnadu, and Pondicherry having a catchment area of 81,155 Km^2. The state wise drainage areas of

Cauvery basin are Karnataka 34,273 Km^2 (42.2%); Tamilnadu 43,867 Km^2 (54.1%); Kerala 2,866 Km^2 (3.5)% and Pondicherry 149 Km^2 (0.2)%. This basin has 16-sub-basins. It has 75% and 50% water year dependable surface water potential of 16,470 MCM and 20,253 MCM, respectively. A total of 3,866 MCM ground water potential is available for future use. The water requirement for the population of human and livestock projected to the year 2050AD for all purposes as estimated in Chapter 4 is 39516 MCM. There are 15 major projects (reservoirs), 58 medium and a large number of minor irrigation projects in the basin. The total irrigable area is 2605200 Ha.

The Supreme Court of India has recently given directives to the Government of India for interlinking of the major rivers of the Himalayan and Peninsular regions for transfer of waters from the water surplus river basins to the water deficit basins to reduce the natural imbalance of the water availability in various basins in the country. The studies on various inter-basin water transfers are carried out, usually on the basis of annual water balance of all the sub-basins lying in the respective major river basins involved, to determine the amount of water available and to identify the water surplus and water deficit basins. But in this study, the monthly water balance studies on an annual basis are carried out for various water year dependable flows. The previous studies carried out for the water balance accounting on an annual basis, do not take into account: (i) the availability and use of the ground water, (ii) the time wise variability and distribution of the water availability with respect to the yearly and within the year time periods, and (iii) the aerial variability and distribution of the water available and its use in a basin/ sub-basin, with respect to the location of the various reservoirs and water use points. In this study to overcome the above mentioned three drawbacks in the previous studies for water balance carried out by conventional method, elsewhere for the Cauvery river basin, the monthly water balance on annual basis is carried out to overcome the first two drawbacks, and a Linear Programming (LP) optimization model to overcome all the three drawbacks.

The methodology adopted to achieve the objectives is outlined below:

(A) Sub-basinwise Monthly Water Balance Studies

The monthly water balance studies were made to know the surplus and deficits to find out whether the monthly water requirements are met or not and whether the monthly intra-basin water transfers within the Cauvery basin are possible.

(1) Estimation of surface water and ground water potential

The 75% water year dependable surface water yields on monthly basis for each sub-basin were calculated by distributing the annual 75% water year dependable yields in the proportion of actual average monthly inflows/yields observed at the nearest gauge and discharge (G&D) site within or outside of the sub-basin. The sub-basinwise ground water potential and the existing uses were computed on the area basis from districtwise ground water statistics, the data collected from the Water Resources of India, a publication of Central Ground Water Board, under the Ministry of water Resources, Government of India, Faridabad. The same procedure was adopted for 50%, 90% and 100% water year dependable flows.

(2) Assessment of the water requirements/needs

(a) Irrigation water requirements/needs

The irrigation needs were calculated by keeping the utilization of existing and ongoing major, medium and minor projects undisturbed while the net and gross crop water requirements for future major, medium and minor projects have been worked out by climatological approach. It was considered that at least 30% of the maximum culturable area for each sub-basin should be under irrigation for the year 2050 AD and in case of sub-basins having less than 30% of irrigation area, the additional area to be brought under irrigation was computed and 50% of this was proposed to be irrigated from future medium projects and the remaining 50% from future minor projects. The ultimate irrigation needs for the future projects are calculated and are used for the water balance studies.

(b) Domestic water requirements/needs

The rural, urban and livestock population had been computed by projecting the 1981 census human population and 1982/83 census livestock population to 2050 AD by using suitable compound annual growth rates for human population and one percent for livestock population. The domestic water requirements were calculated considering the per capita water requirements of 70 liters, 200 liters and 50 liters per day respectively as per the NWDA norms. The urban population by 2050 AD is taken as 60.70% of the total projected population by 2050 AD. The entire water requirement for the urban population and the 50% of the rural population was proposed to be met from surface water. The entire water requirement for live stock population and 50% of the requirement for the rural population was proposed to be met from ground water resources.

(c) Industrial water requirements/needs

For the industrial water requirements, in the absence of relevant data, it had been assumed to be of same order as that of domestic water requirements by 2050 AD.

(d) Hydropower water requirements/needs

The total evaporation losses of all single purpose hydropower projects in the catchment area of each sub-basin are considered, as hydropower needs.

(e) Environmental water requirements/needs

The environmental needs in each month are taken equal to 1% of the inflows of those months.

The intra-basin water transfer quantities are taken from the data collected from NWDA. The regeneration from irrigation, domestic and industrial was taken as 10%, 80%, and 80% of net utilization, respectively. The monthly and annual water balances for each month in each sub-basin were calculated and the monthly and annual surplus and deficits were worked out.

(B) **The Mathematical Modeling Approach**

(1) The optimization model for planning and management was considered suitable for this study in view of the large size of problem to be addressed. The study involved modeling for water transfers to other irrigation areas and the interest of co-basin riparian states (bases on sharing of the river water and limitations of its use under numerous location specific hydrological, techno-economic and management constraints pertaining to agreements and CWDT award. In accordance with the reported findings, regarding the modeling approaches, and the nature and scope of the present study, and huge number of variables to be handled the linear programming model was found to be promising.

(2) To study the effects of the spatial variations with respect to project sites and reservoir storage on the water balance of the system, a project-by-project analysis, and sub-basin wise analysis were carried out.

(3) The optimization model was run for 75%, 50%, 90%, and 100% water year dependable flows by using LINDO software package for solution. Irrigation was considered as lumped. The monthly diversions from reservoirs and ground water were obtained.

(4) The cropping pattern was studied for each reservoir. The water availability was taken from step (3) above. The cropping patterns were analyzed keeping in mind (a) The number of paddy crops to be grown, (b) Reducing the area for water extensive crops, and (c) Opting for high revenue crops.

(5) To see the effect of the water surplus and the water deficit years on the water utilization and on intra basin water transfers, the step (4) was repeated.

(6) The minimum food requirement with respect to calorific value of crops was also studied.

(7) The above studies also include the consideration of the interim award of Cauvery Water Dispute Tribunal (CWDTIA).

9.3 THE WORKS ACCOMPLISHED

The detailed monthly water balance studies on an annual basis for the sixteen sub-basins of Cauvery river system for various water year dependable flows, i.e., (i) 75% water year annual dependable flow representing a water year under normal conditions, (ii) 90% water year annual dependable flow representing a water deficit year, (iii) 100% (lowest flow) water year annual dependable flow representing a critical water deficit year, and (iv) 50% water year annual dependable annual flow representing a water surplus year, are carried out with considerations of ground water and the environmental water requirements. The monthly water balances, without considering the ground water availability in the sub-basin and with the ground water considerations, are carried out and presented in Chapter 4. The Linear Programming (LP) Model is developed and presented in Chapter 5, for the intra-basin water transfers among the various sub-basins. Chapter 6 deals with computation of input data for linear programming model. The LP model is applied to the Cauvery river system, for conjunctive water use development in the basin, taking care of the interim award of Cauvery Water Dispute Tribunal, and presented in Chapter 7. Crop plans are also derived for each major reservoir in the basin. Chapter 8 deals with analysis of linear programming model.

9.4 SUMMARY OF FINDINGS

9.4.1 Water Balance Studies for 75% Water Year Dependable Flows With and Without Ground Water Considerations by Conventional Method

The monthly water balance on an annual basis, with and without ground water considerations, of the sub-basins of the Cauvery river carried out for four water year dependable flows in this thesis. The account of the water balance for 75% water year dependable flow is given in Table 9.1.

Table 9.1: Sub-basin wise Annual Surplus/Deficit in Cauvery Basin from Water Balance for 75% Water Year Dependable Flow

Sl.No.	Name of sub-basin	Without ground water	With ground water
(1)	(2)	(3)	(4)
1	Upper Cauvery	-275.46	303.04
2	Kabini	-271.11	115.29
3	Shimsha	150.72	656.72
4	Arkavathi	-799.19	-695.69
5	Middle Cauvery	66.89	272.49
6	Suvarnavathi	-79.64	-15.74
7	Palar	-161.49	-21.79
8	Chinnar	-13103.10	-12932.21
9	Bhavani	-423.60	-235 90
10	Noyil	-66.40	-31.19
11	Amaravathi	-750.62	-442.62
12	Tirumanimuttar	-225.89	124.24
13	Ponnanai Ar	-13.7109	193.69
14	Upper Coleroon	86.64	339.24
15	Lower Coleroon	222.16	342.76
16	Cauvery Delta	1203.06	1611.16
Total		-14440.70	-10416.21

Note: Export from Mettur reservoir is 12712 MCM.

The water balance study of sixteen sub-basins of Cauvery river basin for the 75% water year dependable flow with ground water availability considerations, show that Table 9.1, on an annual basis, four of them, i.e., Upper Cauvery, Kabini, Tirumanimuttar and Ponnanai Ar have become water surplus from water deficit; seven of them, i.e., Arkavathi, Suvarnavathi, Palar, Chinnar, Bhavani, Noyil and Amaravathi remain still water deficit.

The sub-basin wise monthly deficits in descending order computed from water balance studies with ground water consideration for 75% water year dependable flows for the Cauvery basin are presented in Table 9.2(a) to Table 9.2(d).

From the results of water balance studies for 75% water year dependable flow without and with the considerations of the ground water, the following observations are made.

9.4.1.1 Upper Cauvery sub-basin

In the Upper Cauvery sub-basin it is found that with the ground water availability considerations [refer Table 4.14.1], the maximum water surplus in the sub-basin is increased from 598.37 MCM (9.5 %) to 703.58 MCM (11.01%) in the month of July and the minimum water surplus in the sub-basin is increased from 16.50 MCM (0.26%) to 18.00 MCM (0.29%) in the month of May. The maximum water deficit has reduced from (-391.29) MCM (-6.21%) to (-277.58) MCM (-4.34%) in the month of October and the minimum water deficit of (-17.62) MCM (-0.28%) in the sub-basin is reduced to (-11.32) MCM (0.18%) with the ground water considerations in the month of November. The sub-basin has become water surplus from water deficit on an annual basis due to consideration of ground water availability. The amount of annual water deficit has changed from (-274.45) MCM (-4.36%) to 286.45 MCM (4.48%) in the sub-basin with the ground water availability.

9.4.1.2 Kabini sub-basin

In the Kabini sub-basin it is found that with the ground water availability considerations [refer Table 4.14.2], the maximum water surplus in the sub-basin is increased from 132.86 MCM (2.7%) in the month of June to 192.31 MCM (3.87%) and the minimum water surplus in the sub-basin is increased from 4.46 MCM (0.10%) to 21.54 MCM (0.43%) in the month of November. The maximum water deficit has reduced from (-253.08) MCM (-5.1%) to (-202.50) MCM (-4.07%) in the month of January and the minimum water deficit of (-5.67) MCM (-0.10%) in the sub-basin is reduced to (-0.85) MCM (-0.02%) with the ground water considerations in the month of April. The sub-basin has become water surplus from water deficit on an annual basis due to consideration of ground water availability. The amount of annual water deficit has changed from (-267.77) MCM (-5.4%) to 107.62 MCM (2.16%) in the sub-basin with the ground water availability.

9.4.1.3 Shimsha sub-basin

In the Shimsha sub-basin it is found that with the ground water availability considerations [refer Table 4.14.3], the maximum water surplus in the sub-basin is increased from 294.72 MCM (7.80%) to 299.95 MCM (7.75%) in the month of October and the minimum water surplus in the sub-basin is increased from 2.42 MCM (0.06%) to 8.86 MCM (0.23%) in the month of May. The maximum water deficit has reduced from (-68.87) MCM (-1.82%) to (-2.49) MCM (-0.06%) in the month of April and the minimum water deficit of (-0.25) MCM (-0.01%) in the sub-basin is reduced to (-2.49) MCM (0.06%) with the ground water considerations in the month of November. The amount of annual surplus water has increased from 150.81 MCM (3.99%) to 640.15 MCM (16.55%) in the sub-basin with the ground water availability.

9.4.1.4 Arkavathi sub-basin

In the Arkavathi sub-basin it is found that with the ground water availability considerations [refer Table 4.14.4], the maximum water deficit has reduced from (-205.15) MCM (-8.71%) to (-196.97) MCM (-8.1%) in the month of September and the minimum water deficit of (-24.55) MCM (-1.0%) in the sub-basin is reduced to (-17.63) MCM (0.70%) with the ground water considerations in the month of February. The amount of annual water deficit has reduced from (-799.19) MCM (-34.10%) to –712.56 MCM (-29.4%) in the sub-basin with the ground water availability considerations.

9.4.1.5 Middle Cauvery sub-basin

In the Middle Cauvery sub-basin it is found that with the ground water availability considerations [refer Table 4.14.5], the maximum water surplus in the sub-basin is increased from 24.14 MCM (1.1%) to 54.48 MCM (2.4%) in the month of September and the minimum water surplus in the sub-basin is increased from 1.08 MCM (0.01%) to 2.11 MCM (0.10%) in the month of July. The maximum water deficit has reduced from (-3.31) MCM (-0.2%) in the month of March to (-2.27) MCM (-0.1%) in the month of May and the minimum water deficit of (-1.63) MCM (-0.10%) in the sub-basin is reduced to (-1.28) MCM (-0.1%) with the ground water considerations in the month of June. The amount of annual surplus water has increased from (67.40) MCM (3.1%) to (268.94) MCM (12.10%) in the sub-basin with the ground water availability.

9.4.1.6 Suvarnavathi sub-basin

In the Suvarnavathi sub-basin it is found that with the ground water availability considerations [refer Table 4.14.6], the maximum water surplus in the sub-basin is increased from 6.52 MCM (0.9 %) to 6.84 MCM (9.11%) in the month of October and the minimum water surplus in the sub-basin is increased from 2.67 MCM (0.30%) to 2.83 MCM (0.50%) in the month of September. The maximum water deficit has reduced from (-17.01) MCM (-2.3%) in the month of July to (-6.52) MCM (-0.9%) in the month of January and the minimum water deficit of (-0.55) MCM (-0.1%) in the month of May in the sub-basin is reduced to (-0.70) MCM (-0.1%) with the ground water considerations in the month of May. The amount of annual water deficit has changed from (-80.00) MCM (-10.90%) to (-22.11) MCM (-2.90%) in the sub-basin with the ground water availability.

9.4.1.7 Palar sub-basin

In the Palar sub-basin it is found that with the ground water availability considerations [refer Table 4.14.7], the maximum water surplus in the sub-basin is increased from 6.00 MCM (1.9 %) in the month of June to 10.05 MCM (2.8%) in the month of September and the minimum water surplus in the sub-basin is increased from 1.84 MCM (0.6%) in the month of October to 3.40 MCM (1.0%) in the month of August. The maximum water deficit has reduced from (-30.75) MCM (-9.5%) in the month of July to (-12.35) MCM (-3.5%) in the month of February and the minimum water deficit of (-0.59) MCM (-0.2%) in the sub-basin is reduced to (-0.36) MCM (-0.1%) with the ground water considerations in the month of May. The amount of annual water deficit has reduced from (-161.00) MCM (-50%) to (-28.49) MCM (-8.0 %) in the sub-basin with the ground water availability.

9.4.1.8 Chinnar sub-basin

In the Chinnar sub-basin it is found that with the ground water availability considerations [refer Table 4.14.8], the maximum water surplus in the sub-basin is increased from 6.00 MCM (1.9 %) in the month of June to 10.05 MCM (2.8%) in the month of September and the minimum water surplus in the sub-basin is increased from 1.84 MCM (0.60%) in the month of October to 3.40 MCM (1.0 %) in the month of August. The maximum water deficit has reduced from (-30.75) MCM (9.50%) in the month of July to (12.35) MCM (-3.50%) in the month of February and the minimum water deficit of (-0.59) MCM (-0.2%) in the sub-basin is reduced to (-0.36) MCM (-0.1%) with the ground water considerations in the month of May. The amount of annual water deficit has reduced from (-161) MCM (-50.00%) to (-28.49) MCM (-8.00%) in the sub-basin with the ground water availability.

9.4.1.9 Bhavani sub-basin

In the Bhavani sub-basin it is found that with the ground water availability considerations [refer Table 4.14.9], the maximum water surplus in the sub-basin is increased from 98.80 MCM (3.5 %) in the month of November to 106.39 MCM (9.2%) in the month of October and the minimum water surplus in the sub-basin is increased from 23.26 MCM (1.30%) to 35.44 MCM (2.0%) in the month of December. The maximum water deficit has reduced from (-164.53) MCM (-5.8%) in the month of March to (-49.75) MCM (-4.3%) in the month of June and the minimum water deficit of (-8.84) MCM (-0.3%) in the sub-basin is reduced to (-11.19) MCM (-1.00%) with the ground water considerations in the month of September. The amount of annual water deficit has changed from (-424.9) MCM (-15.0%) to (-66.40) MCM (-5.70%) in the sub-basin, with the ground water considerations.

9.4.1.10 Noyil sub-basin

In the Noyil sub-basin it is found that with the ground water availability considerations [refer Table 4.14.10], the maximum water surplus in the sub-basin is increased from 106.39 MCM (9.2 %) to 105.91 MCM (8.7%) in the month of October and the minimum water surplus in the sub-basin is increased from 23.26 MCM (2.0%) to 23.46 MCM (1.9%) in the month of December. The maximum water deficit has reduced from (-49.75) MCM (-4.3%) to (-42.02) MCM (-3.4%) in the month of June and the minimum water deficit of (-11.19) MCM (-1.0%) in the sub-basin is reduced to (-10.23) MCM (-0.8%) with the ground water considerations in the month of September. The amount of annual water deficit has changed from (-66.40) MCM (-5.7%) to (-39.92) MCM (-3.3%) in the sub-basin with the ground water availability.

9.4.1.11 Amaravathi sub-basin

In the Amaravathi sub-basin it is found that with the ground water availability considerations [refer Table 4.14.11], the maximum water surplus in the sub-basin is increased from 189.79 MCM (7.1 %) to 190.15 MCM (6.9%) in the month of November and the minimum water surplus in the sub-basin is increased from 124.28 MCM (4.6%) to 125.29 MCM (4.61%) in the month of October. The maximum water deficit has reduced from (-207.29) MCM (-7.7%) to (-171.93) MCM (-6.2%) in the month of March and the minimum water deficit of (-40.31) MCM (-1.5%) in the sub-basin is reduced to (-19.87) MCM (-0.7%) with the ground water considerations in the month of September. The amount of annual water deficit has changed from (-746.90) MCM (-27.90%) to (-453.63) MCM (-16.5%) in the sub-basin with the ground water availability.

9.4.1.12 Tirumanimuttar sub-basin

In the Tirumanimuttar sub-basin it is found that with the ground water availability considerations [refer Table 4.14.12], the maximum water surplus in the sub-basin is increased from 267.48 MCM (7.3 %) to 301.08 MCM (7.9%) in the month of October and the minimum water surplus in the sub-basin is increased from 50.49 MCM (1.4%) to 79.69 MCM (2.1%) in the month of December. The maximum water deficit has reduced from (-147.29) MCM (-4.0%) to (-71.71) MCM (-1.9%) in the month of March and the minimum water deficit of (-37.17) MCM (-1.0%) in the sub-basin is reduced to (-18.26) MCM (-0.5%) with the ground water considerations in the month of January. The amount of annual water deficit has changed from (-225.54) MCM (-6.1%) to (-100.64) MCM (-2.7%) in the sub-basin with the ground water availability.

9.4.1.13 Ponnanai Ar sub-basin

In the Ponnanai Ar sub-basin it is found that with the ground water availability considerations [refer Table 4.14.13], the maximum water surplus in the sub-basin is increased from 43.78 MCM (4.5 %) to 69.70 MCM (6.3%) in the month of November and the minimum water surplus in the sub-basin is increased from 0.19 MCM (0.01%) in the month of February to 2.34 MCM (0.2%) in the month of April. The maximum water deficit has reduced from (-18.84) MCM (-1.9%) in the month of July to (-1.59) MCM (-0.2%) in the month of December. The sub-basin has become water surplus from water deficit on an annual basis due to consideration of ground water availability. The amount of annual water deficit has changed from (-13.74) MCM (-1.4%) to 216.89 MCM (19.70%) in the sub-basin with the ground water availability.

9.4.1.14 Upper Coleroon sub-basin

In the Upper Coleroon sub-basin it is found that with the ground water availability considerations [refer Table 4.14.14], the maximum water surplus in the sub-basin is increased from 132.50 MCM (9.8 %) to 149.73 MCM (10.91%) in the month of November and the minimum water surplus in the sub-basin has changed from 4.80 MCM (0.4%) in the month of May to 0.86 MCM (0.06%) in the month of April. The maximum water deficit has reduced from (-69.07) MCM (-5.1%) to (-10.73) MCM (-0.78%) in the month of July and the minimum water deficit of (-2.8) MCM (-0.20%) in the month of June in the sub-basin is reduced to (-0.61) MCM (-0.04%) in the month of March . The amount of annual water deficit has changed from 86.64 MCM 6.4% to 358.44 MCM (26.11%) in the sub-basin with the ground water availability.

9.4.1.15 Lower Coleroon sub-basin

In the Lower Coleroon sub-basin it is found that with the ground water availability considerations [refer Table 4.14.15], the maximum water surplus in the sub-basin is increased from 46.01 MCM (3.6%) to 74.12 MCM (5.7%) in the month of September and the minimum water surplus in the sub-basin is increased from 2.80 MCM (0.2%) to 2.87 MCM (0.2%) in the month of May. The amount of annual surplus water has changed from 222.2 MCM (17.2%) to 340.16 MCM (26.1%) in the sub-basin with the ground water availability.

9.4.1.16 Cauvery Delta sub-basin

In the Cauvery Delta sub-basin it is found that with the ground water availability considerations [refer Table 4.14.16], the maximum water surplus in the sub-basin is increased from 256.38 MCM (2.6 %) to 307.95 MCM (3.10%) in the month of September and the minimum water surplus in the sub-basin has changed from 10.45 MCM (0.11%) to 9.77 MCM (0.10%) in the month of May. The amount of annual surplus water has changed from 1203.1 MCM (12.10%) to 1413.26 MCM (14.10%) in the sub-basin with the ground water availability.

9.4.2 LP Model Studies for Conjunctive Water Resources Development for 75% Water Year Dependable Flow

The results of LP model for 75% water year dependable flow with 5800 MCM exports from Mettur reservoir to the sub-basins below Mettur are presented in Table 9.3 (for the objective function of maximization of water utilization with lumped irrigation).

Table 9.3: Sub-basin wise Annual Surplus/Deficit in Cauvery Basin from LP Model for 75% Water Year Dependable Flow

Sl. No.	Name of sub-basin	With ground water (MCM)
(1)	(2)	(3)
1	Upper Cauvery	-703.41
2	Kabini	-172.39
3	Shimsha	-1389.95
4	Arkavathi	-2121.66
5	Middle Cauvery	1788.19
6	Suvarnavathi	-634.41
7	Palar	-170.06
8	Chinnar	-213.07
9	Bhavani	-1159.90
10	Noyil	-1058.10
11	Amaravathi	-1379.24
12	Tirumanimuttar	-2465.51
13	Ponnanai Ar	-420.10
14	Upper Coleroon	-296.89
15	Lower Coleroon	-506.27
16	Cauvery Delta	-2541.36
Total		**-13444.12**

The basic differences between water balance approach and the linear programming model approach are as follows:

In the water balance study, it is assumed that the total water resources available in a sub-basin are being utilized in the same sub-basin, except exports to other sub-basins. Whereas, in the linear programming model this is not the case, and the difference is that: (i) entire water resources are not being utilized in the same sub-basin, and (ii) there is an influence of reservoir storage, time wise variations in water availability and water use, reservoir spills, and variable evaporation losses with respect to time, etc.

The overall influence on the behavior of various sub-basins due to above factors is summarized below for 75% water year dependable flow with 5800 MCM of water export from Mettur to the sub-basins below Mettur:

(1) From the linear programming results it is found that except Middle Cauvery sub-basin all the other sub-basins are water deficit. Following four types of monthly water deficit patterns are noticed, when the deficits are arranged in descending order.

   (i) In the Suvarnavathi and Palar sub-basins, the decreasing pattern in the monthly percent deficits are found in the same months, except in the months of January and February.

   (ii) In the Bhavani and Amaravathi sub-basins, the decreasing patterns in the monthly percent deficits are found in the same months, except in the months of January, February, June and September.

   (iii) In the sub-basins of Upper Coleroon, Lower Coleroon and Cauvery Delta, the decreasing pattern in the monthly percent deficits are found in the same month, for all the months.

(iv) For the remaining nine sub-basins there is no similarity, and have different monthly percent deficits patterns.

(2) The Arkavathi sub-basin has the maximum percent deficit of 16% in the month of September, in the entire Cauvery river system, and the Upper Cauvery sub-basin has the minimum deficit of 0.001% in the month of May. Similarly, the Noyil and Arkavathi sub-basin have the maximum annual deficits of 87% and the Chinnar sub-basin has the minimum annual deficit of 8%.

(3) As said earlier, Middle Cauvery sub-basin is the only water surplus sub-basin in the entire river system. In this sub-basin, the month of July has the mximum surplus of 15% and the month of May has the minimum surplus of 0.40%. There is a 81% surplus water availability annually in Middle Cauvery sub-basin.

The sub-basin wise monthly deficits in descending order computed from LP model for 75% water year dependable flows for the Cauvery basin are presented in Table 9.4, and the sub-basin wise observations are presented below. [Refer Table 9.4].

9.4.2.1 Upper Cauvery sub-basin

In the case of Upper Cauvery sub-basin, from the LP model results it is found that the maximum water deficit in the sub-basin of -139.96 MCM (-3.9%) in the month of October and the minimum water deficit of –5.01 MCM (-0.1%) in the month of April. The amount of annual deficit water is of -703 MCM (-19.5%) in the sub-basin.

9.4.2.2 Kabini sub-basin

In the case of Kabini sub-basin, from the LP model results it is found that the maximum water deficit in the sub-basin of -164.94 MCM (-3.4 %) in the month of August and the minimum water deficit of –4.95 MCM (-0.1 %) in the month of

February. The amount of annual deficit water is of –625 MCM (-12.7%) in the sub-basin.

9.5.2.3 Shimsha sub-basin

In the case of Shimsha sub-basin, from the LP model results it is observed that the maximum water deficit in the sub-basin of –389.48 MCM (-10.3%) in the month of January and the minimum water deficit of –28.56 MCM (-0.8 %) in the month of October. The amount of annual deficit water is of -2149 MCM (-56.9%) in the sub-basin.

9.5.2.4 Arkavathi sub-basin

In the case of Arkavathi sub-basin, it is found from the LP model results that the maximum water deficit in the sub-basin of –395.41 MCM (-16 %) in the month of September and the minimum water deficit of –96.50 MCM (-4%) in the month of April. The amount of annual deficit water is of -2122 MCM (-87%) in the sub-basin.

9.4.2.5 Middle Cauvery sub-basin

In the case of Middle Cauvery sub-basin, from the LP model results it is found that the maximum water surplus in the sub-basin of 336.8 MCM (15%) in the month of July and the minimum water surplus of 9 MCM (0.4%) in the month of May. The amount of annual surplus water is of 1788 MCM (81%) in the sub-basin.

9.4.2.6 Suvarnavathi sub-basin

In the case of Suvarnavathi sub-basin, from the LP model results it is found that the maximum water deficit in the sub-basin of –111.5 MCM (-15 %) in the month of July and the minimum water deficit of –5.56 MCM (-1%) in the month of May. The amount of annual deficit water is of –607 MCM (-82%) in the sub-basin.

9.4.2.7 Palar sub-basin

In the case of Palar sub-basin, from the LP model results it is observed that the maximum water deficit in the sub-basin of –34.54 MCM (-11%) in the month of July and the minimum water deficit of –2.55 MCM (-1%) in the month of May. The amount of annual deficit water is of -186 MCM (-57%) in the sub-basin.

9.4.2.8 Chinnar sub-basin

In the case of Chinnar sub-basin, from the LP model results it is observed that the maximum water deficit in the sub-basin of –30.58 MCM (-1.1%) in the month of March and the minimum water deficit of –6.10 MCM (-0.2%) in the month of August. The amount of annual deficit water is of -229 MCM (-8%) in the sub-basin.

9.4.2.9 Bhavani sub-basin

From the LP model results in the case of Bhavani sub-basin, it is found that the maximum water deficit in the sub-basin of –101.73 MCM (-4%) in the month of July and the minimum water deficit of –2.99 MCM (-0.1%) in the month of November. The amount of annual deficit water is of -606 MCM (-21%) in the sub-basin.

9.4.2.10 Noyil sub-basin

From the LP model results in the case of Noyil sub-basin, it is found that the maximum water deficit in the sub-basin of –174.11 MCM (-14 %) in the month of June and the minimum water deficit of –38.90 MCM (-3%) in the month of November. The amount of annual deficit water is of -1064 MCM (-87%) in the sub-basin.

9.4.2.11 Amaravathi sub-basin

In the case of Amaravathi sub-basin, from the LP model results it is found that the maximum water deficit in the sub-basin of –262.38 MCM (-10%) in the month of

July and the minimum water deficit of –8.63 MCM (-0.30%) in the month of November. The amount of annual deficit water is of –1506 MCM (-55%) in the sub-basin.

9.4.2.12 Tirumanimuttar sub-basin

In the case of Tirumanimuttar sub-basin, from the LP model results it is found that the maximum water deficit in the sub-basin of -458 MCM (-12%) in the month of March and the minimum water deficit of –309.41 MCM (-8%) in the month of January. The amount of annual deficit water is of –309 MCM (-8%) in the sub-basin.

9.4.2.13 Ponnanai Ar sub-basin

In the case of Ponnanai Ar sub-basin, from the LP model results it is observed that the maximum water deficit in the sub-basin of –61.89 MCM (-6%) in the month of December and the minimum water deficit of –10.64 MCM (-1.0%) in the month of February. The amount of annual deficit water is of -395 MCM (-40%) in the sub-basin.

9.4.2.14 Upper Coleroon sub-basin

In the case of Upper Coleroon sub-basin, it is found from the LP model results that the maximum water deficit in the sub-basin of –112.36 MCM (-8.3%) in the month of August and the minimum water deficit of –1.13 MCM (-0.1%) in the month of May. The amount of annual deficit water is of -468 MCM (-34.7%) in the sub-basin.

9.4.2.15 Lower Coleroon sub-basin

In the case of Lower Coleroon sub-basin, it is found from the LP model results that the maximum water deficit in the sub-basin of –145.60 MCM (-11.2 %) in the month of August and the minimum water deficit of –1.47 MCM (-0.1%) in the month of May. The amount of annual deficit water is of -606 MCM (-46.5%) in the sub-basin.

9.4.2.16 Cauvery Delta sub-basin

In the case of Lower Coleroon sub-basin, from the LP model results it is found that the maximum water deficit in the sub-basin of –1345.44 MCM (-14%) in the month of August and the minimum water deficit of –13.59 MCM (-0.1%) in the month of May. The amount of annual deficit water is of –5600 MCM (-56%) in the sub-basin.

9.4.2.17 Spills from sub-basins

The monthly spills over the year from the respective sub-basins in Cauvery basin obtained from Linear Programming model for 75% water year dependable flows with the 5800 MCM water exports from Mettur to the sub-basins below Mettur are presented in the Table 9.5.

The model results show the following pattern:

There may be sometimes shortages of water to meet the demands even though water is available within the sub-basins, but in the LP model the available water in various sub-basins is to be utilized optimally through the intra-basin water transfers over the Cauvery basin as a whole. Due to the consideration in the model of variability in the water availability and its use, with respect to space and time, there may be imbalance between the water needed and its availability; this at times may cause spills from reservoirs etc.

In Upper Cauvery sub-basin the spills occur during the months of June and August. In case of Kabini sub-basin there are no spills during the months of December to March but other months are having spills. In the case of Shimsha, Arkavathi, Palar, Amaravathi, Tirumanimuttar, Ponnanai Ar, Upper Coleroon, Lower Coleroon and Cauvery Delta sub-basis, the spills occurred in the every month during the year. In the Suvarnavathi sub-basin, no spill occurred during the month of May and remaining months had spills. In the Bhavani and Noyil sub-basins spills occurred during through out the year except in the month of March. In the Cauvery Delta sub-basin spills do not occur during the months of January and February but other months are having spills.

9.4.2.18 Crop Planning

(i) General

The water availability is taken from the results of the LP model for 75% water year dependable flow with 5800 MCM of water exports from Mettur reservoir to the sub-basins below Mettur, for the objective function of maximization of annual water utilization. The irrigation was considered as lumped. The monthly diversions from reservoirs and ground water for lumped irrigation are obtained from LP model results. The cropping patterns is then studied for all the fifteen reservoirs (major projects). The optimal cropping patterns for the remaining areas not covered by these projects in their respective sub-basins, and other sub-basins, which did include any projects, were not determined. The cropping patterns are analyzed below keeping in mind (a) a number of paddy crops to be grown, (b) reducing the area for water extensive crops and (c) opting for higher revenue crops.

(ii) Objective function

Objective Function- Maximization of annual water utilization:

The crops at the reservoirs (major projects) [refer col. (4) in Tables 7.2.1 to 7.2.15], i.e., Mananthvady, Taraka, Upper Nugu, Mettur and Lower Bhavani do not occupy their entire respective proposed culturable command areas, with a minimum cropping intensity of 38% at Upper Nugu and a maximum cropping intensity of 97% at Mananthvady .The crops at the remaining projects do occupy their entire respective proposed culturable command areas, with 137% cropping intensity at Banasurasagar.

Objective function- Maximization of area to be irrigated:

The crops at reservoirs [refer col. (5) in Tables 7.2.1 to 7.2.15], i.e., Cauvery, Mananthvady, Taraka, Upper Nugu, Mettur and Lower Bhavani do not occupy their entire respective proposed culturable command areas, with a minimum cropping intensity of 54% at Upper Nugu and a maximum cropping intensity of 97% at Mananthvady. The crops at the remaining projects do occupy their entire respective proposed culturable command areas with 147% cropping intensity at Banasurasagar.

Objective function- Maximization of annual food production:

The crops at all the reservoirs [refer col. (6) in Tables 7.2.1 to 7.2.15], except Banasursagar and Sagardoddakere, do not occupy their entire respective proposed culturable command areas with a minimum cropping intensity of 53% at Mettur and a maximum cropping intensity of 86% at Mananthvady. The cropping intensities at Banasurasagar and Sagardoddakere are 164% and 273%, respectively. This objective function is the most sensitive in terms of cropping intensity.

Objective function- Maximization of annual benefits from crops (without minimum area for food requirements):

The crops at the reservoirs [refer col. (7) in Tables 7.2.1 to 7.2.15], i.e., Taraka, Upper Nugu, Mettur and Lower Bhavani do not occupy their entire respective proposed culturable command areas, with a minimum cropping intensity of 54% at Upper Nugu and a maximum cropping intensity of 91% at Taraka and Mettur. The crops at the remaining projects do occupy their entire respective proposed culturable command areas, with 135% cropping intensity at Banasurasagar.

Objective function- Maximization of annual benefits from crops (with minimum area for food requirements):

The crops at reservoirs [refer col. (8) in Tables 7.2.1 to 7.2.15], i.e., Mananthvady, Upper Nugu, Nugu and Amaravathi do not occupy their entire respective proposed culturable command areas, with a minimum cropping intensity of 52% at Mananthvady and a maximum cropping intensity of 73% at Nugu .The crops at the remaining projects do occupy their entire respective proposed culturable command areas, with more than 100% cropping intensities.

(iii) Water extensive crops

Except at Yagachi, Banasursagar, Mananthvady, Taraka, Upper Nugu and Mettur reservoirs, at other reservoirs, the water extensive crops, i.e., Sugarcane, Kharif Paddy and Rabi Paddy, almost acquire their respective proposed areas, for both the objective functions (i.e., maximization of annual water utilization, and maximization of area to be irrigated annually).

The variations among these crops are as follows:

Sugarcane: For the objective function of maximization of annual water utilization, this crop has cropping intensities of 99%, 2%, 99% and 0% at Yagachi, Banasursagar, Taraka and Upper Nugu, respectively.

Kharif Paddy: For the objective function of maximization of annual water utilization, this crop has cropping intensities of 78%, 41% and 36% at Mananthvady, Taraka and Upper Nugu, respectively.

Rabi Paddy: For the objective function of maximization of annual water utilization, this crop has cropping intensities of only 75%, 97% and 0% at Banasurasagar, Taraka, Upper Nugu and Mettur, respectively.

For the objective function of maximization of area to be irrigated annually, the behavior of these three crops is almost same as found for the objective function of maximization of annual water utilization, with minor variations.

(iv) Number of paddy crops to be grown

The pattern discussed below is for number of Paddy crops to be grown, obtained for the objective functions, i.e., maximization of annual water utilization and maximization of area to be irrigated annually.

(a) Kharif Paddy: At Taraka and Upper Nugu reservoirs it is possible to cultivate only about 36% to 41% of their respective proposed crop areas. Similarly, at Mananthvady about 78% of the proposed crop areas can be cultivated. And at other reservoirs, it is possible to cultivate with full potential the Kharif Paddy.

(b) Rabi Paddy: As far as the number of Paddy crops to be grown is concerned, it is not possible to cultivate Rabi Paddy at Mettur reservoir. At Banasursagar it is only possible to cultivate 75% of the proposed crop area. And at other reservoirs it is possible to cultivate with full potential the Rabi Paddy.

(v) Imports / Exports of food

Except at Yagachi and Upper Nugu reservoirs, at other reservoirs the crop productions to meet minimum requirements of the agricultural population are fulfilled. At Yagachi and Upper Nugu reservoirs, the production of groundnut crop is not sufficient to fulfill the food requirements of the agricultural population at these reservoirs. The annual quantity of groundnut to be imported for these two projects works out to 24.12 MT and the annual quantities of other food grains exports from the projects are as follows:

Paddy - 749 MT, Jowar - 1159 MT, Ragi - 531 MT, Pulses - 483 MT, Fruits and Vegetables-14066 MT and Groundnut -541 MT.

(vi) **High benefit crops**

The high benefit crops like Sugarcane, Cotton, Tobacco, and Coconut are occupying their respective areas at all the reservoirs, except Sugarcane and Coconut at Banasurasagar and Upper Nugu reservoirs. The areas occupyied for Sugarcane and Coconut at Banasurasagar are 2% and 0%, respectively, and at Upper Nugu reservoir the areas being occupied for Sugarcane and Coconut are nil for both the crops.

(vii) **Most affected reservoir**

Upper Nugu reservoir is the most affected in terms of crop area occupation (i.e., for Kharif Jowar, Kharif Ragi, Rabi Paddy, Pulses, Fruits and Vegetables, Groundnut, and Coconut) for both the objective functions, i.e., maximization of water utilization and maximization of area to be irrigated.

9.4.2.19 Hydropower Generation

During a normal year at Manathvady reservoir about 377 MU (1 MU = 10^6 KWhr) of energy would be generated annually as against 817 MU as per the project proposal. Similarly, at Banasurasagar reservoir about 332 MU of energy would be generated annually as against 406 MU as per the project proposal. At Kabini and Mettur the generated and the proposed values are 769 MU and 98 MU, and 196 and 240 MU, respectively.

9.4.3 Water Utilization Factors

The computed monthly and annual water utilization factors from water balance study (conventional method) with 12712 MCM exports from Mettur reservoir and from LP model results with 5800 MCM water exports from Mettur reservoir, to the sub-basins below Mettur, for 75% water year dependable flows are presented in Table 9.6

and 9.7, respectively. The following are the observations:

From the water balance studies it is found that except at Lower Coleroon and Cauvery Delta sub-basins in all other sub-basins, a maximum monthly water utilization factor of 1.0 (i.e., all the water demands are met from the available water in that month) is attained in different months, for both without and with ground water considerations. Whereas, at Amaravathi sub-basin a minimum of about 0.25 monthly water utilization factor in the month of November is attained.

The minimum monthly water utilization factors from water balance, and the annual water utilization factor from LP model studies are given below for each sub-basin.

As per the water balance studies, in the case of Upper Cauvery sub-basin, minimum monthly utilization factors of 0.36 and 0.71 for without and with ground water considerations are obtained, respectively. The annual water utilization factor in water balance studies is 0.96 for both without and with ground water considerations. From LP model the annual water utilization factor is 0.41 (see col.8 of Table 9.7). The difference is because in the water balance study, it was not possible to consider, the arial variability and distribution of the surface and ground water available and its availability in the basin, with respect to the locations of the various reservoirs and water use points.

The Kabini sub-basin has a minimum monthly utilization factor of 0.67 for both without and with ground water considerations. The annual water utilization factors in water balance studies are 1.00 and 0.98 for without and with ground water considerations. And as per LP model the annual utilization factor is 0.73.

As per the water balance studies, in the case of Shimsha sub-basin, minimum monthly utilization factors of 0.26 and 0.27 for without and with ground water considerations are obtained, respectively. The annual water utilization factors in water balance studies are 0.96 and 0.86 for without and with ground water considerations. From LP model the annual water utilization factor is 0.35 (see col.8 of Table 9.7).

As per the water balance studies, in the case of Arkavathi sub-basin, minimum monthly utilization factors of 1.00 for both without and with ground water considerations are obtained. The annual water utilization factor in water balance studies is 1.00 for both without and with ground water considerations. From LP model the annual water utilization factor is 0.30 (see col.8 of Table 9.7).

In the case of Middle Cauvery sub-basin, as per the water balance studies, minimum monthly utilization factors of 0.80 and 0.78 for without and with ground water considerations are obtained, respectively. The annual water utilization factors in water balance studies are 0.97 and 0.89 for without and with ground water considerations. From LP model the annual water utilization factor is 0.77 (see col.8 of Table 9.7).

As per the water balance studies, in the case of Suvarnavathi sub-basin, minimum monthly utilization factors of 0.72 and 0.73 for without and with ground water considerations are obtained, respectively. The annual water utilization factor in water balance studies is 1.00 for both without and with ground water considerations. From LP model the annual water utilization factor is 0.2 (see col.8 of Table 9.7).

In the case of Palar sub-basin, as per the water balance studies, minimum monthly utilization factors of 0.84 and 0.77 for without and with ground water considerations are obtained, respectively. The annual water utilization factor in water balance studies is 1.00 for both without and with ground water considerations. From LP model the annual water utilization factor is 0.60 (see col.8 of Table 9.7).

Chinnar sub-basin has a minimum monthly utilization factor of 1.00 for both without and with ground water considerations. The annual water utilization factor in water balance studies is 1.00 for both without and with ground water considerations. From LP model the annual water utilization factor is 1.00 (see col.8 of Table 9.7).

As per the water balance studies, in the case of Bhavani sub-basin, minimum monthly utilization factors of 0.65 for both without and with ground water considerations are obtained, respectively. The annual water utilization factor in water balance studies is 1.00 for both without and with ground water considerations. From LP model the annual water utilization factor is 0.52 (see col.8 of Table 9.7).

In the case of Amaravathi sub-basin, As per the water balance studies, minimum monthly utilization factors of 0.24 and 0.25 for without and with ground water considerations are obtained, respectively. The annual water utilization factor in water balance studies is 1.00 for both without and with ground water considerations. From LP model the annual water utilization factor is 0.62 (see col.8 of Table 9.7).

As per the water balance studies, in the case of Tirumanimuttar sub-basin, minimum monthly utilization factors of 0.51 and 0.58 for without and with ground water considerations are obtained, respectively. The annual water utilization factors in water balance studies are 1.00 and 0.94 for without and with ground water considerations, respectively. From LP model the annual water utilization factor is 0.36 (see col.8 of Table 9.7).

As per the water balance studies, in the case of Ponnanai Ar sub-basin, minimum monthly utilization factors of 0.70 and 0.60 for without and with ground water considerations are obtained, respectively. The annual water utilization factor in water balance studies are 1.00 and 0.82 for without and with ground water considerations respectively. From LP model the annual water utilization factor is 0.52 (see col.8 of Table 9.7).

In the case of Upper Coleroon sub-basin, As per the water balance studies, minimum monthly utilization factors of 0.53 and 0.48 for without and with ground water considerations are obtained, respectively. The annual water utilization factors in water balance studies are 0.94 and 0.79 both without and with ground water considerations, respectively. From LP model the annual water utilization factor is 0.63 (see col.8 of Table 9.7).

As per the water balance studies, in the case of Lower Coleroon sub-basin, minimum monthly utilization factors of 0.69 and 0.65 for without and with ground water considerations are obtained, respectively. The annual water utilization factors in water balance studies are 0.85 and 0.79 for without and with ground water considerations. From LP model the annual water utilization factor is 0.50 (see col.8 of Table 9.7).

As per the water balance studies, in the case of Cauvery Delta sub-basin, minimum monthly utilization factors of 0.77 and 0.76 for without and with ground water considerations are obtained, respectively. The annual water utilization factors in water balance studies are 0.89 and 0.88 for without and with ground water considerations. From LP model the annual water utilization factor is 0.40 (see col.8 of Table 9.7).

9.4.4 Comparison of Total Annual Balance from Water Balance and LP Model Studies

While comparing the total annual water balances (refer Table 9.8), obtained from monthly water balance and LP model studies, for the 75 % water year dependable flow with consideration of ground water (when exports from Mettur reservoir to the sub-basins below Mettur in water balance is 12712 MCM and in LP model it is 5800 MCM), the following observations are made:

In the case of Upper Cauvery sub-basin, from water balance studies it is found that the sub-basin is surplus in water by 286.45 MCM (4.48%), while from LP model studies it is seen that there is a water deficit of –703.41 MCM (-11.01 %).

In Kabini sub-basin from water balance studies, it is found that the sub-basin is surplus in water by 107.62 MCM (1.99%), while from LP model studies it is seen that there is a water deficit of –172.40 MCM (-3.47%).

In the case of Shimsha sub-basin, it is observed from water balance studies that, the sub-basin is surplus in water by 640.15 MCM (16.55%), while from LP model studies it is seen that there is a water deficit of –1389.95 MCM (-35.94%).

In the case of Arkavathi sub-basin, from water balance studies it is found that, the sub-basin is deficit in water by -712.56 MCM (-29.35%), while from LP model studies it is seen that there is a water deficit of –2121.66 MCM (-87.38%).

In the case of Middle Cauvery sub-basin, from water balance studies, it is found that the sub-basin is surplus in water by 268.94 MCM (12.11%), while from LP model studies it is seen that there is a water surplus of 1788.15 MCM (80.51%).

In the case of Suvarnavathi sub-basin, from water balance studies it is found that, the sub-basin is deficit in water by -22.11 MCM (-2.88%), while from LP studies it is seen that there is a water deficit of –634.41 MCM (-82.71%).

In the case of Palar sub-basin, from water balance studies it is found that, the sub-basin is deficit in water by –28.49 MCM (-7.98%), while from LP model studies it is seen that there is a water deficit of –170.06 MCM (-47.64%).

In the case of Chinnar sub-basin, from water balance studies it is observed that, the sub-basin is deficit in water by –12932.21 MCM (-78.01%), while from LP studies it is seen that there is a water deficit by –213.00 MCM (-1.28%).

In the case of Bhavani sub-basin, from water balance studies it is found that, the sub-basin is deficit in water by -247.39 MCM (-8.60%), while from LP studies it is seen that there is a water deficit of -1159.90 MCM (-40.30%).

In the case of Noyil sub-basin, it is found from water balance studies that, the sub-basin is water deficit by –39.92 MCM (-3.27%), while from LP studies it is seen that there is a water deficit by – 1058.10 MCM (-86.66%).

In the case of Amaravathi sub-basin, from water balance studies it is found that, the sub-basin is deficit in water by –453.63 MCM (-16.48%), while from LP studies it is seen that there is a water deficit by –1379.24 MCM (-50.10%).

In the case of Tirumanimuttar sub-basin, from water balance studies it is seen that, the sub-basin is surplus in water by 100.64 MCM (2.65%), while from LP studies it is seen that there is a water deficit by –2465.51 MCM (-65.02%).

In the case of Ponnanai Ar sub-basin, from water balance studies it is observed that, the sub-basin is surplus in water by 188.17 MCM (18.72%), while from LP studies it is seen that there is a water deficit of –420.10 MCM (-41.80%).

In the case of Upper Coleroon sub-basin, from water balance studies it is found that, the sub-basin is surplus in water by 334.44 MCM (24.36%), while from LP studies it is seen that there is a water deficit by –296.89 MCM (-21.62%).

In the case of Lower Coleroon sub-basin, from water balance studies it is observed that, the sub-basin is surplus in water by 340.16 MCM (26.09%), while from LP studies it is seen that there is a water deficit by –506.27 MCM (-38.82%).

In the case of Cauvery Delta sub-basin, from water balance studies it is found that,, the sub-basin is surplus in water by 1413.26 MCM (14.12%), while from LP studies it is seen that there is a deficit by –2541.36 MCM (-25.39%).

In the case of Cauvery basin as a whole, from water balance studies it is found that, the Cauvery basin is deficit in water by –10586.00 MCM (-17.95%), while from LP studies it is seen that there is a water deficit of –13444.12 MCM (-22.79%).

From the above discussion for the monthly water balance on annual basis, it is seen that, the Cauvery Delta sub-basin has the maximum surplus of 1413.26 MCM

(14.12%) and the Tirumanimuttar sub-basin has the minimum surplus of 100.64 MCM (2.64%). Whereas, the Chinnar sub-basin has the maximum deficit of -12932.21 MCM (-78.01%) and the Suvarnavathi sub-basin has the minimum deficit of –22.11 MCM (-2.88%).

Similarly, from the LP model results, it is seen that, only the Middle Cauvery sub-basin has the surplus of 1788.15 MCM (80.51%). Whereas, the Cauvery Delta sub-basin has the maximum deficit of –2541.36 MCM (-25.31%) and the Palar sub-basin has the minimum deficit of –170.06 MCM (-47.64%).

9.4.5 Intra-basin Water Exports Within Sub-basins

As per LP model results all the proposed intra-basin water exports except from Kabini project, are possible. Only 76% of proposed as per NWDA reports, intra-basin exports are possible from the Kabini project to the surrounding sub-basins for 75% water year dependable flow after fulfilling its own irrigation and water supply requirements within the sub-basin for 5800 MCM water exports from Mettur to the sub-basins below Mettur. As per the LP model results for 75%, 50%, 90%, and 100% water year dependable flows, the maximum water exports possible to the sub-basins below Mettur are 7200 MCM, 7800 MCM, 6900 MCM, and 6700 MCM, respectively, after fulfilling the irrigation and water supply demands of respective sub-basins.

9.5 NEED OF INTER-BASIN IMPORTS OF WATER FROM OTHER RIVER BASIN/BASINS

The Cauvery basin is always short of water for all the water year dependable flow studied, as determined from the monthly water balance computation on an annual basis. The inter-basin imports required from the other river basin/basins river to the Cauvery river basin for various water years dependable flows, obtained from water balance studies are given in Table 9.9.

Table 9.9: Inter-basin Imports Required from Other River Basin / Basins as per Water Balance Studies

Sl. No.	Water year dependable flow	Without ground water (MCM)	With ground water (MCM)
1	75% water year dependable flow	14434	10586
2	50% water year dependable flow	13572	9859
3	90% water year dependable flow	16896	13364
4	100% water year dependable flow	20300	17719

Note: Exports from Mettur Reservoir is 12712 MCM.

The inter-basin imports required from the other river basin/basins river to the Cauvery river basin for various water years dependable flows, obtained from LP model are given in Table 9.10.

Table 9.10: Inter-basin Imports Required from Other River Basin / Basins as per LP Model Studies

Sl. No.	Water year dependable flow	With ground water consideration (MCM)
1	75% water year dependable flow	13444.12
2	50% water year dependable flow	12468.91
3	90% water year dependable flow	15888.95
4	100% water year dependable flow	18853.4

Note: Exports from Mettur Reservoir is 5800 MCM.

In the water balance studies of the NWDA the maximum proposed exports from Mettur reservoir to the sub-basins below Mettur is shown as 12712 MCM for normal year, i.e. for 75% water year dependable flow, while as per the LP model, for 75%, 50%, 90% and 100% water year dependable flows these are 7200 MCM, 7800 MCM, 6900 MCM, and 6700 MCM, respectively, as given in Section 9.4.4.

9.6 CONCLUSIONS

The conclusions drawn from the study on "Optimal Water Utilization and Intra-basin Water Transfers in Cauvery Basin, India," are stated crisply based on the findings of the work done as below :

(1) A true estimate of water balance of a large river basin can only be achieved, if viewed altogether from a different perspective, unlike the conventional method usually carried out on an annual basis. The basin's variability with respect to the time and space of various parameters, in meeting various water demands and influencing the water balance, i.e. availability of surface and ground waters, use of water, effect of reservoir storages, etc., should be considered and their impact on the water balance should be looked into. Incorporating the variability in space of these parameters, however, is not possible in the conventional method of water balance. In the present study, therefore, only the time variability of the parameters was accounted for in the water balance study of Cauvery river basin. The water balance studies carried out for the Cauvery river system, with and without ground water availability considerations, do provide a clear picture of the monthly variations in the supply and demand in the basin.

(2) A water balance study of a river basin is unable to provide us with all the information, what is needed in planning for the development of its water

resources. This is one thing that the water balance study of a river basin, does not take into account for the impact of the space variability of various parameters on its water balance, but the optimal use of its water resources is another thing. This necessitated the need of adopting a linear programming based optimization model for the solution of the optimal utilization of Cauvery river waters, a model which can easily incorporate the above two aspects of planning into the model and can also handle a large size optimization problem. The affects of the time and aerial variability in the basin, of the supply and demand, have been clearly brought out by the optimization model.

(3) The water balance study showed that, with ground water availability considerations, the Upper Cauvery, Kabini, Tirumanimuttar and Ponnanai Ar sub-basins become water surplus from water deficit, during normal and good water years (i.e., for the flows from the 75% water year dependable flow upwards up to the years of highest flows).

(4) All the sixteen sub-basins in the Cauvery river system, except Middle Cauvery sub-basin, are found short of water during normal and bad water years (i.e., for the flows from the 75% water year dependable flow downwards up to the years of lowest flows), as determined from the linear programming model, whereas the Noyil and Arkavathi sub-basins suffer the most from water deficits, and the Chinnar sub-basin the least.

(5) The Kabini sub-basin is not able to fulfill its intra-basin water exports requirements completely during normal and bad water years, as determined

from linear programming model.

(6) As per the LP model, it is found that the maximum intra-basin water exports (reservoir releases) possible from the Mettur reservoir to the other sub-basins below Mettur for 75%, 50%, 90% and 100% water year dependable flows are 7200 MCM, 7800 MCM, 6900 MCM, and 6700 MCM, respectively, while in the water balance studies of the NWDA the maximum proposed exports from Mettur reservoir to the sub-basins below Mettur is shown as 12712 MCM for a normal water year.

(7) As per LP model results it is found, that the water share ratios for above and below Mettur for a normal water year with 5800 MCM exports from Mettur reservoir to the sub-basins below Mettur, and other water years, i.e., a water surplus year (50% water year dependable flow), a water deficit year (90% water year dependable flow) and a critical water year (100% water year dependable flow) are in the proportion of 0.98:1.07:0.79:0.72, respectively.

(8) From the LP model results it is observed that during a normal water year (i.e., the 75% water year dependable flow) various crops would follow the following pattern:

  (i) The water extensive crops, i.e., Sugarcane, Kharif Paddy and Rabi Paddy would not completely acquire their respective crops areas at Yagachi, Banasurasagar, Mananthvady, Taraka, Upper Nugu and Nugu reservoirs.

  (ii) Except at Mananthvady, Taraka and Upper Nugu it would be possible to cultivate with full potential the Kharif Paddy. Similarly, except at Banasurasagar and Mettur it would be possible to cultivate with full potential the Rabi Paddy.

(iii) Yagachi and Upper Nugu reservoirs would need import of Sugarcane.

(iv) The high benefit crops, i.e., Sugarcane and Coconut would acquire very little crop areas at Banasurasagar and Upper Nugu reservoirs.

(v) Upper Nugu reservoir is the most affected reservoir in terms of the crop area occupation.

(9) The water balance study revealed that during a normal water year, except at Lower Coleroon and Cauvery Delta sub-basins a maximum monthly water utilization factor of 1.00 would be achieved in different months, whereas, at Amaravathi sub-basin a minimum of about 0.25 monthly water utilization factor in the month of November would be achieved both with and without groundwater considerations.

From the linear programming results, the maximum annual water utilization factor is 1 at Chinnar sub-basin and the minimum annual water utilization factor 0.19 at Noyil sub-basin.

(10) Shimsha, Arkavathi, Palar, Amaravathi, Tirumanimuttar, Ponnanai Ar, Upper Coleroon, Lower Coleroon and Cauvery Delta sub-basins, would spill, in all the months during a normal water year.

(11) From the linear programming model results, it is found that during a normal

water year, the annual energy production in the system would be 1675 MU. At Kabini reservoir the annual energy generation would be more than the proposed.

(12) During a normal water year (i.e., the 75% water year dependable flow) about 18.14% of the total annual water demands, i.e., an amount of water equal to the Cauvery basin's annual water needs of 58978 MCM, may need to be imported from the other river basin/basins, as per the water balance studies carried out for conjunctive use development in the basin. The inter-basin water importing needs during a normal and other water years, i.e., a water surplus year, a water deficit year and a critical water year are in the ratios of 1.00:0.93:1.26:1.67, respectively.

(13) From LP model results also the inter-basin water importing needs with 5800 MCM water export from Mettur reservoir to the sub-basins below Mettur during a normal water year and other water years, i.e., a water surplus year, water deficit year and a critical water deficit year are in the ratios of 1.00:0.92:1.18:1.40, respectively.

9.7 SCOPE FOR FUTURE STUDY

The Supreme Court of India has recently given directives to the Government of India for interlinking the major rivers of the Himalayan and Peninsular regions for transfer of waters from the water surplus basins to the water deficit basins to reduce the natural imbalance of the water availability in the country. The studies on various inter-basin water transfers are carried out, usually on the basis of the annual water balance of all the sub-basins lying in the respective major river basins involved, to determine the amount of water available and to identify the water surplus and water deficit basins. The annual water balance studies carried out do not take into account: (i) the areal variability and distribution of the water available and its use in the basin, with respect to the locations of the various reservoirs and water use points, (ii) the time wise variability and distribution in the water availability with respect to the yearly and the within the year time periods, and (iii) the availability and use of the ground water. Therefore, for the proper planning and optimal water use, it may be now essential that before the decisions are arrived at for the final implementation of the reservoir projects etc., involved in these proposed inter-basin water transfers, the yield analysis of the various reservoirs in the entire large integrated river system should be carried out using systems analysis techniques. For this purpose, the following may be further carried out: (i) initially the multireservoir multiyield model for the yield analysis of single and multipurpose reservoirs developed by Dahe and Srivastava (2002) can be applied for preliminary screening, to screen a few most attractive alternatives among all the techno-feasible water transfer alternatives possible, within the framework of the existing agreements and the tribunal awards related to the transboundary river water disputes among the various river basins involved, regarding sharing of the river waters among the respective co-basin states, and then analyze these most attractive alternatives selected earlier, by a detailed simulation model, and (ii) the use of ground water should be also included in these studies. If the above considerations are incorporated further into the studies of the inter-basin water transfers among the major river basins, the purpose is not alone to ascertain, precisely and accurately the extent of the amount of the water available in a water surplus basin which can be exported to the water deficit basins, and the amount of the shortfall of water in a water deficit basin and the need to import water from the water surplus basins, which will also establish if there is a need of the intra-basin water transfers among the various reservoirs and water use points of the sub-basins lying in a major river basin.

Table 9.2(a): Maximum and Minimum Deficits and Surpluses from Water Balance Studies for 75% Water Year Dependable Flows

Sub-basin	1.Upper Cauvery						Kabini					
Ground water	Without ground water			With ground water			Without ground water			With ground water		
Details	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month
Monthly Maximum Deficit	-391.29	-6.21	Oct	-277.58	-4.34	Oct	-253.08	-5.14	Jan	-202.50	-4.07	Jan
Monthly Minimum Deficit	-17.62	-0.28	Nov	-11.32	-0.18	Nov	-5.6735	-0.12	Apr	-0.85	-0.02	Apr
Monthly Minimum Surplus	18.00	0.29	May	16.50	0.26	May	4.4593	0.09	Nov	21.54	0.43	Nov
Monthly Maximum Surplus	598.37	9.50	Jul	703.58	11.01	Jul	132.86	2.70	Jun	192.31	3.87	Aug
Annual Deficits/Surpluses	-274.45	-4.36	Annual	286.45	4.48	Annual	-267.78	-5.44	Annual	107.62	2.16	Annual

Sub-basin	Shimsha						Arkavathi					
Ground water	Without ground water			With ground water			Without ground water			With ground water		
Details	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month
Monthly Maximum Deficit	-68.87	-1.82	Jan	-2.49	-0.06	Apr	-205.15	-8.74	Sep	-196.97	-8.12	Sep
Monthly Minimum Deficit	-0.25	-0.01	Jun	-2.49	-0.06	Apr	-24.555	-1.05	Apr	-17.635	-0.73	Feb
Monthly Minimum Surplus	8.86	0.23	May	2.42	0.06	Mar	0	0.00	0	0	0.00	0
Monthly Maximum Surplus	294.72	7.80	Oct	299.95	7.75	Oct	0	0.00	0	0	0.00	0
Annual Deficits/Surpluses	150.81	3.99	Annual	640.15	16.55	Annual	-799.19	-34.05	Annual	-712.56	-29.36	Annual

Sub-basin	Middle Cauvery						Suvarnavathi					
Ground water	Without ground water			With ground water			Without ground water			With ground water		
Details	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month
Monthly Maximum Deficit	-3.31	-0.15	Mar	-2.27	-0.10	May	-17.01	-2.30	Jul	-6.52	-0.85	Jan
Monthly Minimum Deficit	-1.63	-0.07	Jan	-1.28	-0.06	Jun	-0.55	-0.07	May	-0.70	-0.09	May
Monthly Minimum Surplus	1.08	0.05	Jul	2.11	0.10	Apr	3.83	0.52	Nov	2.67	0.35	Sep
Monthly Maximum Surplus	24.14	1.10	Sep	52.48	2.36	Sep	6.52	0.88	Oct	6.84	0.89	Oct
Annual Deficits/Surpluses	67.4	3.07	Annual	268.94	12.11	Annual	-80	-10.88	Annual	-22.11	-2.88	Annual

Sub-basin	Palar						Chinnar					
Ground water	Without ground water			With ground water			Without ground water			With ground water		
Details	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month
Monthly Maximum Deficit	-30.75	-9.52	Jul	-12.35	-3.46	Feb	-30.75	-9.52	Jul	-12.35	-3.46	Feb
Monthly Minimum Deficit	-0.59	-0.18	May	-0.36	-0.10	May	-0.59	-0.18	May	-0.36	-0.10	May
Monthly Minimum Surplus	1.84	0.57	Oct	3.40	0.95	Aug	1.84	0.57	Oct	3.40	0.95	Aug
Monthly Maximum Surplus	6.00	1.86	Jun	10.05	2.82	Sep	6.00	1.86	Jun	10.05	2.82	Sep
Annual Deficits/Surpluses	-161	-50.00	Annual	-28.49	-7.98	Annual	-161	-50.00	Annual	-28.49	-7.98	Annual

Table 9.2(b): Maximum and Minimum Deficits and Surpluses from Water Balance Studies for 75% Water Year Dependable Flows

Sub-basin	Bhavani						Noyil					
Ground water	Without ground water			With ground water			Without ground water			With ground water		
Details	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month
Monthly Maximum Deficit	-164.53	-5.82	Mar	-49.75	-4.29	Jun	-49.75	-4.29	Jun	-42.02	-3.44	Jun
Monthly Minimum Deficit	-8.84	-0.31	Jul	-11.19	-0.97	Sep	-11.19	-0.97	Sep	-10.23	-0.84	Sep
Monthly Minimum Surplus	35.44	1.25	Dec	23.26	2.01	Dec	23.26	2.01	Dec	23.46	1.92	Dec
Monthly Maximum Surplus	98.8	3.49	Nov	106.39	9.17	Oct	106.39	9.17	Oct	105.91	8.67	Oct
Annual Deficits/Surpluses	-424.9	-15.03	Annual	-66.40	-5.72	Annual	-66.40	-5.72	Annual	-39.92	-3.27	Annual

Sub-basin	Amaravathi						Tirumanimuttar					
Ground water	Without ground water			With ground water			Without ground water			With ground water		
Details	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month
Monthly Maximum Deficit	-207.29	-7.74	Mar	-171.93	-6.25	Mar	-147.29	-4.01	Mar	-71.711	-1.89	Mar
Monthly Minimum Deficit	-40.31	-1.51	Sep	-19.87	-0.72	Sep	-37.17	-1.01	Jan	-18.258	-0.48	Jan
Monthly Minimum Surplus	124.28	4.64	Oct	125.29	4.55	Oct	50.49	1.37	Dec	79.668	2.10	Dec
Monthly Maximum Surplus	189.79	7.09	Nov	190.15	6.91	Nov	267.48	7.28	Oct	301.08	7.94	Oct
Annual Deficits/Surpluses	-746.9	-27.89	Annual	-453.63	-16.48	Annual	-225.54	-6.14	Annual	-100.64	-2.65	Annual

Sub-basin	Ponnanai Ar						Upper Coleroon					
Ground water	Without ground water			With ground water			Without ground water			With ground water		
Details	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month
Monthly Maximum Deficit	-18.84	-1.93	Jul	0	0.00	0	-69.07	-5.12	Jul	-10.73	-0.78	Jul
Monthly Minimum Deficit	-1.59	-0.16	Dec	0	0.00	0	-2.80	-0.21	Jun	-0.61	-0.04	Mar
Monthly Minimum Surplus	0.19	0.02	Feb	2.34	0.21	Apr	4.80	0.36	May	0.86	0.06	Apr
Monthly Maximum Surplus	43.78	4.48	Nov	69.70	6.32	Nov	132.50	9.83	Nov	149.73	10.91	Nov
Annual Deficits/Surpluses	-13.74	-1.41	Annual	216.89	19.66	Annual	86.64	6.42	Annual	358.44	26.11	Annual

Sub-basin	Lower Coleroon						Cauvery Delta					
Ground water	Without ground water			With ground water			Without ground water			With ground water		
Details	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month	Quantity	%	Month
Monthly Maximum Deficit	0	0	0	0	0	0	0	0.0	0	0	0	0
Monthly Minimum Deficit	0	0	0	0	0	0	0	0.0	0	0	0	0
Monthly Minimum Surplus	2.80	0.22	May	2.87	0.22	May	10.45	0.11	May	9.77	0.10	May
Monthly Maximum Surplus	46.01	3.56	Sep	74.12	5.68	Sep	256.38	2.58	Sep	307.95	3.08	Sep
Annual Deficits/Surpluses	222.2	17.21	Annual	340.16	26.09	Annual	1203.1	12.11	Annual	1413.26	14.12	Annual

* Surpluses / Descending

Table 9.4.(a): Monthly Deficits/in/Ascending Order Computed from LP Model for 75% Water Year Dependable Flows for Cauvery River System (With the Water Export of 5800 MCM from Mettur to The Sub-basins Below Mettur)

Upper Cauvery Sub-basin			Kabini Sub-basin			Shimsha Sub-basin			Arkavathi Sub-basin			Middle Cauvery			Suvarnavathi Sub-basin			Palar Sub-basin			Chinar Sub-basin.		
Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Oct	-139.96	-3.9	Aug	-164.94	-3.4	Jan	-389.48	-10.3	Sep	-395.41	-16	May	9	0.4	Jul	-111.50	-15	Jul	-34.54	-11	Mar	-30.58	-1.1
Aug	-130.85	-3.6	Jul	-163.31	-3.3	Feb	-307.26	-8.1	Oct	-361.07	-15	Jun	17.9	1	Aug	-102.69	-14	Aug	-31.88	-10	Feb	-25.06	-0.9
Jul	-129.63	-3.6	Sep	-78.75	-1.6	Dec	-294.08	-7.8	Nov	-212.43	-9	Oct	22.4	1	Sep	-84.04	-11	Sep	-26.11	-8	Dec	-24.49	-0.9
Sep	-128.12	-3.6	Jun	-62.94	-1.3	Aug	-255.11	-6.8	Dec	-168.16	-7	Apr	48.7	2	Jan	-79.02	-11	Feb	-19.89	-6	Apr	-23.54	-0.8
Jun	-55.56	-1.5	Oct	-55.44	-1.1	Jul	-227.46	-6.0	Jan	-157.80	-6	Nov	75.4	3	Feb	-70.69	-10	Jan	-19.06	-6	May	-22.15	-0.8
Feb	-30.36	-0.8	Nov	-35.94	-0.7	Sep	-193.99	-5.1	Aug	-150.99	-6	Mar	139.9	6	Dec	-54.26	-7	Dec	-16.00	-5	Sep	-21.45	-0.7
Mar	-29.30	-0.8	Dec	-18.19	-0.4	Mar	-165.84	-4.4	Jul	-124.47	-5	Dec	155.6	7	Mar	-41.86	-6	Mar	-12.61	-4	Nov	-20.80	-0.7
Jan	-24.14	-0.7	May	-18.06	-0.4	Nov	-159.73	-4.2	Feb	-121.91	-5	Feb	201.4	9	Nov	-26.68	-4	Nov	-10.09	-3	Oct	-17.56	-0.6
Dec	-20.49	-0.6	Apr	-11.12	-0.2	Apr	-64.26	-1.7	Jun	-114.45	-5	Jan	222.3	10	Apr	-12.89	-2	Apr	-4.64	-1	Jun	-16.76	-0.6
Nov	-9.41	-0.3	Mar	-6.50	-0.1	Jun	-34.39	-0.9	Mar	-110.90	-5	Sep	248.8	11	Oct	-9.88	-1	Oct	-4.59	-1	Jan	-12.08	-0.4
Apr	-5.01	-0.1	Jan	-5.37	-0.1	May	-28.90	-0.8	May	-107.47	-4	Aug	309.8	14	Jun	-8.36	-1	Jun	-3.43	-1	Jul	-8.92	-0.3
May	0.00	0.0	Feb	-4.95	-0.1	Oct	-28.56	-0.8	Apr	-96.50	-4	Jul	336.8	15	May	-5.56	-1	May	-2.55	-1	Aug	-6.10	-0.2
Total	-703	-19.5	Total	-625	-12.7	Total	-2149	-56.9	Total	-2122	-87	Total	1788.0	81	Total	-607	-82	Total	-186	-57	Total	-229	-8.0

* Note: Deficit values are shown by -ve sign only for convenience.

Table 9.4.(b): Monthly Deficits in Ascending Order Computed from LP Model for 75% Water Year Dependable Flows for Cauvery River System (With the Water Export of 5800 MCM from Mettur to The Sub-basins Below Mettur)

Bhavani Sub-basin			Noyil Sub-basin			Amaravathi Sub-basin			Tirumanimuttar S.b.			Ponnana Ar S.B.			Upper Coleroon S.B.			Lower Coleroon S.B.			Cauvery Delta S.B.		
Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%	Months	Quantity	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Jul	-101.73	-4	Jun	-174.11	-14	Jul	-262.38	-10	Mar	-458.82	-12	Dec	-61.89	-6	Aug	-112.36	-8.3	Aug	-145.60	-11.2	Aug	-1345.44	-14
Aug	-92.65	-3	May	-150.73	-12	Aug	-228.18	-8	Feb	-309.41	-8	Oct	-55.64	-6	Sep	-109.84	-8.1	Sep	-142.33	-10.9	Sep	-1315.30	-13
Mar	-87.69	-3	Jul	-114.38	-9	Mar	-199.00	-7	Apr	-309.41	-8	Jan	-48.90	-5	Jul	-104.99	-7.8	Jul	-136.06	-10.4	Jul	-1257.28	-13
Feb	-78.33	-3	Aug	-96.85	-8	Jun	-196.86	-7	Sep	-309.41	-8	Nov	-45.77	-5	Oct	-32.92	-2.4	Oct	-42.66	-3.3	Oct	-394.22	-4
Jun	-75.54	-3	Mar	-92.67	-8	Feb	-173.13	-6	Nov	-309.41	-8	Jul	-44.07	-5	Nov	-28.96	-2.1	Nov	-37.53	-2.9	Nov	-346.85	-3
Jan	-53.27	-2	Feb	-83.70	-7	Sep	-117.70	-4	Oct	-309.41	-8	Jun	-28.01	-3	Dec	-22.81	-1.7	Dec	-29.55	-2.3	Dec	-273.11	-3
Sep	-41.19	-1	Apr	-77.69	-6	Jan	-116.57	-4	Aug	-309.41	-8	Aug	-26.39	-3	Mar	-20.84	-1.5	Mar	-27.01	-2.1	Mar	-249.57	-3
Apr	-31.91	-1	Jan	-75.34	-6	Apr	-72.60	-3	May	-309.41	-8	Sep	-23.10	-2	Feb	-13.80	-1.0	Feb	-17.88	-1.4	Feb	-165.21	-2
May	-21.40	-1	Sep	-65.07	-5	May	-71.86	-3	Dec	-309.41	-8	Mar	-21.31	-2	Jan	-7.91	-0.6	Jan	-10.24	-0.8	Jan	-94.67	-1
Dec	-15.65	-1	Dec	-55.64	-5	Dec	-46.30	-2	Jun	-309.41	-8	Apr	-17.66	-2	Jun	-6.28	-0.5	Jun	-8.14	-0.6	Jun	-75.16	-1
Oct	-3.18	0	Oct	-39.01	-3	Oct	-12.44	-0.5	Jul	-309.41	-8	May	-11.94	-1	Apr	-5.81	-0.4	Apr	-7.53	-0.6	Apr	-69.62	-1
Nov	-2.99	0	Nov	-38.90	-3	Nov	-8.63	-0.3	Jan	-309.41	-8	Feb	-10.64	-1	May	-1.13	-0.1	May	-1.47	-0.1	May	-13.59	-0.1
Total	-606	-21	Total	-1064	-87	Total	-1506	-55	Total	-309.41	-8	Total	-395	-40	Total	-468	-34.7	Total	-606	-46.5	Total	-5600	-56

Table 9.5: Monthly Spills as per LP Model for 75% Water Year Dependable Flows with 5800 MCM Water Exports from Mettur to the Sub-basins Below Mettur

Months	Upper Cauvery	Kabini	Shimsha	Arkavathi	Middle Cauvery	Suvarna-vathi	Palar	Chinnar	Bhavani	Noyil	Amara-vathi	Tirumani-muttar	Ponnanai Ar	Upper Coleroon	Lower Coleroon	Cauvery Delta
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Jun	602.72	31.06	2.09	9.32	721.48	2.09	9.66	8.40	60.98	38.89	80.72	36.36	42.42	143.30	158.66	173.37
Jul	0.00	42.65	186.36	6.81	364.16	74.58	20.44	0.18	149.57	23.09	165.47	23.44	67.16	316.31	512.59	411.86
Aug	72.32	465.87	216.35	13.17	915.39	66.89	25.66	1.40	104.71	17.10	133.80	62.38	29.55	308.47	540.97	498.45
Sep	0.00	363.18	225.58	98.58	875.45	62.09	28.32	78.00	37.91	14.48	57.76	106.79	43.61	321.52	569.39	569.86
Oct	0.00	517.96	271.09	89.27	1039.39	10.98	7.22	0.00	51.89	116.78	35.76	391.39	136.27	444.20	551.38	750.94
Nov	0.00	95.25	225.09	36.25	516.68	22.77	0.15	73.71	63.97	64.00	101.03	256.24	143.43	470.36	553.71	556.16
Dec	0.00	0.00	258.06	9.62	373.36	32.72	3.71	15.86	41.24	43.07	80.54	152.05	135.78	307.25	363.37	304.45
Jan	0.00	0.00	337.27	3.64	439.45	48.97	2.75	4.46	235.18	11.16	103.98	4.88	88.27	200.45	185.85	0.00
Feb	0.00	0.00	260.72	2.06	363.44	44.27	1.59	1.58	173.05	14.40	45.63	143.41	5.19	175.54	172.62	0.00
Mar	0.00	0.00	116.21	1.28	196.54	23.52	1.44	1.55	0.00	0.00	50.08	223.75	27.42	170.08	204.49	158.86
Apr	0.00	83.68	21.20	2.08	180.51	4.13	0.07	3.18	249.28	27.90	4.54	95.15	20.02	198.01	215.33	274.60
May	0.00	58.33	1.96	6.97	144.79	0.00	1.66	8.83	12.83	31.86	10.11	52.41	11.45	88.43	96.64	98.84
Annual	675.04	1657.98	2121.98	279.05	6130.64	393.01	102.67	197.15	1180.61	402.73	869.42	1548.25	750.57	3143.92	4125.00	3797.39

Table 9.6: Computed Monthly and Annual Water Utilization Factors from Water Balance Studies

Sl.No.	Name of Sub-basin	Water Balance Study	Annual Water Utilization Factors from Water Balance Studies												
			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1	Upper Cauvery	Without ground water	0.58	1.00	1.00	0.66	0.54	0.85	0.67	0.44	0.38	0.36	0.76	1.00	0.96
		With ground water	1.00	0.71	0.76	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	0.96
2	Kabini	Without ground water	0.68	0.90	0.89	1.00	0.67	0.98	1.00	1.00	1.00	1.00	1.00	0.79	1.00
		With ground water	0.67	0.84	0.84	1.00	0.67	0.93	1.00	1.00	1.00	1.00	1.00	0.79	0.98
3	Shimsha	Without ground water	1.00	1.00	1.00	0.88	0.26	0.76	1.00	1.00	1.00	1.00	1.00	0.91	0.96
		With ground water	0.94	0.96	0.95	0.79	0.27	0.70	0.95	0.97	0.97	0.99	1.02	0.88	0.86
4	Arkavathi	Without ground water	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		With ground water	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	Middle Cauvery	Without ground water	1.00	1.00	0.97	0.93	0.80	0.86	0.98	1.00	1.00	1.00	1.00	1.00	0.97
		With ground water	1.00	0.90	0.88	0.86	0.78	0.82	0.90	0.91	0.92	0.93	0.97	1.00	0.89
6	Suvarnavathi	Without ground water	1.00	1.00	1.00	1.00	0.72	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		With ground water	1.00	1.00	1.00	0.97	0.73	0.86	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	Palar	Without ground water	0.56	1.00	1.00	1.00	0.84	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		With ground water	0.60	1.00	0.94	0.82	0.77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	Chinnar	Without ground water	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		With ground water	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	Bhavani	Without ground water	1.00	1.00	1.00	1.00	0.68	0.65	0.82	1.00	1.00	1.00	1.00	1.00	1.00
		With ground water	1.00	0.96	1.00	1.00	0.68	0.65	0.81	1.00	1.00	1.00	1.00	1.00	1.00
10	Noyil	Without ground water	1.00	1.00	1.00	1.00	0.30	0.45	0.73	1.32	1.00	1.00	1.00	1.00	1.00
		With ground water	1.00	1.00	1.00	1.00	0.31	0.47	0.74	1.00	1.00	1.00	1.00	1.00	1.00
11	Amaravathi	Without ground water	1.00	1.00	1.00	1.00	0.34	0.24	0.44	1.00	1.00	1.00	1.00	1.00	1.00
		With ground water	1.00	1.00	1.00	1.00	0.36	0.25	0.45	1.00	1.00	1.00	1.00	1.00	1.00
12	Tirumanimuttar	Without ground water	1.00	1.00	1.00	1.00	0.51	0.74	0.83	1.00	1.00	1.00	1.00	1.00	1.00
		With ground water	1.00	1.00	1.00	1.00	0.48	0.68	0.76	1.00	1.00	1.00	1.00	1.00	0.94
13	Ponnanai Ar	Without ground water	1.00	1.00	1.00	0.88	0.93	0.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		With ground water	0.95	0.94	0.94	0.74	0.75	0.60	0.80	0.89	0.84	0.91	0.96	0.88	0.82
14	Upper Coleroon	Without ground water	1.00	1.00	1.00	1.00	0.68	0.40	0.53	0.80	1.00	1.00	1.00	0.83	0.94
		With ground water	0.94	1.00	1.00	0.87	0.60	0.37	0.48	0.72	0.91	1.00	0.98	0.77	0.79
15	Lower Coleroon	Without ground water	0.88	0.93	0.88	0.86	0.74	0.75	0.69	0.77	0.92	0.94	0.86	0.85	0.85
		With ground water	0.85	0.85	0.81	0.79	0.70	0.71	0.65	0.75	0.87	0.87	0.83	0.85	0.79
16	Cauvery Delta	Without ground water	0.92	0.94	0.91	0.90	0.81	0.82	0.77	0.84	0.94	0.95	0.90	0.90	0.89
		With ground water	0.92	0.92	0.89	0.88	0.80	0.81	0.76	0.83	0.93	0.94	0.90	0.91	0.88

Note: (1) Utilization factor calculated in water balance studies is the ratio between the water utilization (demands) and the amount of water availability

(2) Further in the water balance studies it is assumed that the available water in a sub-basin is to be utilized first within the sub-basin, and then to be exported to other sub-basins if surplus, as water balance are done independent of other sub-basins.

(3) Exports from Mettur reservoir to the sub-basins below Mettur is 12712 MCMC

Table 9.7: Computed Annual Water Utilization Factors from LP Model Results with 5800 MCM Water Exports from Mettur to the Sub-basins Below Mettur for 75% Water Year Dependable Flows

Sl.No.	Name of Sub-basin	Utilization factor-with					
		sw	sw + imp	sw+imp+swr	g.w.	gw + gwr	sw+imp+swr+gw+gwr
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Upper Cauvery	0.40	0.40	1.00	1.00	0.83	0.41
2	Kabini	0.90	0.82	0.92	0.94	0.79	0.73
3	Shimsha	1.00	0.28	0.31	1.00	0.81	0.35
4	Arkavathi	0.71	0.29	0.51	1.00	0.61	0.30
5	Middle C.	1.00	0.89	0.28	1.00	0.84	0.77
6	Suvarnavathi	1.00	0.13	0.16	1.00	0.71	0.20
7	Palar	0.51	0.51	1.00	0.95	0.76	0.60
8	Chinnar	1.00	1.00	1.00	0.90	0.73	1.02
9	Bhavani	0.59	0.58	0.99	1.00	0.78	0.52
10	Noyil	0.58	0.20	0.42	0.60	0.48	0.19
11	Amaravathi	1.00	0.83	0.74	0.78	0.62	0.62
12	Tirumanimuttar	1.00	0.40	0.42	1.00	0.58	0.36
13	Ponnai Ar	1.00	0.59	0.48	0.94	0.81	0.52
14	Upper Coleroon	1.00	0.74	0.59	0.85	0.72	0.63
15	Lower Coleroon	1.00	0.53	0.27	0.93	0.82	0.50
16	Cauvery Delta	1.00	0.44	0.19	1.00	0.57	0.40

Note: (1) sw = Surface water.
sw + imp = Surface water + imports.
sw + imp + swr = Surface water + imports + regenerations from surface water use.
g.w. = Ground water
gw+gwr = Ground water + regenerations from geround water use
sw+imp+swr+gw+gwr = Surfacw water + imports + regenerations from surface water use + ground water + regenerations from ground water use

(2) The utilization factors calculated from LP model, where, the utilization factor is less than one, the surplus water is available; however, when the utilization factor is equal to one, it means the demands are not completely met with the following interpretations:

(i) the available water is less than the demands, and (ii) the available water is more than the demands and a part of available water is being diverted optimally to downstream sub-basins. This shows the impact of storages and locations on water utilization.

This is because , the entire river system is considered as one, unlike in water balance studies where each sub-basin was considered independently.

Table 9.8: Comparison of Total Annual Water Balance from Water Balance and LP Model Studies

Sl. No.	Name of Sub-basin	Total Annual Water Balance With Ground Water Consideration															
		Water year dependable flow															
		75%				50%				90%				100%			
		LP		WB		LP		WB		LP		WB		LP		WB	
		Quantity	%	Quantity	%	Quantity	%	Quantity	%	Quantity	%	Quantity	%	Quantity	%	Quantity	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
1	Upper Cauvry	-703.41	-11.01	286.45	4.48	-839.72	-13.14	660.90	10.34	-1655.14	-25.91	-262.19	-4.10	-1750.46	-27.40	-1935.29	-30.29
2	Kabini	-172.40	-3.47	107.62	2.16	95.16	1.91	835.27	16.79	-1387.17	-27.89	-487.37	-9.80	-2247.62	-45.19	-1534.79	-30.86
3	Shimsha	-1389.95	-35.94	640.15	16.55	-1169.95	-30.25	782.71	20.24	-1664.64	-43.05	628.26	16.25	-1664.64	-43.05	341.17	8.82
4	Arkavathi	-2121.66	-87.38	-712.56	-29.35	-2060.66	-84.87	-676.56	-27.87	-2232.66	-91.95	-795.72	-32.77	-2235.66	-92.08	-415.48	-17.11
5	Middle Cauvery	1788.15	80.51	268.94	12.11	1788.00	80.50	330.95	14.90	781.00	35.16	214.50	9.66	415.00	18.69	127.95	5.76
6	Suvarnavathi	-634.41	-82.71	-22.11	-2.88	-604.41	-78.80	12.48	1.63	-660.41	-86.10	-50.11	-6.53	-667.41	-87.02	-60.11	-7.84
7	Palar	-170.06	-47.64	-28.49	-7.98	-55.46	-15.54	44.22	12.39	-156.86	-43.94	-61.49	-17.22	-190.86	-53.46	-115.48	-32.35
8	Chinnar	-213.00	-1.28	-12932.21	-78.01	-115.07	-1.71	-15822.55	-95.45	-223.00	-1.35	-13012.21	-78.50	-233.15	-1.41	-13155.21	-79.36
9	Bhavani	-1159.90	-40.30	-247.39	-8.60	-1159.90	-40.30	239.43	8.32	-1150.00	-39.96	-651.57	-22.64	-1219.52	-42.37	-946.57	-32.89
10	Noyil	-1058.10	-86.66	-39.92	-3.27	-1058.10	-86.66	-64.52	-5.28	-1068.10	-87.48	-51.92	-4.25	-1100.10	-90.10	-63.92	-5.23
11	Amaravathi	-1379.24	-50.10	-453.63	-16.48	-1335.66	-48.52	-303.63	-11.03	-1548.54	-56.25	-546.63	-19.86	-2145.22	-77.92	-710.63	-25.81
12	Tirumanimuttar	-2465.51	-65.02	100.64	2.65	-2332.72	-61.52	465.24	12.27	-2397.72	-63.23	75.64	1.99	-2469.07	-65.11	16.64	0.44
13	Ponnai Ar	-420.10	-41.80	188.17	18.72	-400.50	-39.85	214.97	21.39	-412.79	-41.07	157.17	15.64	-408.99	-40.70	61.17	6.09
14	Upper Coleroon	-296.89	-21.62	334.44	24.36	-296.89	-21.62	484.44	35.28	-296.89	-21.62	243.44	17.73	-296.89	-21.62	-64.56	-4.70
15	Lower Coleroon	-506.27	-38.82	340.16	26.09	-506.27	-38.82	485.19	37.21	-506.27	-38.82	284.72	21.83	-506.27	-38.82	182.75	14.01
16	Cauvery Delta	-2541.36	-25.39	1413.26	14.12	-2416.76	-24.15	2120.53	21.19	-2316.76	-23.15	951.63	9.51	-5416.76	-54.12	553.63	5.53
Total Cauvery Basin		-13444.12	-22.79	-10586.00	-17.95	-12468.91	-21.14	-9859.00	-16.72	-16895.95	-28.65	-13363.85	-22.66	-22137.63	-37.53	-17718.73	-30.04

Note: Exports from Mettur in (i) LP is 5800 MCM, and (ii) Water balance (WB) is 12712 MCM.

REFERENCES AND BIBLIOGRAPHY

1. **Abbas, A., Miguel, A. M., and Ahmad, A.** (1990). "Reservoir planning for irrigation district." J.Water Resour. Plng. And Mgmt. ASCE, 116(1), 74-85.

2. **Afzal, J., Noble, D.H.,and Weatherhead, E.K.** (1992). "Optimization model for alternative use of different quality irrigation waters." *J. Irrigation and Drainage, ASCE,* 118(2), 2218-228.

3. **Afshar, A. Marino, M. A. and Abrishamchi. A.** (1991). "Reservoir Planning for an irrigation district." J. Water Resour. Plng. And Mgmt., ASCE, 117(1), 74-75.

4. **Agrawal, M.C. and Agrawal, R.P.,** (1982). Crop planning model under limited irrigation water availability in Hissar District) (India). Third World Congress on Water Resources IWRA, Mexico.

5. **Badenhop, M.B. and Cashdoller,** P.D., (1974). Land and water use potentials Tungabhadra project, Karnataka. University of Agricultural Sciences, Technical Series, pp 1-38.

6. **Bazarra, M.S., Jarvis, J., and Sherali, H.** (1990). *Linear programming and network flow.* John Wiley and Sons, New York, U.S.A.

7. **Beeson, R.M. and Meisel, W.S.** (1971). "The optimization of complex systems with respect to multiple criteria." *Proc. systems, man and cybernetics conference*, Anaheim, California, U.S.A.

8. **Belenson, S.M. and Kapoor, K.C.** (1993). "An algorithm for solving multicriterion linear programming problems with examples." *Operation Research Quarterly*, 21 (1), 65-77.

9. **Benayoun, R., Montgolfier, J. de., Tergny, J. and Laritchev, O.** (1971). "Linear programming and multiple objective functions STEP method (STEM)." *Mathematical Programming*, 1(3) 366-375.

10. **Beveridge, G.S. and Schecter, R.S.** (1970). *Optimization theory and practice*. McGraw Hill, New York, U.S.A.

11. **Bishop, A.B.**, et al. (1976). "Multi-objective planning concepts and methods," *Water Resour. Plan. Manage., ASCE*, 123(2), 239-253.

12. **Blanchard, B.** (1964). "A first trial in the optimal design operation of water resources systems." , M.S. Thesis, M.I.T., Cambridge, Mass.

13. **Bony, M.** (1993). "Techno economic and management (Team) approach to river basin planning." Ph.D. Thesis, Water Resources Development Training Center (WRDTC), University of Roorkee, Roorkee, India.

14. **Braga, B.P.F., Yeh, W.W.G., Becker, L., and Barros, M.T.L.** (1991). "Stochastic optimization of multiple reservoir system operation." *J. Water Resources Planning and Management, ASCE* , 117(4), 471-481.

15. **Bugliarello, George** (1987). "Computers and water resources education: A projection." J. *Water Resour. Plan. Manage.*, 113 (4), 498-511.

16. **Buras, N.** (1985). "An application of mathematical programming in planning surface water storage." *Water Resour. Bulletin*, 21(6), 1013-1020.

17. **Bargur, J.**, (1972). "Dynamic Multi sector Programming Approach to Regional Water resources management", *Water Resour. Res.*, vol. 8(4), pp.801.

18. **Chachadi, A.G. and Sinha, S.** (1988). "*System approach to optimize conjunctive use of surface and ground water*." Technical report No. TR-37, NIH Publications, Roorkee, India.

19. **Chara, A. M.** (1982). Optimal sequencing and operating policies of multipurpose multireservoir river basin projects. Ph.D. Thesis, Department of Electrical Engineering, University of Roorkee, Roorkee, India.

20. **Chaturvedi, M.C. and Duggal, K.N.** (1982). "Multilevel multiobjective systems analysis in agriculture and irrigation." *2nd International symposium on large scale engineering systems*, University of Waterloo, Canada.

21. **Chaturvedi, M.C. and Rogers, P.** (1985). "Water Resources Systems Planning-Some Case Studies for India." Indian Academy of Sciences, Bangalore, India.

22. **Chaturvedi, M.C. and Srivastava, D.K.** (1981). "Study of a complex water resources system with screening and simulation models." *Water Resour. Res.*, 17(4), 783-794.

23. **Chaturvedi, M.C.** (1987). *Water Resources Planning and Management*. Tata McGraw Hill, New Delhi, India.

24. **Chaturvedi, M.C.** (1985). "Large scale water resources systems planning-approach and Case study." J. Water Resour. Plan. Manage., *Speciality Conference, Computer applications in water resources*, Buffalo, New York, U.S.A.

25. **Chaturvedi, M.C.** (1983). "Regional water resources systems planning." *XX Congress of international association of hydraulic research*, Moscow.

26. **Chaturvedi, M.C.** (1978). "Water resources development problems of India and issues of information transfer." *Second international conference on transfer of water resources knowledge*, Colorado State University, U.S.A.

27. **Chaube, U.C.** (1983). "Two level multi-objective reconnaissance system study of a large water resource system." Ph.D. Thesis, Indian Institute of Technology, Delhi, India.

28. **Chaudhary, M.T., Labadie, J.W., Hall, W.A. and Albertson, M.L.** (1974). "Optimal conjunctive use model for Indus basin." *J. Hydraulics Div.*, HY5.

29. **Chavez-Morales, Marino, M.A., and Holzapfel, E.A.** (1992). "Planning simulation model of irrigation district." *J. Irrigation and drainage, ASCE* 118(1), 74-87.

30. **Coe, J.J.** (1990). Conjunctive use: Advantages, constraints and examples. *Journal of irrigation and Drainage Engg., ASCE.* pp. 427-433.

31. **Cohon, J.L. and Marks, D.H.** (1975). "A review and evaluation of multi objective planning techniques." *Water Resour. Res.*, 11(2), 208-222.

32. **Cohon, J.L.** (1978). *Multiobjective programming and planning*. Academic press, New York, U.S.A.

33. **Cohon,J.L., and Marks,D.H.** (1973). "Multiobjective screening model and water resources investment." *Water Resour. Res.*, 9(4), 826-836.

34. **Crawley, P.D. and Dandy, G.C.** (1993). "Optimal operation of multireservoir system." J. *Water Resour. Plan. Manage., ASCE*, 119(1), 1-17.

35. **Dahe, P.D. and Srivastava, D.K.** (2000). " Assessment of reliable reservoir yield for an irrigation project." Proceedings of the National Seminar on Irrigation Strategies- Present and Future, Irrigation Management and Training Institute Thuvakudy, Tiruchirappali, Tamilnadu, India, Volume section on Theme II, 5-15.

36. **Dahe, P.D.** (2001). "Planning for optimal development of a river basin." Ph.D. Thesis, Deptt. of Hydrology, Indian Institute of Technology, Roorkee, India.

37. **Dahe, P.D. and Srivastava, D.K.** (2002). "Multireservoir multiyield model with allowable deficit in annual yield." J. *Water Resource Plan. Manage., ASCE*, 123(6), 350-358.

38. **Dandy, G.C., Connarty, M.C. and Loucks, D.P. (1997).** "Comparison of yield assessment of multiple reservoir systems." J. *Water Resour. Plan. Manage.*, 123(6), 350-358.

39. **Deepti Rani,** (2004). "Multilevel optimization of a water resources system." Ph.D. Thesis, Deptt. of Mathematics, Indian Institute of Technology, Roorkee (India).

40. **Doorenbos, J. and Pruitt, W.O.** (1977). "Guidelines for Predicting Crop Water Requirements." FAO-24, Revised.

41. **Dorfman, R.**, (1961). Mathematical analysis simple valley projects. Economics of water shed planning. Edited by G.S. Tolly and F.E. Riggs.

42. **Duckstein, L. and Opricovic, S.** (1980). "Multiobjective optimization in river basin development." *Water Resour. Res.*, 16(1), 14-20.

43. **Duggal, K.N.** (1975). "Three level optimization of a irrigated agriculture growth system." Ph.D. thesis, Indian Institute of Technology, Delhi, India.

44. **Duggal, K.N.** (1979). "Conjunctive use of surface water and ground water an optimization approach." *Seminar on development and management of ground water resources*, University of Roorkee, Roorkee, India.

45. **Grygier, T.C. and Stedinger. J.R.** (1985). "Algorithms for optimizing hydropower system operation." Water Resources Research, 21(2), 114-122.

46. **Gershon, M. and Duckstein, L.** (1983). "Multiobjective approaches to river basin planning." J. *Water Resour. Plan. Manage., ASCE,* 109 (1), 13-28.

47. **Ghei, A.N., and Ghei, P.** (1973). Textbook of food and nutrition. Sagar Publication, New Delhi, India.

48. **Goodman, A.S.** (1984). *Principles of Water Resources Planning.* Prentice Hall Inc., Englewood Cliff, New Jersey, U.S.A.

49. **Guise, J.W.B. and Flinn, J.C.,** (1970). The allocation of water in a river basin. American Journal of Agricultural Economics, Vol. 52(3).

50. **Government of India**, Ministry of Water Resources (1987). *National Water Policy 1987.* New Delhi, India. Pp.15.

51. **Government of India,** Central Water Commission (CWC) (1987). Report on "*Application of system analysis for water resources development.*"

52. **Government of India**, Central Ground Water Board, Ministry of Water Resources (1995). A publication "Ground Water Resources of India.", New Delhi, India.

53. **Government of India**, Ministry of Water Resources (1999). *Integrated water resource development a plan for action, a report of the national commission for integrated water resources development,* New Delhi, India.

54. **Government of India**, Ministry of Water Resources (2002). *National Water Policy 2002.* New Delhi, India.

55. **Government of Karnataka,** Water Resources Development organization (1976). *Master plan for an Equitable Use of the waters of the Cauvery basin in Karnataka-an outline part I-III.* Bangalore, Karnataka, India.

56. **Haimes, Y.Y.** (1977). *Hierarchical Analysis of Water Resources Systems.* McGraw Hill Inc., New York, U.S.A.

57. **Hall, W.A., Butcher, W.S., and Esogbue, A.** (1968). "Optimization of the operations of a multipurpose reservoir by dynamic programming." *Water Resources Research*, 4(3), 471-477.

58. **Hall, W.A. and Dracup, J.A.** (1970). *Water Resources Systems Engineering.* McGraw Hill, New York, U.S.A.

59. **Hashimoto, T., Stedinger, J.R. and Loucks, D.P.** (1982). Reliability, resiliency, and vulnerability criteria for water resource system performance evaluation." Water Resour. Res., 18(1), 14-20.

60. **Heady, E.O.**, (1961). Mathematical analysis: models for quantitative application in watershed planning, economics of watershed planning edited by G.S. Tolly and E.E. Riggs, Ames Iowa State University, Press.

61. **Heady, E.O and Nicol, K.J.,** (1975). Model of land and water allocation to improve environment and water quality through soil loss control. *Water Resources Research*, Vol. 11, No. 6 pp 795-800.

62. **Helweg, O.J.** (1985). *Water resources planning and management.* John Willey & Sons. New York, U.S.A.

63. **Hiramath, K.C.,** (1973). Temporal and spatial allocation of irrigation water in Krishnarajsagar Project (Mysore) Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi.

64. **Husfschmidt, M.M. and Fiering, N.B.** (1996). Simulation Techniques for Design of Water Resources Systems. Harvard University Press, Mass. Cambridge.

65. **INCID** (1995). *Guidelines for planning conjunctive use of surface and groundwater in irrigation projects.* Published by Indian National Committee on Irrigation and Drainage (INCID); Bhikaji Cama Palace, New Delhi, India.

66. **Jacoby, H.D. and Loucks, D.P.** (1972). "Combined use of optimization and simulation models in river basin planning." *Water Resour. Res.*, 8(6), 1401-1414.

67. **Jena, J.** (2004). "Systems analysis of an Irrigation and Cascade hydropower scheme." Ph.D. Thesis, Deptt. of Hydrology, Indian Institute of technology, Roorkee, India.

68. **Kamal-Ali Abd Al-Mohseen** (2002). "Optimal operation of multi-purpose multi-reservoir water resources system." Ph.D.Thesis, Deptt. of Civil Engineering, Indian Institute of Technology, Delhi, India.

69. **Karamouz, M. and Houck, M.H.** (1972). "Annual monthly reservoir operating rules generated by deterministic optimization." *Water Resour. Res.*, 18(5), 1337-1344.

70. **Karamouz, M., Houck M.H. and Delleur, J.W.** (1992). "Optimization and simulation of multiple reservoir system." J. *Water Resour. Plan. Manage.*, 1181(1), 71-81.

71. **Kashyap D. and Chandra, S.** (1982). "A distributed conjunctive use model for optimal cropping pattern." *IAHS Publication*, 135, 377-384.

72. **Kashyap, D.** (1982). "Mathematical modeling of groundwater system." Ph.D. Thesis, Deptt. of Hydrology, University of Roorkee, Roorkee, India.

73. **Khepar, S.D.** (1980). "System studies for micro level irrigation water management." Ph.D. Thesis, Indian Institute of Technology, New Delhi, India.

74. **Kohistani, Assadullah.** (1995). "Integrated planning and operation of a reservoir." Ph.D. Thesis, Deptt. of Hydrology, University of Roorkee, Roorkee, India.

75. **Kumar,V.V., Rao,B.V., Mujumdar,P.P.** (1996). "Optimal operation of a multibasin reservoir system." Sadhana-Academy Proceeding in Engineering Sciences, 21(4), 447-502.

76. **Kumar R. and Singh, J.** (1980). Effect of Interaction of irrigation and labour on cropping pattern Proc. Third Afro-Asian, Reginal Conference ICID, New Delhi Vol. 2, C-1.

77. **Kuczera,G.** (1989). "Fast multireservoir multiperiod linear programming models." Water Resour. Res., 25(2), 169-176.

78. **Lasdon, L.S.** (1970). *Optimization theory for large systems.* Macmillan, New York, U.S.A.

79. **Lakshminarayana, V. and Rajagopalan, S.P.**, (1977). Optimal cropping pattern in a river basin. *Journal of Irrigation and Drainage Division. Vol. 103. American Society of Civil Engineering, ASCE*, pp. 53-70.

80. **Loganathan, G.V.** (1996). "Optimal operating policy for reservoir systems, Applications of management science: Engineering applications," Vol. 9. Editors: Kenneth D. Lawrence and Gary R. Reeves, JAI Press.

81. **Loganathan, G.V. and Battacharya, D.** (1990). "Goal programming techniques for optimal reservoir operations." J. *Water Resour. Plan. Manage.*, 116(6), 820-838.

82. **Logenbaugh, R.A.** (1970). "Determining optimum operational policies for conjunctive use for ground and surface water using linear programming." *Paper Presented at Hydraulic. Div. Spec. Conf., ASCE*, Minneapolis, Minn., pp. 19-21.

83. **Loucks, D.P.** (1968). "Computer models for reservoir regulation." *J. Sanitory Engg. Div.*, 94 (SA4), 657-671.

84. **Loucks, D.P.** (1970). "Some comments on linear decision rule and chance constraints." *Water Resour. Res.*, 6(2), 668-671.

85. **Loucks, D.P.** (1992). "Water resource systems models: Their role in planning." J. *Water Resour. Plan. Manage.*, 118(3), 214-223.

86. **Loucks, D.P.** (1995). "Development and implementing decision support systems: a critique and a challenge." *Water Resour. Bulletin*, 31(4), 571-582.

87. **Loucks,D.P., Stakhiv,E.Z. and Martin,L.R.**(2000). "Sustainable water resources management." Editorial, J. *Water Resour. Plng. And Mgmt.*, ASCE, 126(2), 43-47.

88. **Loucks, D.P. and Dorfman, R.** (1975). " An evaluation of some linear decision rules in chance constrained models for reservoir planning and operation." *Water Resour. Res., 116(6), 777-782.*

89. **Loucks, D.P. and Falkson, L.M.** (1970). "A comparison of some dynamic linear and policy iteration methods for reservoir operation." *Water Resour. Bulletin*, 6(3), 384-400.

90. **Loucks, D.P., Stedinger J.R. and Haith D.A.** (1981). *Water resources systems planning and analysis.* Prentice Hall, Inc., Englewood Cliffs, New Jersey, U.S.A.

91. **Marino, M.A., and Mohammadi, B.** (1983). "Reservoir management: A reliability programming approach." *Water Resources Research*, 19(3), 613-620.

92. **Marino, M.A., and Loaiciga, H.A.** (1985). "Dynamic model for multireservoir operation." *Water Resources Research*, 21(5), 619-630.

93. **Maass, A., Hufschmidt, M.M., Dorfman, R., Thomas Jr., H.A., Marglin, S.A., and Fair, G.M.** (1962). *Design of water resources systems*. Edited by A. Mass et al., Harvard University Press, Cambridge.

94. **Matanga, G.P. and Marino M.A.,** (1979). Irrigation planning cropping pattern. *Water Resources Research*. Vol. 15(3), pp 672-678.

95. **Mishra, A. K.** (2003). "Cauvery water sharing: challenges ahead." 10th national water–convention, Bhubaneshwar, sponsored by Ministry of Water Resources, Government of India, organized jointly by: National water development Agency and Government of Orissa, pp.142-153.

96. **Mishra, S.K.** (1998). "Operation of a multipurpose reservoir." Ph.D. Thesis. Deptt. of Hydrology, University of Roorkee, Roorkee, India.

97. **Mohan, C., Srivastava, D.K. and Sunita Devi,** (1996). "Study of ICHA Reservoir for optimal water utilization using linear programming model." *Mathematics and its applications in engineering and industry*, pp.50-57.

98. **Mohan, S. and Arumugam, N.** (1994). "A rule based expert system for crop selection in India." *Transactions of the ASAE*, 37(4), 1355-1363.

99. **Mohan, S. and Arumugam, N.** (1997). "Expert system applications in irrigation management: an overview." *J. Computers and Electronics in Agriculture*, 17(3), 263-280.

100. **Mohan, S. and Raipure, D.M.** (1992). "Multiobjective Analysis of Multireservoir System." *J. Water Resour. Plan. Manage.*, 118(4), 356-370.

101. **Mohan, S. and Rangacharya, N.C.V.** (1991). "A modified method for drought identification." *J. Hydrological Sciences*, 36(1), 11-21.

102. **Mohan, S. and Vedula, S.** (1990). "Real-time multipurpose reservoir operation.." *J. Hydrological Sciences*, 35(4), 447-462.

103. **Mohan., S. and Keskar, J.B.** (1991). "Optimization of multipurpose reservoir system operation.." *Water Resources Bulletin,* 27(4), 621-629.

104. **Nayak, S.C. and Arora, S.R.** (1973). Capacity decision in a multipurpose multireservoir system. J. Water Resour. Ras., 7(3), 485-498.

105. NWDA (1989). "Compilation of basic data of Amaravathi sub-basin of Cauvery basin,." Index No. 65, Investigation Division, Madras, India.

106. NWDA (1988). "Compilation of basic data of Upper Cauvery sub-basin of Cauvery basin." Index No. 55, Investigation Division-I, Bangalore, India.

107. NWDA (1990). "Compilation of basic data of Arkavathi sub-basin of Cauvery basin." Index No. 59, Investigation Division-I, Bangalore, India.

108. NWDA (1990). "Compilation of basic data of Shimsha sub-basin of Cauvery basin." Index No. 58, Investigation Division-I, Bangalore, India.

109. NWDA (1992). "Compilation of basic data of Lower Coleroon sub-basin of Cauvery basin." Index No. 69, Investigation Division, Madras, India.

110. NWDA (1992). "Compilation of basic data of Kabini sub-basin of Cauvery basin." Index No. 56, Investigation Division-I, Bangalore, India.

111. NWDA (1998). "Compilation of basic data of Bhavani sub-basin of Cauvery basin." Index No. 63, Investigation Division, NWDA-Madras, India.

112. NWDA (1988). "Compilation of basic data of Noyil sub-basin of Cauvery basin." Index No. 64, Investigation Division, Madras, India.

113. NWDA (1989). "Preliminary water balance study of the Amaravathi sub-basin of Cauvery basin." Technical study No. 102, New Delhi, India.

114. NWDA (1990). "Preliminary water balance study of the Arkavathii sub-basin of Cauvery basin." Index no. 59, Technical study No. 108, New Delhi, India.

90 NWDA (1990). "Preliminary water balance study of the Chinnar sub-basin of Cauvery basin." Technical study No. 113, New Delhi, India.

115. NWDA (1990). "Preliminary water balance study of the Middle Cauvery sub-basin of Cauvery basin." Technical study No. WB 118, Index no.60, New Delhi, India.

116. NWDA (1990). "Preliminary water balance study of the Shimsha sub-basin of Cauvery basin." Index no.58, Technical study No. WB/123, New Delhi, India.

117. NWDA (1990). "Preliminary water balance study of the Tirumanimuttar sub-basin of Cauvery basin." Technical study No.PWBS/119/90, New Delhi, India.

118. NWDA (1990). "Preliminary water balance study of the Upper Cauvery sub-basin of Cauvery basin." Technical study, New Delhi, India.

119. NWDA (1990). "Preliminary water balance study of the Upper Coleroon sub-basin of Cauvery basin." Technical study, New Delhi, India.

120. NWDA (1991). "Preliminary water balance study of the Kabini sub-basin of Cauvery basin." Index no.56, Technical study no. WB/151, New Delhi, India.

121. NWDA (1991). "Preliminary water balance study of the Lower Coleroon sub-basin of Cauvery basin." Index no.69, Technical study no. PWBS/168/91, New Delhi, India.

122. NWDA (1991). "Preliminary water balance study of the Palar sub-basin of Cauvery basin." Index no.61, Technical study No. WB/152, New Delhi, India.

123. NWDA (1991). "Preliminary water balance study of the Ponnanai Ar sub-basin of Cauvery basin." Technical study No. PWBS/36/91, New Delhi, India.

124. NWDA (1991). "Preliminary water balance study of the Suvarnavathi sub-basin of Cauvery basin." Index no.57, Technical study No.WB/149, New Delhi, India.

125. NWDA (1991). "Compilation of basic data of Middle Cauvery sub-basin of Cauvery basin." Index No. 60, Investigation Division-I, Bangalore, India.

126. NWDA (1992). "Preliminary water balance study of the Cauvery Delta sub-basin of Cauvery basin." Index no.70, Technical studies No. PWBS/170/91, New Delhi, India.

127. NWDA (1992). "Preliminary water balance study of the Noyil sub-basin of Cauvery basin." Index no.64, Technical studies No. PWBS/49/92, New Delhi, India.

128. NWDA (1992). "Compilation of basic data of Palar sub-basin of Cauvery basin." Index No. 61, Investigation Division-I, Bangalore, India.

129. NWDA (1992), "Compilation of basic data of Suvarnavathi sub-basin of Cauvery basin." Index No. 57, Investigation Division-I, Bangalore, India.

130. NWDA (1998). "Preliminary water balance study of Cauvery basin at Grand Anicut." Technical study No. 192, New Delhi, India.

131. NWDA (1998). "Preliminary water balance study of the Bhavani sub-basin of Cauvery basin." Technical study, New Delhi, India.

132. **Onta, P.R., Das Gupta, A. and Harboe, R.** (1991). "Multistep planning for conjunctive use of surface and groundwater resources." J. *Water Resour. Plan. Manage.*, 117(6), pp. 662-678.

133. **Rao, B.V.** (1991). "Some aspects of water quality prediction and management models." *In: Proc. of national seminar on use of computers in hydrology and water resources*, Central Water Commission, New Delhi, Vol. II, 9-1-9-11.

134. **Rao, B.V. and Vijay, V.K.** (1991). "Inter basin transfer of water among peninsular Indian rivers- a study of Godavari-Cauvery river link." *Proc. of national seminar of use of computers in hydrology and water resources,* Central Water Commission, New Delhi, Vol. II. 8-11-8-23.

135. **Rao, S.S.** (1984). *Optimization theory and applications.* Second edition, Wiley Eastern Limited, New Delhi, India.

136. **Ravi Kumar, V. and Venugopal, K.** (1988). "Optimal operation of south Indian irrigation system." J. *Water Resour. Plan. Manage.*, 124(5), 264-271.

137. **Razavian, D.** (1990). Multistage screening process for river basin planning. Water Resour. Plan. And Management, ASCE, 116(3), 323-334.

138. **Rogers, P.P. and Fiering, M.B.** (1986). "Use of systems analysis in water resources management." *Water Resour. Res.*, 229(9), 146S-158S.

139. **Rogers, P.P. and Smith, D.V.**, (1970). The integrated use of ground and surface water in irrigation projects planning. American Journal of Agricultural Economics, Vol. 52, No. 1. pp. 13.14.

140. **Sadeghian, M.S.** (1995). "System analysis of complex water resources system." Ph.D. Thesis, Deptt. of Hydrology, University of Roorkee, Roorkee, India.

141. **Sarkar, T.K. and Maji, C.C**, (1976). Optimal development of drainage project proceedings All India Symposium on agricultural systems. Theory and applications. Punjab Agricultural University, Ludhiyana, India. Pp 117-121.

142. **Simonovic, S.P. and Marino, M.A.** (1982). Reliability programming in reservoir management system of multipurpose reservoirs, Water Resour. Res., 18(4); 735-743.

143. **Simonovic, S.P.** (1992). "Reservoir system analysis: closing gap between theory and practice." J. *Water Resour. Plan. Manage.*, 118(3), 262-280.

144. **Singh, A.** (1991). "Optimal use and development of water resources in Narmada basin." Ph.D. Thesis, Deptt. of Humanities and Social Sciences, University of Roorkee, Roorkee, India.

145. **Singh, R.** (1981). "Study of some aspects of water resources and agricultural policy of India." Ph.D. Thesis, Indian Institute of Technology, New Delhi.

146. **Singh, P., Singh, P. and Singh, D.P.**, (1976). Optimal allocation of land and water., Proceeding, All India Symposium on agricultural systems theory and applications. Punjab Agricultural University, Ludhiyana, India. Pp 62-66.

147. **Singh, I. and Sirohi, A.S.**, (1977). An application of linear programming for optimal allocation of land and tube well water among crop areas. Proceeding All India Symposium on agricultural system. Theory and application. Punjab agricultural University, Ludhiyana, India. Pp. 62-66.

148. **Sinha, C.P. and Charyulu, P.G.,** (1979). Optimal crop planning, for Gomati Kalayni Doab. Proceeding, International Symposium on Water Resources, University of Roorkee, Roorkee, U.P., India.

149. **Srinivasan, K., Neelkanthan, T.R., Narayan, S.P. and Nagarajukumar, C.** (1999). "Mixed integer programming model for reservoir performance optimization." J. *Water Resour. Plan. Manage.*, 125(5), 298-301.

150. **Srivastava, D.K. and Patel I. A.** (1992). "Optimization-Simulation Models for the Design of an Irrigation Project." Journal of Water Resources Management 6: 315-338, Kluwer Academic Publishers, Netherlands.

151. **Srivastava, D.K. and Tiwari, V.K.** (1978). "Optimization model for optimal allocation of Narmada waters." *Forty Seventh Research Session of the CBIP*, Hubli-Dharwar, Karanataka, India, Vol. 1.

152. **Srivastava, D.K. and Uddihal, V.P.** (1985). "Linear programming as screening model in Karanja irrigation project planning." *2nd international conf. on computer aided analysis in civil engineering*, Department of Civil Engineering, University of Roorkee, Roorkee, India.

153. **Srivastava, D.K.** (1976). "Optimization of complex water resources systems by screening- simulation model." Ph.D. Thesis, Indian Institute of Technology, Delhi, India.

154. **Stedinger, J.R.** (1984). "Performance of LDR models for preliminary design and reservoir operation." *Water Resour. Res.*, 20(2), 215-224.

155. **Stedinger, J.R., and Sule, B.F. and Pei, D.** (1983). "Multiple reservoir system screening models." *Water Resour. Res.*, 19(6), 1383-1393.

156. **Stedinger, J.R., Sule, B.F. and Loucks, D. P. (1984).** "Stochastic dynamic programming models for reservoir operation optimization." *Water Resour. Res.*, 20(11), 1499-1505.

157. **Stephnson, D.** (1970). "Optimum Design of Complex Water Resources Projects." J. of Hyd. Div., HY-6, Vol. 96, pp. 1383-1393.

158. **Sunita Devi** (1997). "Optimization of large size water resources systems." Ph.D. Thesis, Deptt. of Mathematics, University of Roorkee, Roorkee, India.

159. **Taha Hamdy, A.** (1987). *Operations research*. Fourth edition, Macmillan Publishing Company, Inc., New York, U.S.A.

160. **Thangraj, C.** (1987). "Integrated water-power systems planning." Ph.D. Thesis, Indian Institute of Technology, Delhi, India.

161. **Todd, D.K.** (1980). "Ground Water Hydrology." John Wiley and Sons, Inc. New York, pp 535.

162. **Vedula, S.** (1985). "Optimal irrigation planning in river basin development: the case of Upper Cauvery basin." *Water resources system planning: some case studies for India.* M.C. Chaturvedi and P. Rogers, Eds., Indian Academy of Sciences, Bangalore, India, pp. 223-252.

163. **Vedula, S. and Majumdar, P.P.** (1992). "Optimal reservoir operation for irrigation of multiple crops." *Water Resour. Res.*, 28(1), 1-9.

164. **Vedula, S., and Nagesh Kumar, D.** (1996). "An Integrated model for optimal reservoir operation for irrigation of multiple crops." Water Resour. Res., 32 (4), 1101-1108.

165. **Vedula, S. and Rogers, P.P.** (1981). "Multi objective analysis of irrigation planning in river basin development." *Water Resour. Res.*, 17(5), 1304-1310.

166. **Venugopal, K. and Patnaik, P.C.** (1991). "Irrigation planning for branch canal VI of Periyar Vaigai System." *Proc. of national seminar of use of computers in hydrology and water resources,* CWC, New Delhi, Vol. I, 3-43 3-52.

167. **Verma, S.K.** (1997). "Solution of optimization problems in crisp, fuzzy and stochastic environments." Ph.D. thesis, Univ. of Roorkee, Roorkee, India.

168. **Waikar, M.L.** (1998). "Capacity expansion of a water resources system." Ph.D. thesis, Deptt. of Hydrology, Univ. of Roorkee, Roorkee, India.

169. **Wurbs, R.A.** (1987). "Reservoir management in Texas." J. *Water Resour. Plan. Manage.*, 113(1), 130-148.

170. **Wurbs, R.A.** (1993). "Reservoir management and operations models." J. *Water Resour. Plan. Manage.*, 119(4), 455-472.

171. **Wurbs, R.A. (1996).** *Modeling and analysis of reservoir system operations.* Prentice Hall PTR, Upper Saddle River, New Jersey, U.S.A.

172. **Wurbs, R.A.** (1997). "Water availability under the Texas water rights system." *J. American Water Assoc.*, 89(5), 55-63.

173. **Wurbs, R.A. and Bergman, C.E.** (1990). "Evaluation of factors affecting reservoir yield estimates." *J. Hydrology*, 112(31), 219-235.

174. **Wurbs, R.A. and Karama, A.S.** (1995). "Salinity and water supply reliability." J. *Water Resour. Plan. Manage.*, 121(5),352-358.

175. **Wurbs, R.A. and Walls, W.B.** (1989). "Water rights modeling and analysis." J. *Water Resour. Plan. Manage.*, 115(4), 416-430.

176. **Wurbs, R.A. and Yerramreddy, A.** (1994). "Reservoir/River system analysis models: Conventional simulation versus network flow programming." *J. Water Resour. Develop.*, 10(2), 131-142.

177. **Yeh, W.** (1985). "Reservoir management and optimization modes: a state of the art review." *Water Resour. Res.*, 21(12), 1797-1818.

178. **Yoganarashimhan and Chand** (1979). "A linear programming model to Gomti Kalayani Doab for maximizing the benefits from irrigation works.

179. **Zadeh, L.A.** (1963). "Optimality and non-scalar-valued performance criteria." *IEEE Trans. on Automatic control AC*- 8(59).

THE DISTRICT WISE CATCHMENT AREAS OF THE SUB-BASINS LYING IN THE CAUVERY RIVER BASIN

Table I.1: Districtwise Catchment Area of the Upper Cauvery Sub-Basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Karnataka	Chikmagalur	714	6.72
Karnataka	Kodagu	2515	23.68
Karnataka	Hassan	4369	41.14
Karnataka	Mandya	965	9.10
Karnataka	Mysore	2056	19.36
	Total	**10619**	**100.00**

Table I.2: District wise Catchment Area of the Kabini Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Karnataka	Kodagu	151	2.14
Karnataka	Mysore	4757	67.58
Kerala	Cannanore	18	0.26
Kerala	Wynad	1873	26.60
Kerala	Kozhikode	29	0.41
Tamilnadu	Niligiris	212	3.01
	Total	**7040**	**100.00**

Table I.3: District wise Catchment Area of the Shimsha Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Karnataka	Hassan	527	6.23
Karnataka	Mandya	2750	32.47
Karnataka	Mysore	49	0.58
Karnataka	Tumkur	3799	44.86
	Total	**8469**	**100.00**

Table I.4: District wise Catchment Area of the Arkavathi Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Karnataka	Bangalore	4109	94.43
Karnataka	Kolar	6	0.14
Karnataka	Mandya	69	1.59
Tamilnadu	Dharmapuri	167	3.84
	Total	4351	**100.00**

Table I.5: District wise Catchment Area of the Middle Cauvery Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Karnataka	Mandya	1148	42.89
Karnataka	Mysore	1528	57.11
	Total	**2676**	**100.00**

Table I.6: District wise Catchment Area of the Suvarnavathi Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Karnataka	Mysore	1207	67.5
Tamilnadu	Periyar	580	32.5
Total		**1787**	**100.0**

Table I.7: District wise Catchment Area of the Palar Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Karnataka	Mysore	1870	58.2
Tamilnadu	Periyar	1097	34.1
Tamilnadu	Salem	247	7.7
Total		**3214**	**100.0**

Table I.8: District wise Catchment Area of the Chinnar Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Karnataka	Bangalore	100	2.46
Tamilnadu	Dharmapuri	3630	89.38
Tamilnadu	Salem	331	8.16
Total		**4061**	**100.00**

Table I.9: District wise Catchment Area of the Bhavani Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Karnataka	Mysore	240	3.9
Kerala	Palghat	562	9.1
Tamilnadu	Coimbatore	1002	16.3
Tamilnadu	Periyar	2469	40.1
Tamilnadu	Nilgiris	1881	30.6
Total		6154	**100.0**

Table I.10: District wise Catchment Area of the Noyil Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Tamilnadu	Coimbatore	2117	70.6
Tamilnadu	Periyar	742	24.7
Tamilnadu	Tiruchirapalli	140	4.7
Total		**2999**	**100.0**

Table I.11: District wise Catchment Area of the Amaravathi Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Kerala	Iddukki	384	4.6
Tamilnadu	Coimbatore	1515	18.3
Tamilnadu	Madurai	3888	47.0
Tamilnadu	Periyar	1663	20.1
Tamilnadu	Tiruchirapalli	830	10.0
Total		**8280**	**100.0**

Table I.12: District wise Catchment Area of the Tirumanimuttar Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Tamilnadu	Dindigul Anna	165	1.96
Tamilnadu	Pariyar	976	11.58
Tamilnadu	Salem	5042	59.81
Tamilnadu	Tiruchirapalli	2246	26.65
Total		**8429.00**	**100.00**

Table I.13: District wise Catchment Area of the Ponnanai Ar Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Tamilnadu	Madurai	24	1.16
Tamilnadu	Pudukkottai	486	23.69
Tamilnadu	Thanjavur	3	0.16
Tamilnadu	Tiruchirapalli	1537	74.99
Total		**2050.00**	**100.00**

Table I.14: District wise Catchment Area of the Upper Coleroon Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Tamilnadu	Tiruchirapalli	3080	99.94
Tamilnadu	Thanjavur	2	0.06
Total		**3082.00**	**100.00**

Table I.15: District wise Catchment Area of the Lower Coleroon Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Tamilnadu	Tiruchchirappalli	522	37.91
Tamilnadu	Thanjavur	144	10.44
Tamilnadu	South Arcot	712	51.65
	Total	**1378**	**100.00**

Table I.16: District wise Catchment Area of the Cauvery Delta Sub-basin

State	District	Area Falling in the Sub-basin (Km^2)	Total Area of the Sub-basin (%)
(1)	(2)	(3)	(4)
Tamilnadu	Pudukkottai	144	2.19
Tamilnadu	Thanjavur	1915	29.17
Tamilnadu	Nagappattinam Quaid-E- Millad	4269	65.03
Tamilnadu	Tiruchchirappalli	89	1.34
Pondicherry	Karaikal	149	2.27
	Total	**6566**	**100.00**

METEOROLOGICAL DATA FOR VARIOUS SUB-BASINS IN CAUVERY RIVER BASIN

Table II.1: Meteorological Data for: Upper Cauvery Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotran-spiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	28.3	16.4	75	30	11.3	225	3	2.9	2.8	128.4
Feb	31.2	18.2	69	25	9.1	181	2.8	2.9	5.5	133.5
Mar	33.5	20.2	71	21	8.8	175	2.3	3.2	12	165.9
Apr	34.0	21.4	75	34	8.4	167	3.7	5.1	67.6	154.2
May	32.6	21.2	79	51	10.2	203	4.9	5.5	156.9	147.6
Jun	28.9	20.2	81	66	13.9	277	5.9	6.4	60.5	123.5
Jul	27.3	19.7	84	70	14.1	281	6.4	6.8	71.9	115.5
Aug	27.9	19.6	84	67	12.5	249	6.2	6.7	80.1	117.2
Sep	28.7	19.3	83	61	10.7	213	5.7	6.1	116.3	116.9
Oct	28.4	19.6	85	61	7.9	157	5.6	5.9	179.9	110.5
Nov	27.4	18.3	80	54	9.3	185	4.7	4.9	66.6	106
Dec	27.0	16.5	78	43	11.3	225	3.6	3.9	14.7	114.3

Latitude : 12^0 18' N   Height above MSL : 767 M
Longitude : 76^0 42' E   Height of anemometer : 9 M.

Table II.2: Meteorological Data for: Kabini Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotran-spiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	28.3	16.4	75	30	11.3	225	3.0	2.9	2.8	128.4
Feb	31.2	18.2	69	25	9.1	181	2.8	2.9	5.5	133.5
Mar	33.5	20.2	71	21	8.8	175	2.3	3.2	12.0	165.9
Apr	34.0	21.4	75	34	8.4	167	3.7	5.1	67.6	154.2
May	32.6	21.2	79	51	10.2	203	4.9	5.5	156.9	147.6
Jun	28.9	20.2	81	66	13.9	277	5.9	6.4	60.5	123.5
Jul	27.3	19.7	84	70	14.1	281	6.4	6.8	71.9	115.5
Aug	27.9	19.6	84	67	12.5	249	6.2	6.7	80.1	117.2
Sep	28.7	19.3	83	61	10.7	213	5.7	6.1	116.3	116.9
Oct	28.4	19.6	85	61	7.9	157	5.6	5.9	179.9	110.5
Nov	27.4	18.3	80	54	9.3	185	4.7	4.9	66.6	106.0
Dec	27.0	16.5	78	43	11.3	225	3.6	3.9	14.7	114.3

Latitude : 12^0 18' N   Height above MSL : 767 M
Longitude : 76^0 42' E   Height of anemometer : 9 M.

Table II.3: Meteorological Data for: Shimsha Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotran-spiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	28.3	16.4	75	30	11.3	225	3	2.9	2.8	128.4
Feb	31.2	18.2	69	25	9.1	181	2.8	2.9	5.5	133.5
Mar	33.5	20.2	71	21	8.8	175	2.3	3.2	12	165.9
Apr	34.0	21.4	75	34	8.4	167	3.7	5.1	67.6	154.2
May	32.6	21.2	79	51	10.2	203	4.9	5.5	156.9	147.6
Jun	28.9	20.2	81	66	13.9	277	5.9	6.4	60.5	123.5
Jul	27.3	19.7	84	70	14.1	281	6.4	6.8	71.9	115.5
Aug	27.9	19.6	84	67	12.5	249	6.2	6.7	80.1	117.2
Sep	28.7	19.3	83	61	10.7	213	5.7	6.1	116.3	116.9
Oct	28.4	19.6	85	61	7.9	157	5.6	5.9	179.9	110.5
Nov	27.4	18.3	80	54	9.3	185	4.7	4.9	66.6	106
Dec	27.0	16.5	78	43	11.3	225	3.6	3.9	14.7	114.3

Latitude : 12° 18' N Height above MSL : 767 M
Longitude : 76° 42' E Height of anemometer : 9 M.

Table II.4: Meteorological Data for: Arkavathi Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotran-spiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	26.9	15	77	40	10.4	207	3.7	2.9	3.3	117.4
Feb	29.7	16.5	67	29	9.7	193	2.6	2.8	10.2	130.0
Mar	32.3	19	63	24	9.4	187	2.0	2.9	6.1	166.2
Apr	33.4	21.2	70	34	9.0	179	3.6	5.0	45.7	158.2
May	32.7	21.1	75	46	11.3	225	5.0	5.7	116.5	156.5
Jun	28.9	19.7	82	62	17.1	341	6.9	6.9	80.1	126.5
Jul	27.2	19.2	86	68	17.5	349	7.6	7.4	116.6	115.7
Aug	27.3	19.2	86	66	15.2	303	7.5	7.1	147.1	114.2
Sep	27.6	18.9	85	62	12.1	241	6.9	6.8	142.7	108.9
Oct	27.5	18.9	83	64	8.2	163	6.1	6.3	184.9	105.1
Nov	26.3	17.2	78	59	8.5	169	4.9	5.2	54.3	98.3
Dec	25.7	15.3	78	51	9.6	191	4.2	3.9	16.2	102.9

Latitude : 12° 58' N Height above MSL : 921 M
Longitude : 77° 35' E Height of anemometer : 16 M.

Table II.5: Meteorological Data for: Middle Cauvery Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotranspiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	28.3	16.4	75.0	30.0	11.3	225.0	3.0	2.9	2.8	128.4
Feb	31.2	18.2	69.0	25.0	9.1	181.0	2.8	2.9	5.5	133.5
Mar	33.5	20.2	71.0	21.0	8.8	175.0	2.3	3.2	12.0	165.9
Apr	34.0	21.4	75.0	34.0	8.4	167.0	3.7	5.1	67.6	154.2
May	32.6	21.2	79.0	51.0	10.2	203.0	4.9	5.5	156.9	147.6
Jun	28.9	20.2	81.0	66.0	13.9	277.0	5.9	6.4	60.5	123.5
Jul	27.3	19.7	84.0	70.0	14.1	281.0	6.4	6.8	71.9	115.5
Aug	27.9	19.6	84.0	67.0	12.5	249.0	6.2	6.7	80.1	117.2
Sep	28.7	19.3	83.0	61.0	10.7	213.0	5.7	6.1	116.3	116.9
Oct	28.4	19.6	85.0	61.0	7.9	157.0	5.6	5.9	179.9	110.5
Nov	27.4	18.3	80.0	54.0	9.3	185.0	4.7	4.9	66.6	106
Dec	27.0	16.5	78.0	43.0	11.3	225.0	3.6	3.9	14.7	114.3

Latitude : 12° 18' N Height above MSL : 767 M
Longitude : 76° 42' E Height of anemometer : 9 M.

Table II.6: Meteorological Data for: Suvarnavathi Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotranspiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	28.3	16.4	75	30	11.3	225.0	3.0	2.9	2.8	128.4
Feb	31.2	18.2	69	25	9.1	181.0	2.9	2.9	5.5	133.5
Mar	33.5	20.2	71	21	8.8	175.0	2.8	3.2	12.0	165.9
Apr	34.0	21.4	75	34	8.4	167.0	4.4	5.1	67.6	154.2
May	32.6	21.2	79	51	10.2	203.0	5.2	5.5	156.9	147.6
Jun	28.9	20.2	81	66	13.9	277.0	6.2	6.4	60.5	123.5
Jul	27.3	19.7	84	70	14.1	281.0	6.6	6.8	71.9	115.5
Aug	27.9	19.6	84	67	12.5	249.0	6.5	6.7	80.1	117.2
Sep	28.7	19.3	83	61	10.7	213.0	5.9	6.1	116.3	116.9
Oct	28.4	19.6	85	61	7.9	187.0	5.8	5.9	179.9	110.5
Nov	27.4	18.3	80	54	9.3	185.0	4.8	4.9	66.6	106.0
Dec	27.0	16.5	78	43	11.3	225.0	3.8	3.9	14.7	114.3

Latitude : 12° 18' N Height above MSL : 767 M
Longitude : 76° 42' E Height of anemometer : 9 M.

Table II.7: Meteorological Data for: Palar Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotran-spiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	28.3	16.4	75	30	11.3	225	2.95	2.9	2.8	128.4
Feb	31.2	18.2	69	25	9.1	181	2.85	2.9	5.5	133.5
Mar	33.5	20.2	71	21	8.8	175	2.75	3.2	12.0	165.9
Apr	34.0	21.4	75	34	8.4	167	4.4	5.1	67.6	154.2
May	32.6	21.2	79	51	10.2	203	5.2	5.5	156.9	147.6
Jun	28.9	20.2	81	66	13.9	277	6.15	6.4	60.5	123.5
Jul	27.3	19.7	84	70	14.1	281	6.6	6.8	71.9	115.5
Aug	279.0	19.6	84	67	12.5	249	6.45	6.7	80.1	117.2
Sep	28.7	19.3	83	61	10.7	213	5.9	6.1	116.3	116.9
Oct	28.4	19.6	85	61	7.9	157	5.75	5.9	179.9	110.5
Nov	27.4	18.3	80	54	9.3	185	4.8	4.9	66.6	106
Dec	27.0	16.5	78	43	11.3	225	3.75	3.9	14.7	114.3

Latitude : 12^0 18' N   Height above MSL : 767 M
Longitude : 76^0 42' E   Height of anemometer : 9 M.

Table II.8: Meteorological Data for: Chinnar Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotran-spiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	31.1	19.2	73	43	10.2	203	2.5	3	8.6	138.9
Feb	33.1	19.2	72	35	10.7	213	2.1	2.5	11.8	151.7
Mar	36.1	22.5	69	32	10.3	205	1.9	2.4	14.8	189.5
Apr	36.9	25.1	70	41	8.3	165	3.1	4.5	55.1	174.9
May	36.8	25.5	71	47	8.1	161	4	5.1	92.8	170.8
Jun	34.9	24.4	74	51	9.6	191	5.2	6.4	82.4	147.2
Jul	33.4	23.6	78	56	9	179	6.1	7	104.7	135.1
Aug	33.2	23.4	79	55	7.9	157	5.7	6.7	143.2	134.8
Sep	33.1	23.3	77	54	6.9	137	5.1	5.9	141.6	133.1
Oct	31.9	22.8	80	62	5.3	106	5.2	6	185.9	120
Nov	30.5	21.2	78	61	6.5	129	4.4	5.3	89.3	111.5
Dec	30.1	19.6	75	52	8.4	167	3.4	4.2	34.3	120.2

For the period From 1931 To 1960

Latitude : 11^0 39' N   Height above MSL : 278 M
Longitude : 78 10' E   Height of anemometer : 8.1 M.

Table II.9: Meteorological Data for: Bhavani Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotranspiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	29.7	19.2	75	41	6.5	129	3.9	3.3	11.4	122.2
Feb	32.2	20.2	70	32	6.5	129	3.5	3.0	7.4	132.4
Mar	34.7	22.1	67	29	7.1	141	2.7	2.8	8.9	170.4
Apr	34.6	23.4	73	45	7.0	139	3.7	4.7	61.0	156.8
May	33.5	23.6	74	57	10.6	211	4.5	5.3	69.1	158.0
Jun	30.5	22.5	75	65	16.3	325	5.9	6.4	34.0	140.0
Jul	29.0	22.0	77	66	16.3	325	6.5	6.8	41.7	132.1
Aug	29.9	22.1	77	65	14.9	297	5.8	6.3	33.9	139.4
Sep	30.7	22.0	77	63	13.1	261	5.1	6.0	37.3	137.5
Oct	30.4	22.0	78	67	7.8	155	5.5	6.3	148.7	118.0
Nov	29.3	21.1	78	61	5.4	108	5.4	5.4	125.3	103.9
Dec	28.9	19.6	75	49	6.1	122	4.5	4.4	33.5	110.4

(Average for the period from 1931 to 1960)

Latitude : 11^0 00' N Height above MSL : 409 M
Longitude : 76^0 58' E Height of anemometer : 12.7 M.

Table II.10: Meteorological Data for: Noyil Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotranspiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	29.7	19.2	75	41	6.5	129	3.9	3.3	11.4	122.2
Feb	32.2	20.2	70	32	6.5	129	3.5	3.0	7.4	132.4
Mar	34.7	22.1	67	29	7.1	141	2.7	2.8	8.9	170.4
Apr	34.6	23.4	73	45	7.0	139	3.7	4.7	61.0	156.8
May	33.5	23.6	74	57	10.6	211	4.5	5.3	69.1	158.0
Jun	30.5	22.5	75	65	16.3	325	5.9	6.4	34.0	140.0
Jul	29.0	22.0	77	66	16.3	325	6.5	6.8	41.7	132.1
Aug	29.9	22.1	77	65	14.9	297	5.8	6.3	33.9	139.4
Sep	30.7	22.0	77	63	13.1	261	5.1	6.0	37.3	137.5
Oct	30.4	22.0	78	67	7.8	155	5.5	6.3	148.7	118.0
Nov	29.3	21.1	78	61	5.4	108	5.4	5.4	125.3	103.9
Dec	28.9	19.6	75	49	6.1	122	4.5	4.4	33.5	110.4

(Average for the period from 1931 to 1960)

Latitude : 11^0 00' N Height above MSL : 409 M
Longitude : 76^0 58' E Height of anemometer : 12.7 M.

Table II.11: Meteorological Data for: Amaravathi Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotranspiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	30.0	18.8	76	40	10.3	205	3.7	3.0	6.7	136.0
Feb	32.5	19.1	71	32	10.7	213	3.2	2.8	4.0	146.3
Mar	35.1	21.4	69	29	12.0	239	2.7	2.6	4.8	192.0
Apr	35.3	23.4	73	44	14.7	293	3.9	5.1	70.3	183.8
May	33.9	23.3	75	56	23.0	458	4.6	5.5	76.0	197.9
Jun	31.4	22.3	77	66	32.6	649	5.7	6.2	35.2	183.8
Jul	30.0	21.7	81	68	31.0	618	5.6	6.6	37.0	171.5
Aug	31.1	21.8	80	67	30.8	613	5.9	6.3	18.1	178.6
Sep	31.9	21.7	79	63	26.2	522	4.6	5.7	41.9	176.7
Oct	30.9	21.9	81	67	16.3	325	5.3	6.0	127.1	141.2
Nov	29.0	20.7	79	60	9.5	189	5.0	5.2	127.4	114.2
Dec	29.0	18.7	76	48	10.1	201	4.1	3.8	25.7	123.2

Latitude : 11° 02' N Height above MSL : 400 M
Longitude : 77° 08' E Height of anemometer : 6.75 M.

Table II.12: Meteorological Data for: Tirumanimuttar Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotranspiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	31.1	19.2	73	43	10.2	203	2.5	3	8.6	138.9
Feb	33.1	19.2	72	35	10.7	213	2.1	3	11.8	151.7
Mar	36.1	22.5	69	32	10.3	205	1.9	2	14.8	189.5
Apr	36.9	25.1	70	41	8.3	165	3.1	5	55.1	174.9
May	36.8	25.5	71	47	8.1	161	4.0	5	92.8	170.8
Jun	34.9	24.4	74	51	9.6	191	5.2	6	82.4	147.2
Jul	33.4	23.6	78	56	9.0	179	6.1	7	104.7	135.1
Aug	33.2	23.4	79	55	7.9	157	5.7	7	143.2	134.8
Sep	33.1	23.3	77	54	6.9	137	5.1	6	141.6	133.1
Oct	31.9	22.8	80	62	5.3	106	5.2	6	185.9	120.0
Nov	30.5	21.2	78	61	6.5	129	4.4	5	89.3	111.5
Dec	30.1	19.6	75	52	8.4	167	3.4	4	34.3	120.2

(Average for the period from 1931 to 1960)

Latitude : 11° 39' N Height above MSL : 278 M
Longitude : 78° 10' E Height of anemometer : 8.1 M.

Table II.13: Meteorological Data for: Ponnanai Ar Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotranspiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	30.1	20.6	79	54	10.1	201	3.4	3.7	18.4	131.3
Feb	32.7	21.3	78	43	7.7	153	3.1	3.1	7.5	136.8
Mar	35.1	22.9	76	38	8.8	175	3.1	2.5	8.4	176.9
Apr	36.7	25.8	73	42	9.7	193	2.8	4.2	70.1	178.6
May	37.1	26.4	67	31	17.4	347	4.3	5.0	79.8	210.1
Jun	36.4	26.5	59	33	28.9	576	4.5	6.2	33.9	239.2
Jul	35.5	25.9	61	33	31.4	625	6.1	6.4	40.5	248.0
Aug	35.1	25.4	65	47	25.8	514	5.7	6.2	104.6	218.8
Sep	34.2	24.9	70	51	19.4	386	5.1	4.3	107.6	187.5
Oct	32.3	23.9	79	63	10.9	217	5.3	6.0	170	135.2
Nov	29.9	22.7	81	65	8.5	169	5.1	5.6	156.2	110.4
Dec	25.3	21.3	79	65	11.1	221	4.3	5.2	70.6	117.5

(Average for the period from 1931 to 1960)

Latitude : 10^0 46' N   Height above MSL : 88 M
Longitude : 78^0 43' E   Height of anemometer : 17.2 M.

Table II.14: Meteorological Data for: Upper Coleroon Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotranspiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	30.1	20.6	79	54	10.1	201	3.4	3.7	18.4	131.3
Feb	32.7	21.3	78	43	7.7	153	3.1	3.1	7.5	136.8
Mar	35.1	22.9	76	38	8.8	175	3.1	2.5	8.4	176.9
Apr	36.7	25.8	73	42	9.7	193	2.8	4.2	70.1	178.6
May	37.1	26.4	67	31	17.4	347	4.3	5.0	79.8	210.1
Jun	36.4	26.5	59	33	28.9	576	4.5	6.2	33.9	239.2
Jul	35.5	25.9	61	33	31.4	625	6.1	6.4	40.5	248.0
Aug	35.1	25.4	65	47	25.8	514	5.7	6.2	104.6	218.8
Sep	34.2	24.9	70	51	19.4	386	5.1	4.3	107.6	187.5
Oct	32.3	23.9	79	63	10.9	217	5.3	6.0	170.0	135.2
Nov	29.9	22.7	81	65	8.5	169	5.1	5.6	156.2	110.4
Dec	29.3	21.3	79	65	11.1	221	4.3	5.2	70.6	117.5

(Average for the period from 1931 to 1960)

Latitude : 10^0 46' N   Height above MSL : 88 M
Longitude : 78^0 43' E   Height of anemometer : 17.2 M.

Table II.15: Meteorological Data for: Lower Coleroon Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotran-spiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	27.9	20.8	83	71	10.4	200	4.1	3.7	41.7	112.6
Feb	29.0	21.2	84	70	9.0	173	3.5	3.4	14.8	116.4
Mar	30.8	22.9	79	69	9.7	186	3.1	2.9	26.8	151.4
Apr	32.8	25.7	75	73	11.7	225	4.1	3.5	37.8	159.2
May	35.7	27.1	67	72	12.6	242	4.4	4.5	70.7	176.6
Jun	36.9	27.0	63	62	11.8	227	5.3	5.9	34.5	164.1
Jul	35.4	26.1	68	60	10.4	200	6.0	6.5	68.9	150.3
Aug	34.5	25.4	73	66	9.8	188	5.8	6.0	109.5	145.4
Sep	33.8	25.1	73	70	9.2	177	5.3	5.4	113.4	139.4
Oct	31.5	24.3	81	75	7.4	142	5.3	5.6	241.5	100.5
Nov	29.0	22.8	83	76	9.0	173	5.3	5.4	362.2	102.5
Dec	27.9	21.5	83	74	11.1	213	4.7	4.7	183.4	106.2

(Average for the period from 1931 to 1960)

Latitude : 11° 46' N   Height above MSL : 12 M
Longitude : 79° 46' E   Height of anemometer : 17.2 M.

Table II.16: Meteorological Data for: Cauvery Delta Sub-basin

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed		Cloud cover of sky (Oktas)		Normal Rainfall	Monthly Evapotran-spiration
	Max	Min	08.30 hrs	17.30 hrs	km/hr	km/day	08.30 hrs	17.30 hrs	mm	mm
1	2	3	4	5	6	7	8	9	10	11
Jan	27.7	22.8	78	74	18.8	374	4.4	4.0	57.2	133.6
Feb	28.7	23.5	77	72	15.8	315	4.0	3.2	25.2	136.2
Mar	30.3	25.1	74	71	14.3	285	3.7	2.8	21.5	167.4
Apr	32.5	26.8	73	73	13.1	261	4.5	3.7	55.1	164.1
May	35.5	27.4	69	69	12.7	253	4.9	4.4	56.0	177.1
Jun	36.6	27.0	61	61	12.5	249	5.4	5.5	28.8	171.6
Jul	35.3	26.3	65	63	11.3	225	5.8	5.9	47.7	162.0
Aug	34.4	26.0	70	67	10.3	205	5.5	5.4	62.0	156.9
Sep	33.7	25.7	71	69	9.7	193	5.1	4.9	61.8	148.8
Oct	31.4	25.0	79	75	8.7	173	5.5	5.4	224.0	127.2
Nov	28.9	23.9	82	77	13.3	265	6.0	5.5	458.2	112.2
Dec	27.7	22.8	81	76	17.8	355	5.2	5.1	239.0	118.8

(Average for the period from 1931 to 1960)

Latitude : 10° 46' N   Height above MSL : 9 M
Longitude : 79° 51' E   Height of anemometer : 4.96 M.

Appendix – III

Table III.1: Cauvery River Basin: Annual Irrigation and Utilizations through Existing, Ongoing, Future; Major, Medium and Minor Projects

Sl. No	Name of Sub-basin State/Category	C.C.A. (ha)	Annual Irriga-tion (ha)	Annual Utilisa-tion (MCM)	Irriga-tion Intensity (%)	Delta (m)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	*Upper Cauvery sub-basin*					
	(Area lie fully in Karnataka)					
	EXISTING PROJECTS					
	I. Major projects:	-	-	-	-	-
	II. Medium projects:					
	21 Nos. of Anicut channels Located upstream KRS Dam		36800	612.30	100	1.66
	III. Minor projects		90378	876.70	100	0.97
	Total		127178	1489.00		
	ONGOING PROJECTS					
	I. Major projects					
	i) Hemavathi project	61,000	61,000	339.72	100	0.556
	ii) Yagachi project	21,450	21,450	163.02	100	0.760
	iii) Harangi project	52,611	66372	471.24	126	0.71
	II. Medium projects					
	i) Votehole project	7,487	7,487	67.38	100	0.90
	ii) Chiklihole project	2,752	3,481	31.33	126	0.90
	III) Minor projects	2,900	2,900	28.13	100	0.97
	Total	148300	162790	1,100.82	-	-
	FUTURE PROJECTS					
	I. Major project					
	i) Cauvery reservoir project	40,500	40,500	433.35	100	1.07
	Lakshmanthirta project	2800	2800	29.96	100	1.07
	III. Minor projects	-	-	NIL	-	-
	Sub-total	43300	43300	463		
	Grand total					

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2	***Kabini sub-basin***					
	EXISTING PROJECTS					
	I. Major projects:					
	a) Karnataka					
	i) Nagu Reservoir	10526	10526	217.91	100	2.07
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala	-	-	NIL	-	-
	II) Medium projects:			.		
	a) Karnataka					
	i) Hebballa Reservoir	1214	1214	16.60	100	1.37
	ii) Nallur Ammanikere	1619	1300	6.23	80	0.48
	iii) Anicut Channels (2 Nos.) on Kabini	6555	6555	310.98	100	-
	iv) Anicut Channels on Lakshmanathirtha	1400	1400	25.20	100	1.80
	v) Command of Anicut Channels on Cauvery river	180	180	3.24	100	1.80
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala	-	-	NIL	-	-
	III) Minor projects					
	i) Tanks	3723	3876	27.74	104	0.70 (kh.)
	ii) Other Sources	28	285	1.28	101	0.45
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala					
	i) Tanks	64	121	0.92	189	0.45 (kh.)
	ii) Other sources	6633	12469	56.11	188	0.45
	Total	32195	37926	666.21	-	-
	ONGOING PROJECTS					
	I. Major projects					
	a) Karanataka					
	i) Kabini project stage-I	12020	23262	224.65	195	0.97
	ii) Taraka project	8903	8903	193.2	100	2.17
	iii) Extension under Krishna-rajasagar (stage-I)	33600	41700	297.33	124	0.71
	b) Tamilnadu	-	-	-	-	-
	c) Kerala					
	iv) Kuttiyadi Augmentation Scheme/Banasurasagar project	3800	7600	69.92	200	0.92

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Kabini sub-basin					
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala					
	i) Karapuzha project	4650	9300	85.56	200	0.92
	III) Minor					
	a) Karanataka	223	223	1.56	100	0.70
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala	-	-	NIL	-	-
	Total		90988	872.22	-	-
	FUTURE PROJECTS					
	I. Major projects					
	a) Karanataka					
	i) Kabini project stage-II	19692	29538	336.73	150	1.14
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka					
	i) Kudrehundi halla	2000	2500	28.5	125	1.14
	ii) Anicut channels	180	180	2.05	100	1.14
	b) Tamilnadu					
	c) Kerala					
	iii) Vythiri	4000	5000	57.00	125	1.14
	iv) Kallampatti Puzha	3000	3750	42.75	125	1.14
	v) Tirunelli	4860	6075	69.26	125	1.14
	vi) Manjat	2800	3500	39.90	125	1.14
	vii) Narasipuzha	3800	4750	54.15	125	1.14
	viii) Chandali puzha	2500	3125	35.63	125	1.14
	Ix) Noolpuzha	4250	5313	60.57	125	1.14
	x) Perungatpuzha	4000	5000	57.00	125	1.14
	xi) Chengat	2200	2750	31.35	125	1.14
	xii) Kandananthodu	1200	1500	17.10	125	1.14
	xiii) Kurichiyal	3000	3750	42.75	125	1.14
	xiv) Thondar	3040	3800	43.32	125	1.14
	xv) Chembinathodu	2100	2625	29.93	125	1.14
	III) Minor					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala					
	i) Vellakil	400	400	3.52	100	0.88
	ii) Pullakhod	400	400	3.52	100	0.88
	iii) Kollavi	1000	1000	8.8	100	0.88
	iv) L I. Schemes	8100	8100	71.28	100	0.88
	Total	72522				
	Grand total					

(1)	(2)	(3)	(4)	(5)	(6)	(7)
3	***Shimsha sub-basin***					
	(Area lie fully in Karnataka)					
	EXISTING PROJECTS					
	I.Major projects:					
	i) K.R.S.projects (Visveswarayya Canal)	68029	68029	1272.14	100.00	1.87
	II. Medium projects					
	i) Marconhally project	6073	6073	112.96	100.00	1.86
	ii) Mangala reservoir project	1636	2486	16.90	152.00	0.68
	iii) Kanva project	2024	2024	34.00	100.00	1.68
	iv) Shimsha Anicut Channels	3078	3078	55.40	100.00	1.80
	III) Minor projects					
	i) Tanks	33108	47146	330.02	142.40	0.70
	ii) Other Sources	1818	2081	9.36	114.50	0.45
	Total	115766	130917	1830.78	-	-
	ONGOING PROJECTS					
	I. Major projects					
	i) Hemavathi Project	179280	179280	1001	100	0.56
	II) Medium projects					
	i) Iggalur project	3797	5024	45.72	132	0.91
	III) Minor projects					
	i) Tanks	1284	1284	8.99	100	0.70
	Total	184361	185588	1055.71	-	-
	FUTURE PROJECTS					
	I. Major projects					
	i) KRS Stage-II(Visveswarayya Canal extension)	13200	19800	182.00	150	0.92
	II. Medium projects					
	i) Upper Shimsha project	5000	46.00		125	0.92
	ii) Shimsha Anicut Channels	3078	3848	35.00	125	0.92
	III) Minor projects	-	-	NIL	-	-
	Total	20278	28648	263.00		

(1)	(2)	(3)	(4)	(5)	(6)	(7)
4	*Arkavathi sub-basin*					
	EXISTING PROJECTS					
	I. Major projects:					
	a) Karnataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka					
	i) Byramangala project	1619	1619	28.33	100	1.75
	b) Tamilnadu	-	-	NIL	-	-
	III) Minor projects					
	a) Karanataka					
	i)) Suvarnavathi Channels	332	332	5.98	100	1.80
	ii) Tanks	15088	19454	136.18	129	0.70
	iii) Other sources	1323	1834	8.25	139	0.45
	b) Tamilnadu					
	i) Tanks	333	333	2.33	100	0.70
	Total	18695	23572	181.07	-	-
	ONGOING PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka					
	i) Manchanabele	3845	3845	21.92	100	0.57
	ii) Arkavathi Reservoir	8560	8560	89.02	100	1.04
	iii) Iggalur project	250	500	4.60	200	0.92
	b) Tamilnadu	-	-	NIL	-	-
	III) Minor					
	a) Karanataka	129	129	0.9	100	0.7
	i) Tanks	884	884	6.19	100	0.70
	b) Tamilnadu	-	-	NIL	-	-
	Total	13539	13789	121.73	-	-
	FUTURE PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka					

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Arkavathi sub-basin					
	i) Additional area to bring total area of irrigation to 30%of cultural area	-	19495	105.27	-	0.54
	b) Tamilnadu	-	-	NIL	-	-
	III) Minor projects					
	a) Karanataka					
	i) Suvarnavathi Channels	332	332	1.53	100	0.46
	a) Additional area to bring total area of irrigation to 30% of culturable area	-	19494	89.68	-	0.46
	b) Tamilnadu	-	-	NIL	-	-
	Total		39321	196.48	-	-
	Grand total					
5	*Middle Cauvery sub-basin*					
	(Area lie fully in Karnataka)					
	EXISTING PROJECTS					
	I.Major projects:					
	i) K. R. S.projects	11283	11283	210.99	100	1.87
	II. Medium projects					
	i) Anicut Channels below KRS Dam (8 No..)	23470	23470	422.44	100	1.80
	ii) Madhavamantri Anicut Channel	1874	1874	33.73	100	1.80
	iii) Gundal project	2066	2066	37.19	100	1.80
	III) Minor projects					
	ii) Tanks & other sources Kharif Rabi Other Sources	4205	5359	43.28	127	 0.7 1.1
	ii) Other Sources	610	717	3.23	117	0.45
	Total	47556	48817	790.48		
	ONGOING PROJECTS					
	I. Major projects					
	i) Hemavathi Project	24699	24699	138.31	100	0.56
	ii) Extension under KRS Stage-I	28100	40800	226.54	145	0.56
	iii) KRS Stage-II-Visweswaraya Canal	1915	1915		-	-
	iv) Kabini project-Stage-I	22860	44058	425.48	193	0.96
	II. Medium projects	-	-	NIL	-	-
	III) Minor projects					
	i) Tanks	466	466	3.26	100	0.70
	Total	78040	111938	793.59	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Middle Cauvery sub-basin					
	FUTURE PROJECTS					
	I. Major projects					
	i) Kabini project stage-I	5537	8305	95.55	150	1.14
	II. Medium projects					
	i) 8 Nos. of Anicut Channels below KRSDam	23470	5668	67.00	25	1.14
	ii) Lokapavani project	3000	3750	43.00	125	1.14
	III) Minor projects	-	-	NIL	-	-
	Total	32007	17923	205.00	-	-
	Grand total					
6	*Suvarnavathi sub-basin*					
	EXISTING PROJECTS					
	I. Major projects:					
	a) Karnataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka					
	i) Suvarnavathi project	6756	6756	102.02	1.51	
	b) Tamilnadu	-	-	NIL	-	-
	III) Minor projects					
	a) Karanataka					
	i) Chikkahole project	1650	1650	19.81	100	1.2
	ii) Tanks & other sources Kharif Rabi Other Sources	1319	1674	13.12	127	 0.7 1.1 0.45
	b) Tamilnadu					
	ii) Tanks & other sources Kharif Rabi Other Sources	38	53	0.4	139	 0.7 1.1 0.45
	Total	9763	10133	135.35	-	-
	ONGOING PROJECTS					
	I. Major projects					
	a) Karanataka					
	i) Kabini project stage-I	10850	20904	201.87		0.97
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	III) Minor					
	a) Karanataka	129	129	0.9	100	0.7
	b) Tamilnadu	-	-	NIL	-	-
	Total	10,979	21,033	202.77	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Suvarnavathi sub-basin					
	FUTURE PROJECTS					
	I. Major projects					
	a) Karanataka					
	i) Kabini project stage-I	16941	25411	289.69	150	1.14
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	III) Minor projects					
	a) Karanataka	129	129	0.9	100	0.7
	i) Hebbanalla	800	800	7.04	100	0.88
	b) Tamilnadu	-	-	NIL	-	-
	i) Bellahalla project	500	500	4.4	100	0.88
	Total	18241	26711	301.13	-	-
	Grand total					
7	***Palar sub-basin***					
	EXISTING PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	III) Minor					
	a) Karanataka					
	i) Tanks	1334	1334	9.00	100	0.7-kh 1.1-rabi
	ii) Other Sources	188	188	0.85	100	0.45
	b) Tamilnadu					
	i) Tanks	60	85	1.00	142.00	0.70-kh 1.10-rabi
	ii) Other Sources	199	300	1.35	151	0.45
	Total	1781	1907	12.20	-	-
	ONGOING PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	i) Uduthore halla	6597	6597	34.96	100	0.53
	b) Tamilnadu	-	-	NIL	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Palar sub-basin					
	III) Minor					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	Total	6597	6597	34.96		
	FUTURE PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	i) Chengawadi	2600	3250	37.05	125	1.14
	b) Tamilnadu					
	i) Additional area to bring total area of irrigation to 30% of culturable area		7522	85.75	-	
	III) Minor projects					
	a) Karanataka					
	i) Minnathuhalla	1200	1200	10.56	100	0.88
	ii) Dodihalla	1200	1200	10.56	100	0.88
	iii) Additional area to bring total area of irrigation to 30% of culturable area	-	266	2.34		0.88
	b) Tamilnadu					
	iv) Maniyarpallam	900	900	7.92	100	0.88
	v) Additional area to bring total area of irrigation to 30% of culturable area	-	7522	66.19	100	0.88
	Total	21860	220.37			
	Grand total					
8	*Chinnar sub-basin*					
	EXISTING PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu					
	i) Thoppaiyar Reservoir	2157	2157	10.79	100	0.50
	III) Minor					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu					
	i) Chinnar Reservoir	757	757	9.08	100	1.20

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Chinnar sub-basin					
	ii) KasarigulihallReservoir	1619	1619	8.10	100	0.50
	iii) Nagavathi Reservoir	807	807	4.04	100	0.50
	iv) Tanks	8305	8305	116.27	100	1.40
	Total	13645	13645	148.28		
	ONGOING PROJECTS					
	I. Major projects	-	-	NIL	-	-
	II. Medium projects	-	-	NIL	-	-
	III) Minor	-	-	NIL	-	-
	FUTURE PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu					
	i) Additional area to bring total area of irrigation to 30% of culturable area		24878	291.07	-	1.17
	III) Minor projects					
	a) Karanataka					
	i) Doddahalla reservoir	971	971	8.64	100	0.89
	ii) Sastramuttu scheme	437	437	3.89	100	0.89
	iii) Tank across Vellamalaipallam	30	30	0.27	100	0.89
	iv) Tank across Chinnar	884	884	7.87	100	0.89
	v) Tank across Perumpallam Odai	123	123	1.09	100	0.89
	vi) Additional area to bring total area of irrigation to 30% of culturable area	24878	24878	221.41	100	0.89
	b) Tamilnadu	-	-	NIL	-	-
	Total		52201	534.24		
	Grand total					
9	***Bhavani sub-basin***					
	EXISTING PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu					
	i) Kodiveri Anicut	11048	19830	531.44	179	2.68
	ii) Lower Bhavani	36794	32410	395.40	100	1.22
	iii) Mettur Channels	797	797	12.03	100	1.51
	c) Kerala	-	-	NIL	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Bhavani sub-basin					
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala	-	-	NIL	-	-
	III) Minor					
	a) Karanataka	-	200	2.80	-	1.4
	b) Tamilnadu					
	i) Gunderipallam	-	1001	12.21	-	1.22
	ii) Varattapallam	-	1210	15.73	-	1.30
	iii) Tanks	-	3756	52.58	-	1.40
	c) Kerala	-	680	11.29	-	1.66
	Total	-	59884	1033.48		
	ONGOING PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala					
	i) Attapady	8300	8387	119.93	101	1.43
	III) Minor Projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu					
	i) Perumpallam reservoir	-	1400	6.02	-	0.43
	c) Kerala	-	-	NIL	-	-
	Total		9787	125.95	-	-
	FUTURE PROJECTS					
	I. Major projects					
	a) Karanataka	-	-	NIL	-	-
	b) Tamilnadu	-	-	NIL	-	-
	c) Kerala	-	-	NIL	-	-
	II. Medium projects					
	a) Karanataka					
	Additional area to bring total area of irrigation to 30% of culturable area	1442	1643	17.42	125	1.06
	b) Tamilnadu					
	i) Additional area to bring total area of irrigation to 30% of culturable area	4066	5082	53.87	125	1.06
	c) Kerala					
	iii) Arali irrigation project	1000	1250	13.25	125	1.06

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Bhavani sub-basin					
	III) Minor projects					
	a) Karanataka					
	iii) Additional area to bring total area of irrigation to 30% of culturable area	-	1642	13.96	100	0.85
	b) Tamilnadu					
	ii) Tank across Periapallam	102	102	0.87	100	0.85
	iii) Reservoir across Valukkupparaipallam	954	954	8.11	100	0.85
	iv) Remodeling of Thaddalapalli Channel	145	145	1.23	100	0.85
	v) Reservoir across Kombulapallam	469	469	3.99	100	0.85
	vi) Reservoir across Bollipallam	174	174	1.48	100	0.85
	vi) Rainfed tanks (10 Nos.)	1497	1497	12.72	100	0.85
	v) Additional area to bring total area of irrigation to 30% of culturable area	5081	5081	43.19	100	0.85
	c) Kerala	-	-	NIL	-	-
	Total		18039	170.09		
	Grand total					
10	*Noyil sub-basin*					
	(Area lie fully in Tamilnadu					
	EXISTING PROJECTS					
	I. Major projects					
	i) Noyil River Channels		6920	96.88	116	1.40
	ii) P.A.P.System		14857	157.48	42	1.06
	iii) Lower Bhavani Project	20888	18399	224.47	88	1.22
	iv) Kalingarayan Anicut		251	5.02		2.00
	II. Medium projects					
	i) Noyil Reservoir Schme		3895	24.15	100	0.62
	III) Minor Projects					
	i) Tanks		2778	38.89	100	1.40
	Total		47100	546.89	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Noyil sub-basin					
	ONGOING PROJECTS					
	I. Major projects	-	-	NIL	-	-
	II. Medium projects					
	i) Noyil Orathupalayam Reservoir Schme	4200	4200	17.44	100	0.42
	III) Minor Projects					
	i) Chinna Vedampatti Tank	397	397	2.3	100	0.58
	Total	4597	4597	19.74	-	-
	FUTURE PROJECTS					
	I. Major projects					
	i) Anamalaiyar diversion (From periyar basin)		2979	23		
	II. Medium projects					
	Additional area to bring total area of irrigation to 30% of culturable area		7913	66.47	0.84	
	III) Minor Projects					
	i) Mannarai and Anaipalay anicut diversion scheme		501	3.00		0.65
	ii) Rainfed tanks		782	5.00	100	0.65
	iii) Additional area to bring total area of irrigation to 30% of culturable area		7914	51.00		0.65
	Total		20089	148.47	-	-
11	*Amaravathi sub-basin*					
	EXISTING PROJECTS					
	I. Major projects					
	a) Tamilnadu					
	i) Old Amaravathi Channel	-	19628	341.53	-	1.74
	ii) Amaravathi Reservoir	-	10118	159.86	-	1.58
	iii) P.A.P. System	-	57202	435	-	
	b) Kerala	-	-	NIL	-	-
	II. Medium projects					
	a) Tamilnadu					
	i) Palar-Porandalar Scheme	-	6063	78.82	-	1.30
	ii) Varadamanadhi Scheme	-	2105	27.37	-	1.30
	iii) Upper Reservoir	-	2454	40	-	1.63
	b) Kerala	-	-	NIL	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Amaravathi sub-basin					
	III) Minor Projects					
	a) Thailand					
	i) Parappalar Scheme	-	936	12.17	1.3	
	ii) Vattamalai Karai Odai	-	1200	15.60	-	1.40
	iii) Tanks	-	18058	252.81	-	1.40
	b) Kerala					
	iv) Riverfed Scheme	-	3000	57.00	-	1.90
	Total		120764	1420.16		
	ONGOING PROJECTS					
	I. Major projects					
	a) Thailand	-	-	NIL	-	-
	b) Karalla	-	-	NIL	-	-
	II. Medium projects	-	-	NIL	-	-
	a) Thailand					
	i) Kodaganar Scheme	-	2313	24.75		1.07
	b) Kerala	-	-	NIL	-	-
	Total		3811	39.58		
	III) Minor Projects	-	-	NIL	-	-
	a) Thailand					
	i) Kudhirayar Scheme	-	1498	14.83		0.99
	b) Kerala	-	-	NIL	-	-
	Total		3811	39.58		
	FUTURE PROJECTS					
	I. Major projects					
	a) Thailand	-	-	NIL	-	-
	i) Anamalaiyar diversion		3846	40.00		
	b) Kerala	-	-	NIL	-	-
	II. Medium projects					
	a) Thailand					
	i) Naganjiyar Reservoir		3191	42.00		
	ii) Additional area to bring total area of irrigation to 30% of culturable area		21651	285.79	-	1.32
	b) Kerala	-	-	NIL	-	-
	III) Minor Projects					
	a) Thailand					
	i) Pachiyar		1181	12.28		
	ii) Chinnakkarai Odai		345	3.59		
	iii) Additional area to bring total area of irrigation to 30% of culturable area		21651	225.17	-	1.04
	b) Kerala					
	iv) Thalaryar		1902	19.78		
	v) Chanalar		1710	17.78		
	vi) Chamabakkad		1336	13.89		
	vii) Vebbavada		405	4.21		
	viii) Ottamavam		243	2.53		
	ix) Pulandialiaka		405	4.21		
	x) Padagiri		162	1.68		
	Total		58028	672.91		

(1)	(2)	(3)	(4)	(5)	(6)	(7)
12	*Tirumanimuttar sub-basin*					
	(Area lie fully in Tamilnadu					
	EXISTING PROJECTS					
	I. Major projects					
	i) Mettur Canals	18212	17415	262.97	100	1.51
	ii) Lower Bhavani Project	95105	33026	402.92	100	1.22
	iii) Salem Tiruchi Channels	28841	19245	350.26	158	1.82
	iv) Kattalai Canal Scheme	30879	23405	425.97	160	1.82
	v) Kalingarayan Anicut	5713	15532	329.28	272	2.12
	II. Medium projects	-	-	NIL	-	-
	III) Minor Projects					
	i) Tanks	38235	38235	535.29	100	1.40
	Total		146858	2306.69	-	-
	ONGOING PROJECTS					
	I. Major projects	-	-	NIL	-	-
	II. Medium projects	-	-	NIL	-	-
	III) Minor Projects	-	-	NIL	-	-
	Total	-	-	NIL	-	-
	FUTURE PROJECTS					
	I. Major projects	-	-	NIL	-	-
	II. Medium projects					
	i) Reservoir across Ayyar	-	2500	30.75	-	1.23
	ii) Additional area to bring total area of irrigation to 30% of culturable area	-	18264	224.65	-	1.23
	III) Minor Projects					
	i) Across Chittar	-	854	7.43	-	0.87
	ii) Additional area to bring total area of irrigation to 30% of culturable area	-	18264	158.9	-	0.87
	Total		39882	421.73	-	-
13	*Ponnanai Ar sub-basin*					
	(Area lie fully in Thailand					
	EXISTING PROJECTS					
	I. Major projects					
	i) Salem Tiruchi Channels		1996	36.00	158	1.82
	ii) Kattalai Canal Scheme	30879	19705	359.00	160	1.82
	II. Medium projects					
	i) New Kattalai HLC		4229	72.00	100	1.71

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Ponnanai Ar sub-basin					
	III) Minor Projects					
	i) Ponnanai Ar Reservoir	850	850	10.03	100	1.18
	i) Tanks		13123	183.72	100	1.40
	Total		39903	660.75		
	ONGOING PROJECTS					
	I. Major projects	-	-	NIL	-	-
	II. Medium projects	-	-	NIL	-	-
	III) Minor Projects	-	-	NIL	-	-
	Total	-	-	NIL	-	-
	FUTURE PROJECTS					
	I. Major projects	-	-	NIL	-	-
	II. Medium projects					
	i) Additional area to bring total area of irrigation to 30% of culturable area	-	1327	17.65	-	1.33
	III) Minor Projects					
	i) Minnakkaradu Tank	67	67	0.72	100	1.07
	ii) Additional area to bring total area of irrigation to 30% of culturable area	-	1326	14.19	-	1.07
	Total		2720	32.56		
14	*Upper Coleroon Sub-basin*					
	(Area lie fully in Thailand					
	EXISTING PROJECTS					
	I. Major projects					
	i) Salem Tiruchi Channels	15398	24329	443	158	1.82
	II. Medium projects					
	i) Nandiyar Channels	3837	3978	56	125	1.40
	ii) Sidhamalli reservoir	2056	2056	14	100	0.70
	iii) Pullambadi	8944	8944	139	100	1.55
	III) Minor Projects					
	i) Upper Reservoir	723	723	4	100	0.50
	Total	42187	51914	822		
	ONGOING PROJECTS					
	I. Major projects	-	-	NIL	-	-
	II. Medium projects	-	-	NIL	-	-
	III) Minor Projects	-	-	NIL	-	-
	Total	-	-	NIL	-	-

(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Upper Coleroon Sub-basin					
	FUTURE PROJECTS					
	I. Major projects	-	-	NIL	-	-
	II. Medium projects					
	i) Kottarai reservoir scheme	-	3056	53	-	1.75
	ii) Additional area to bring total area of irrigation to 30% of culturable area	-	6657	116	-	1.75
	Total					
	III) Minor Projects					
	i) Anicut across Andiodai	216	216	3	1.32	-
	ii) Tank near Kiliyanallur	164	164	2	1.32	-
	iii) Anaipadivari reservoir	1034	1034	14	1.32	-
	iv) Additional area to bring total area of irrigation to 30% of culturable area		6657	88	1.32	-
	Total	-	17784	276	-	-
15	***Lower Coleroon sub-basin***					
	(Area lie fully in Thailand					
	EXISTING PROJECTS					
	I. Major projects					
	i) Lower Coleroon Anicut Scheme	-	66007	1077	123	1.63
	II. Medium projects	-	-	NIL	-	-
	III) Minor Projects					
	i) Riverfed and rainfed Schemes	-	4236	59	100	1.40
	Total	-	70243	1136	-	-
	There are no ongoing and					
	Identified future major,					
	Medium or minor schemes in sub-basin.					

(1)	(2)	(3)	(4)	(5)	(6)	(7)
16	***Cauvery Delta sub-basin***					
	(Area lie fully in Tamilnadu					
	EXISTING PROJECTS					
	I. Major projects					
	i) Kattalai Canal Scheme	3935	6296	115	160	1.82
	ii) Cauvery Mettur project (Grand Anicut Canal)	59898	75488	1012	126	1.34
	iii) Cauvery Delta Scheme	377990	522063	7487	138	1.43
	II. Medium projects					
	i) New Kattalai High level Canal	4108	4108	70	100	1.71
	III) Minor Projects					
	i) Riverfed and rainfed Schemes	27919	27919	391	100	1.40
	Total	473850	635874	9075		
	There are no ongoing and					
	Identified future major,					
	Medium or minor schemes in Cauvery Delta sub-basin.					

Table III.2: Cauvery River Basin: Computation of Human Population Projected to 2050AD

Sl.No.	Sub-basin	HUMAN POPULATION DURING THE YEAR 1981							
		Karnataka		Tamilnadu		Kerala		Total	
		Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
1	2	3	4	5	6	7	8	9	10
1	Upper Cauvery	1652645	383247	0	0	0	0	1652645	383247
2	Kabini	729808	713705	16140	0	511531	0	1257479	713705
3	Suvarnavathi	217804	47132	48410	0	0	0	266214	47132
4	Middle Cauvery	572681	80622	0	0	0	0	572681	80622
5	Shimsha	1858539	414980	0	0	0	0	1858539	414980
6	Arkavathi	832301	3326576	30502	0	0	0	862803	3326576
7	Chinnar	27469	0	716552	17470	0	0	744021	17470
8	Palar	153379	0	238505	0	0	0	391884	0
9	Bhavani	25261	0	951234	465554	125625	0	1102120	465554
10	Noyil	0	0	686673	1156590	0	0	686673	1156590
11	Tirumanimuttar	0	0	2296415	1302514	0	0	2296415	1302514
12	Amaravathi	0	0	1476482	491845	39479	0	1515961	491845
13	Ponnani Ar	0	0	450436	645479	0	0	450436	645479
14	Upper Coleroon	0	0	808365	155511	0	0	808365	155511
15	Lower Coleroon	0	0	549641	62543	0	0	549641	62543
16	Cauvery Delta	0	0	2467839	934422	0	0	2467839	934422
	Total	6069887	4966262						

Sl.No.	Sub-basin	PROJECTED HUMAN POPULATION FOR THE YEAR 2050 A.D.								
		Karnataka		Tamilnadu		Kerala		Total	Total	
		Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Total
1	2	11	12	13	14	15	16	17	18	19
1	Upper Cauvery	1852896	2861851	0	0	0	0	1852896	2861851	4714747
2	Kabini	1041194	2770894	23027	0	729785	0	1794006	2770894	4564900
3	Suvarnavathi	233322	440470	51859	0	0	0	285181	440470	725651
4	Middle Cauvery	658399	1016916	0	0	0	0	658399	1016916	1675315
5	Shimsha	2069164	3195884	0	0	0	0	2069164	3195884	5265048
6	Arkavathi	3678025	5889007	134791	0	0	0	3812816	5889007	9701823
7	Chinnar	25587	0	667457	1070428	0	0	693044	1070428	1763472
8	Palar	355197	0	552334	0	0	0	907531	0	907531
9	Bhavani	32702	0	1231433	2203679	162629	0	1426764	2203679	3630443
10	Noyil	0	0	1677581	2591074	0	0	1677581	2591074	4268655
11	Tirumanimuttar	0	0	3275440	5059012	0	0	3275440	5059012	8334452
12	Amaravathi	0	0	1779746	2822370	47588	0	1827334	2822370	4649704
13	Ponnani Ar	0	0	997409	1540527	0	0	997409	1540527	2537936
14	Upper Coleroon	0	0	877238	1354920	0	0	877238	1354920	2232158
15	Lower Coleroon	0	0	557157	860547	0	0	557157	860547	1417704
16	Cauvery Delta	0	0	3096448	4782556	0	0	3096448	4782556	7879004
	Total						0			

Table III.3: Cauvery River Basin- Live Stock Population Projected to 2050AD

Sl. No.	Sub-basin	Karnataka (1983)	Tamilnadu (1982)	Kerala (1982)	Total	Annual growth rate	Projected population to 2050 AD			
							Karnataka	Tamilnadu	Kerala	Total
1	Upper Cauvery	1832217	0	0	1832217	1.00	3568691	0	0	3568691
2	Kabini	711434	8777	181849	902060	1.00	1385692	17266	357737	1760695
3	Suvarnavathi	177049	483106	0	660155	1.00	344846	950377	0	1295223
4	Middle Cauvery	503488	. 0	0	503488	1.00	980666	0	0	980666
5	Shimsha	1751920	0	0	1751920	1.00	3412293	0	0	3412293
6	Arkavathi	873525	29695	0	903220	1.00	1701404	58417	0	1759821
7	Chinnar	21047	737614	0	758661	1.00	40994	1451051	0	1492045
8	Palar	274301	314262	0	588563	1.00	534268	618223	0	1152491
9	Bhavani	28405	774997	75955	879357	1.00	55326	1524591	149420	1729337
10	Noyil	0	544854	0	544854	1.00	0	1071845	0	1071845
11	Tirumanimuttar	0	2113326	0	2113326	1.00	0	4157382	0	4157382
12	Amaravathi	0	1435190	23893	1459083	1.00	0	2823338	47003	2870341
13	Ponnani Ar	0	445058	0	445058	1.00	0	875528	0	875528
14	Upper Coleroon	0	683367	0	683367	1.00	0	1344335	0	1344335
15	Lower Coleroon	0	316646	0	3116646	1.00	0	622913	0	622913
16	Cauvery Delta	0	1757547	Pd.56931	1814478	1.00	0	3569481 pd.	0	3569481
	Total									35184219

Table III.4 : Cauvery River Basin -Domestic Water Demands

Sl.No.	Sub-basin	Karnataka						Tamilnadu					
		Rural	Urban	Live stock	Total	Surface water	Ground water	Rural	Urban	Live stock	Total	Surface water	Ground water
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Upper Cauvery	47	209	65	321	233	88	0	0	0	0	0	0
2	Kabini	27	202	25	254	215	39	1	0	1	2	1	1
3	Suvarnavathi	6	32	6	44	35	9	1	0	18	19	0	19
4	Middle Cauvery	17	74	18	109	83	26	0	0	0	0	0	0
5	Shimsha	53	233	62	348	259	89	0	0	0	0	0	0
6	Arkavathi	94	430	31	555	477	78	3	0	1	4	2	2
7	Chinnar	1	0	1	2	1	1	17	78	26	121	86	35
8	Palar	9	0	10	19	4	15	14	0	11	25	7	18
9	Bhavani	1	0	1	2	0	2	31	161	28	220	177	43
10	Noyil	0	0	0	0	0	0	43	189	20	252	210	42
11	Tirumanimuttar	0	0	0	0	0	0	84	370	76	530	412	118
12	Amaravathi	0	0	0	0	0	0	46	206	51	303	229	74
13	Ponnani Ar	0	0	0	0	0	0	26	113	16	155	126	29
14	Upper Coleroon	0	0	0	0	0	0	22	99	12	134	110	24
15	Lower Coleroon	0	0	0	0	0	0	14	63	6	83	70	13
16	Cauvery Delta	0	0	0	0	0	0	79	349	33	461	389	72
	Total	255	1180	219	1654	1307	347	381	1628	299	2309	1819	490

Table III.4 (Contd...)

Sl.No.	Sub-basin	Kerala						Total					
		Rural	Urban	Live stock	Total	Surface water	Ground water	Rural	Urban	Live stock	Total	Surface water	Ground water
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Upper Cauvery	0	0	0	0	0	0	47	209	33	321	233	88
2	Kabini	18	0	6	24	9	15	46	202	32	280	225	55
3	Suvarnavathi	0	0	0	0	0	0	7	32	24	63	35	28
4	Middle Cauvery	0	0	0	0	0	0	17	74	18	109	83	26
5	Shimsha	0	0	0	0	0	0	53	233	62	348	259	89
6	Arkavathi	0	0	0	0	0	0	97	430	32	559	479	80
7	Chinnar	0	0	0	0	0	0	18	78	27	123	87	36
8	Palar	0	0	0	0	0	0	23	0	21	44	11	33
9	Bhavani	4	0	3	7	2	5	36	161	32	229	179	50
10	Noyil	0	0	0	0	0	0	43	189	20	252	210	42
11	Tirumanimuttar	0	0	0	0	0	0	84	370	76	530	412	118
12	Amaravathi	1	0	1	2	1	1	47	206	52	305	230	75
13	Ponnani Ar	0	0	0	0	0	0	26	113	16	155	126	29
14	Upper Coleroon	0	0	0	0	0	0	22	99	12	134	110	24
15	Lower Coleroon	0	0	0	0	0	0	14	63	6	83	70	13
16	Cauvery Delta	0	0	0	0	0	0	79	349	33	461	389	72
	Total	23	0	10	33	12	21	659	2808	528	3996	3138	858

Table III.5: Cauvery River Basin- Computation of Regeneration from Domestic and Industrial Water Use

Unit: MCM

Sl. No.	Sub-basin	Karnataka		Tamilnadu		Kerala		Total	
		Domestic	Industrial	Domestic	Industrial	Domestic	Industrial	Domestic	Industrial
1	2	3	4	5	6	7	8	9	10
1	Upper Cauvery	186	257	0	0	0	0	186	257
2	Kabini	172	203	1	2	7	19	180	224
3	Suvarnavathi	28	35	0	15	0	0	28	50
4	Middle Cauvery	66	87	0	0	0	0	66	87
5	Shimsha	207	278	0	0	0	0	207	278
6	Arkavathi	382	444	1	3	0	0	383	447
7	Chinnar	1	2	69	97	0	0	70	99
8	Palar	3	15	5	20	0	0	8	35
9	Bhavani	1	2	142	176	1	6	144	184
10	Noyil	0	0	168	202	0	0	168	202
11	Tirumanimuttar	0	0	330	424	0	0	330	424
12	Amaravathi	0	0	183	242	0	1	184	243
13	Ponnani Ar	0	0	101	124	0	0	101	124
14	Upper Coleroon	0	0	0	0	0	0	0	0
15	Lower Coleroon	0	0	0	0	0	0	0	0
16	Cauvery Delta	0	0	0	0	0	0	0	0
	Total	1046	1323	1000	1305	9	26	2055	2654

Table III.6: Cauvery Basin -Details of Imports and Exports

Sl. No.	Name of Project	Importing/exporting sub-basin of Cauvery basin	Basin from which imported/Basin to which exported	Annual Irrigation (ha)	Annual Utilization (MCM)
1	2	3	4	5	6
	I IMPORTS				
1	Parambikulam Aliyar System (T.Sholayur Kerala, Sholayar, Parimbikulam, Tunnakkadavu, Prruvaripallam, Upper Aliyar and Lower Aliyar reservoir)	Amravathi sub-basin	From Chalakudy basin	57202	435.00
2	Upper Nirar Project	Noyil sub-basin	From Periyar basin	41657	213.00
3	Netravathi-Hemavathi project		From Netravathi basin	33813	188.00
4	Annamalaiyar Diversion	i) Noyil sub-basin ii)Amravathi	From Periyar basin From Periyar basin	2979 3191	23.00 42.00
	Total				744.00
	II EXPORTS				
1	Bangalore City Water Supply (including CWSS Stage-I and II)	Kabini sub-basin	To S.B.Palar & Cauvery		106.44
2	Bangalore City Water Supply CWSS Stage-III	Kabini sub-basin	To S.B.Palar &Cauvery		62.09
3	Bangalore City Water Supply CWSS Stage-IV	Middle Cauvery sub-basin	To S.B.Palar &Cauvery		124.17
4	Pullambadi Canal	Chinnar (Mettur dam)	To Upper Coleroon	8944	139.00
5	Salem-Tiruchi Channel	Chinnar (Mettur dam)	To Upper Coleroon	24329	443.00
6	Kattalai Canal	Chinnar (Mettur dam)	Cauvery Delta		115.00
7	New High Level Kattalai Canal	Chinnar (Mettur dam)	Cauvery Delta		70.00
8	Grand Anicut System		i)Cauvery Delta ii)S.B.Cauvery and Vaigai		1012.00 737
9	Water meant for Lower Coleroon Anicut	Chinnar (Mettur dam)	i)Lower Coleroon ii)S.B.Palar & Cauvery	66007 7178	1077.00 117.00
10	Cauvery Delta System	Chinnar (Mettur dam)	Cauvery Delta	522063	7487.00
11	Banasurasagar project	Kabini sub-basin	Kuttiadi	5200	208.00
12	Mananthavady M.P.project	Kabini sub-basin	Valapattanam	44500	527.00
13	Panthanthodu diversion	Bhawani sub-basin	Bharathpuzha	1800	23.00
14	Kerala Bhawani H.E.Project	Bhawani sub-basin	Bharathpuzha	18210	231.00
			Total		12478.70

THE LP LINDO FORM OF EQUATIONS

IV.1 GENERAL

In this research work the readily available LINDO SOFTWARE package of version 6.1, which is released in August 2001, by LINDO Systems, inc, 1415 North Dayton st. Chicago, IL, USA, having the maximum capacity of 4000 constraints and 8000 variables with 100 integer variables and 2000000 non zeros, was used to solve the LP model, as there are many constraints and variables to handle such a big problem.

The LP LINDO format for equations is prepared for running the model by writing the equations in the required form of equations for LINDO software version 6.1 2001 as given below.

The sample LINDO form of equation as given below is prepared for Kabini reservoir in Kabini sub-basin.

The nomenclature was done by using the first letter of name of the site, first two letters of the sub-basin name and maximum five letters of a variable because the LINDO software version 6.1 2001 takes maximum eight letter for the nomenclature for the model writing and running on it for getting the feasible solution of the problem.

The projectwise and vaiablewise notations used in the model running on the LINDO software are given in Tables 6.7 and 6.8, respectively.

For running and solving the Linear Programming model by using, LINDO SOFTWARE, the first objective function, i.e., to maximize the annual water utilization and the constraint equations are written in the following form of equations:

IV.2 OBJECTIVE FUNCTION

To maximize the total annual reservoir diversion (Annual water utilization) from a multipurpose reservoir for irrigation, domestic, industrial, hydropower, and environmental site i, for the proposed river basin system can be calculated as follows.

Let, <u>K</u>KB, i.e., <u>K</u> = <u>K</u>abini project and KB = Kabini Sub-Basin

Equation 5.2.1-a

Original equation 5.2.1-a is given below:

$$\text{Max.}Z = \sum_{j=1}^{NB} \sum_{i=1}^{N_j} Ir_{i,j} \quad \text{for lumped irrigation model} \quad 5.2.1\text{-a}$$

for each i and j.

LINDO form of equation of 5.2.1-a is as follows:

MAX KKBIRD

IV.3 CONSTRAINTS

IV.3.1 Reservoir Continuity Equation Constraints

Equation 5.3.1.1

The original equation 5.3.1.1 is as follows:

$$\begin{aligned}
& K^{'}_{i,j,t} * S_{i,j,t} = S_{i,j,t-1} + I_{i,j,t} + F_{i,j,t} + \sum(\psi^{q,j_I}_{i,j,t} * TI^{q,j_I}_{i,j}) + \\
& \sum_{p=1}^{X_{i,j}} K^{"}_{p,j,t}(*\psi^{q,j_I}_{i,j,p} * OI^{q,j_I}_{i,j,p}) + P_{i,j,t} + \bar{I}_{i,j,t} - O^{m}_{i,j,t} - O_{i,j,t} - O^{se}_{i,j,t} \\
& -(\alpha_{i,j,t} * Iu^{rs}_{i,j} + \beta_{i,j,t} * Iu^{mhs}_{i,j}) + (\alpha^{"}_{i,j,t} * \alpha_{i,j,t} * Iu^{r}_{i,j}) + (\beta^{"}_{i,j,t} * \beta_{i,j,t} Iu^{m}_{i,j}) \\
& -\sum(\omega^{q,j_E}_{i,j} * TE^{q,j_E}_{i,j})
\end{aligned}$$

Rearranged equation 5.3.1.1 is as follows:

$$\begin{aligned}
& K^{'}_{i,j,t} * S_{i,j,t} - S_{i,j,t-1} + O_{i,j,t} - F_{i,j,t} - P_{i,j,t} - \bar{I}_{i,j,t} + O^{se}_{i,j,t} \\
& -(\psi^{q,j_I}_{i,j,t} * TI^{q,j_I}_{i,j}) + \sum(\omega^{q,j_E}_{i,j,t} * TE^{q,j_E}_{i,j}) + \alpha_{i,j,t} * Iu^{rs}_{i,j} + \beta_{i,j,t} * Iu^{mhs}_{i,j} \\
& -(\alpha^{"}_{i,j,t} * \alpha_{i,j,t} * Iu^{r}_{i,j}) - (\beta^{"}_{i,j,t} * \beta_{i,j,t} * Iu^{m}_{i,j}) + O^{m}_{i,j,t} - I_{i,j,1} = 0
\end{aligned}$$

LINDO form of equation of 5.3.1.1 is as follows:

$$K'_{i,j,t} * KKBSt - KKBS0 + KKBOt - KKBFt - KKBPt - KKB\dot{I}t + KKBOse$$
$$- \psi^{q,j_I}_{i,j,t} * KKBTI + \omega^{q,j_E}_{i,j,t} * KKBKUTTE + \alpha_{i,j,t} * KKBIURS +$$
$$\beta_{i,j,t} KKBIUMHS - (\alpha'_{i,j,t} * \alpha_{i,j,t}) KKBIUR - (\beta'_{i,j,t} * \beta_{i,j,t}) KKBIUM$$
$$+ KKBOMt - KKBIt = 0$$

Equation 5.3.1.8

Original equation 5.3.1.8 is as follows:

$$F_{i,j,t} = \sum_{w=1}^{Z_{i,j}} \left[Sp_{w,j,t} + (K''_{w,j,t} * K_{w,j,t} * Ir'_{w,j}) + (\beta''_{w,j,t} * \beta_{w,j,t} * Ws'_{w,j}) + \delta''_{w,j,t} * O^{m}_{w,j,t} \right]$$
$$+ (\alpha''_{i,j,t} * \alpha_{i,j,t} * Iu^{r}_{i,j}) + (\beta''_{i,j,t} * \beta_{i,j,t} * Iu^{m}_{i,j})$$

Rearranged equation 5.3.1.8 is as follows:

$$F_{i,j,t} - \sum_{w=1}^{Z_i} \left[Sp_{w,j,t} + (K''_{w,j,t} * K_{w,j,t} * Ir'_{w,j}) + (\beta''_{w,j,t} * \beta_{w,j,t} * Ws'_{w,j}) + \delta''_{w,j,t} * O^{m}_{w,j,t} \right]$$
$$- (\alpha''_{i,j,t} * \alpha_{i,j,t} * Iu^{r}_{i,j}) + (\beta''_{i,j,t} * \beta_{i,j,t} * Iu^{m}_{i,j}) = 0$$

LINDO form of equation 5.3.1.1 is as follows:

$$KKBFt - \sum_{W=1}^{Zi,j} [wjSPt + (K''_{w,j,t} * K_{w,j,t}) * wjIR' + (\beta''_{w,j,t} * \beta_{w,j,t}) * wjWS + \delta''_{w,j,t} * wjOMAt]$$
$$- (\alpha''_{i,j,t} * \alpha_{i,j,t} * KKBIUMR) + (\beta''_{i,j,t} * \beta_{i,j,t} * KKBIUM) = 0$$

LIMITS:

$TI^{q,j_I}_{i,j} \leq$, i.e., $KKBOIUC \leq$

$TE^{q,j_E}_{i,j} \leq$, i.e., $KKBOESMS \leq$

If export is nil , i.e., NILOE

$Iu^{mrh}_{i,j} \leq$, i.e., $KKBIUMRH \leq$

$Iu^{rs}_{i,j} \leq$, i.e., $KKBIURS \leq$

Equation 5.3.1.9

Original equation 5.3.1.9 is as follows:

$$Ft_{i,j,t} = \sum KKBF_t$$

LINDO form of equation 5.3.1.9 is as follows:

KKBFT = KKBF1 + KKBF2 + KKBF3 + KKBF4 + KKBF5 + KKBF6 + KKBF7 + KKBF8 + KKBF9 + KKBF10 + KKBF11 + KKBF12

BKBFT = BKBF1 + BKBF2 + BKBF3 + BKBF4 + BKBF5 + BKBF6 + BKBF7 + BKBF8 + BKBF9 + BKBF10 + BKBF11 + BKBF12

MKBFT = MKBF1 + MKBF2 + MKBF3 + MKBF4 + MKBF5 + MKBF6 + MKBF7 + MKBF8 + MKBF9 + MKBF10 + MKBF11 + MKBF12

Equation 5.3.1.10

Original equation 5.3.1.10 is as follows:

$$OT_{i,j} = \Sigma KKBO_t$$

LINDO form of equation at 5.3.1.10 is as follows:

KKBOT = KKBO1 + KKBO2 + KKBO3 + KKBO4 + KKBO5 + KKBO6 + KKBO7 + KKBO8 + KKBO9 + KKBO10 + KKBO11 + KKBO12

Equation 5.31.2

Original equation 5.31.2 is as follows:

$$O^{m}_{i,j,t} - 0.01 * I_{i,j,t} = 0$$

LINDO Form of equation 5.3.1.2 is as follows:

KKBOMt −0.01KKBIt=0

Equation.5.3.1.3

Original equation.5.3.1.3 is as follows:

$$Iu^{mh}_{i,j} + Iu^{ml}_{i,j} - Iu^{m}_{i,j} = 0$$

LINDO Form of equation 5.3.1.3 is as follows:

KKBIUMH + KKBIUML - KKBIUM = 0

Original equation 5.3.1.4 is as follows:

$$Iu^{rg}_{i,j} + Iu^{rs}_{i,j} - Iu^{r}_{i,j} = 0$$

LINDO Form of equation 5.3.1.4 is as follows:

KKBIURG + KKBIURS - KKBIUR = 0

Equation 5.3.1.5

Original equation 5.3.1.5 is as follows:

$$Iu^{rg}_{i,j} \le Og^{us}_{i,j} - (Iu^{ml}_{i,j} + Iu^{mhg}_{i,j})\text{if} \quad -\text{ve} = 0$$

LINDO Form of equation 5.3.1.5 is as follows:

KKBIURG <= KKBOGUS – KKBIUML – KKBIUMHG, IF, –VE; =0

Equation 5.3.1.6

Original equation 5.3.1.6 is as follows:

$$Iu^{mhg}_{i,j} - 0.5Iu^{mh}_{i,j} = 0$$

LINDO Form of equation 5.3.1.6 is as follows:

KKBIUMHG – 0.5KKBIUMH = 0

Equation 5.3.1.7

Original equation 5.3.1.7 is as follows:

$$Iu^{mhs}_{i,j} - 0.5Iu^{mh}_{i,j} = 0$$

LINDO Form of equation 5.3.1.7 is as follows:

KKBIUMHS – 0.5 KKBIUMH = 0

IV.3.2. Storage Limits Constraints

Equation 5.3.2

Original equation 5.3.2 is as follows:

$$Yd_{i,j} \le min_{i,j,t} \le S_{i,j,t-1} \le Ymax_{i,j,t} \le Y_{i,j}$$

LINDO form of equation 5.3.2 is as follows:

KKBSt ≤ KKBY

KKBSt ≥ KKBYD

IV.4 RESERVOIR RELEASE CONSTRAINTS

Equation 5.3.3.1

Original equation 5.3.3.1 is as follows:

$$O_{i,j,t} + I''_{i,j,t} = Od_{i,j,t} + Sp_{i,j,t}$$

Rearranged equation 5.3.3.1 is as follows:

$$Od_{i,j,t} + Sp_{i,j,t} - O_{i,j,t} = I''_{i,j,t}$$

LINDO form of equation 5.3.3.1 is as follows:

KKBODt + KKBSPt − KKBOt = KKBIt

Equation 5.3.3.2

Original equation 5.3.3.2 is as follows:

$$Od_{i,j,t} = Od^{r}_{i,j,t} + Od^{m}_{i,j,t}$$

Rearranged equation 5.3.3.2 is as follows:

$$Od_{i,j,t} - Od^{r}_{i,j,t} - Od^{m}_{i,j,t} = 0$$

LINDO form of equation 5.3.3.2 is as follows:

KKBODt − KKBODRt − KKBODMt = 0

Equation 5.3.3.3

Original equation 5.3.3.3 is as follows:

$$Og^{r}_{i,j,t} = K_{i,j,t} * Ir^{g}_{i,j}$$

Rearranged equation 5.3.3.3 is as follows:

$$Og^{r}_{i,j,t} - K_{i,j,t} * Ir^{g}_{i,j} = 0$$

LINDO form of equation 5.3.3.3 is as follows:

$$KKBOGRt - K_{i,j,t} * KKBIRG = 0$$

Equation 5.3.3.4

Original equation 5.3.3.4 is as follows:

$$Od^{r}_{i,j,t} = K_{i,j,t} * Ir^{s}_{i,j}$$

LINDO form of equation 5.3.3.4 is as follows:

$$KKBODRt - K_{i,j,t} * KKBIRS = 0$$

Original equation 5.3.3.5 is as follows:

$$Og^{m}_{i,j,t} = \xi_{i,j,t}(\phi^{Ug}_{i,j} Ws^{U}_{i,j} + \phi^{Ig}_{i,j} Ws^{I}_{i,j})$$

Rearranged equation 5.3.3.5 is as follows:

$$Og^{m}_{i,j,t} - \xi_{i,j,t}(\phi^{Ug}_{i,j} Ws^{U}_{i,j} + \phi^{Ig}_{i,j} Ws^{I}_{i,j}) = 0$$

LINDO form of equation 5.3.3.5 is as follows:

$$KKBOGMt - (\xi_{i,j,t} * \varphi^{Ug}_{i,j} * KKBWSU) - (\xi_{i,j,t} * \varphi^{Ig}_{i,j} * KKBWSI) = 0$$

LIMITS:

$Ws^{U}_{i,j} \leq$, i.e., $KKBWSU \leq$

$Ws^{I}_{i,j} \leq$, i.e., $KKBWSI \leq$

Equation 5.3.3.6

Original equation 5.3.3.6 is as follows:

$$Od^{m}_{i,j,t} = \xi_{i,j,t}(\phi^{U^s}_{i,j} Ws^{U}_{i,j} + \phi^{I^s}_{i,j} Ws^{I}_{i,j})$$

Rearranged equation 5.3.3.6 is as follows:

$$Od^{m}_{i,j,t} - \xi_{i,j,t}(\phi^{U^s}_{i,j} Ws^{U}_{i,j} + \phi^{I^s}_{i,j} Ws^{I}_{i,j}) = 0$$

LINDO form of equation 5.3.3.6 is as follows:

$$\text{KKBODMt} - (\xi_{i,j,t} * \varphi^{U^s}_{i,j} * \text{KKBWSU}) - (\xi_{i,j,t} * \varphi^{I^s}_{i,j} * \text{KKBWSI}) = 0$$

LIMITS:

$Ws^{U}_{i,j} \leq$, i.e., KKBWSU $\leq$

$Ws^{I}_{i,j} \leq$, i.e., KKBWSI $\leq$

Equation 5.3.3.7

Original equation 5.3.3.7 is as follows:

$$Ir^{'}_{i,j} = Ir^{s}_{i,j} + Ir^{g}_{i,j}$$

Rearranged equation 5.3.3.7 is as follows:

$$Ir^{'}_{i,j} - Ir^{s}_{i,j} - Ir^{g}_{i,j} = 0$$

LINDO form of equation 5.3.3.7 is as follows:

KKBIR'−KKBIRS − KKBIRG = 0

Equation 5.3.3.8

Original equation 5.3.3.8 is as follows:

$$Ws^{'}_{i,j} = Ws^{u}_{i,j} + Ws^{I}_{i,j}$$

Rearranged equation 5.3.3.8 is as follows:

$$Ws^{'}_{i,j} - Ws^{U}_{i,j} - Ws^{I}_{i,j} = 0$$

LINDO form of equation 5.3.3.8 is as follows:

$$KKBWS' - KKBWSU - KKBWSI = 0$$

1.5 GROUND WATER AVAILABLILITY CONSTRAINTS

Equation5.3.4-1

Original equation5.3.4-1 is as follows:

$$\sum_{t} Og^{m}_{i,j,t} + \sum_{t} Og^{r}_{i,j,t} = Og^{ds}_{i,j} \quad \text{for each i, j and t.}$$

LINDO form of equation is as follows:

$$\sum KKBOGMt + \sum KKBOGRt = KKBOGDS$$

Not to be used equations 5.4-2 & 5.4-3

For each i and j.

Equation 5.3.4-2

Original equation 5.3.4-2 is as follows:

$$Iu^{m,g}_{i,j} + Iu^{r,g}_{i,j} = Og^{us}_{i,j}$$

LINDO form of equation is as follows:

$$\sum KKBIUMG + KKBIURG = KKBOGUS$$

Equation 5.3.4-3

Original equation 5.3.4-3 is as follows:

$$Og^{us}_{i,j} + Og^{ds}_{i,j} = Og_{i,j} \quad \text{for each i and j.}$$

LINDO form of equation is as follows:

$$\sum KKBOGUS + KKBOGDS = KKBOG$$

IV.6 SUB-BASINWISE ANNUAL IRRIGATION CONSTRAINTS

Equation 5.3.4.1

Original equation 5.3.4.1 is as follows:

$$OC^{r}_{i,j} = \sum_{t=1}^{12} Od^{r}_{i,j,t}$$

Rearranged equation 5.3.4.1 is as follows:

$$OC^{r}_{i,j} - \sum_{t=1}^{12} Od^{r}_{i,j,t} = 0$$

LINDO form of equation 5.3.4.1 is as follows:

$$KKBOCR - \sum(KKBODRt) = 0$$

IV.7 SUB-BASINWISE ANNUAL WATER SUPPLY CONSTRAINTS

Equation 5.3.6

Original equation 5.3.6 is as follows:

$$OC^{m}_{i,j} = \sum_{t=1}^{12} Od^{m}_{i,j,t}$$

Rearranged equation 5.3.6 is as follows:

$$OC^{m}_{i,j} - \sum_{t=1}^{12} Od^{m}_{i,j,t} = 0$$

LINDO form of equation 5.3.6 is as follows:

$$KKBOCM - \sum KKBODMt = 0$$

IV.8 SUB-BASINWISE CANAL CAPACITY CONSTRAINTS

Equation 5.3.7

Original equation 5.3.7 is as follows:

$$(OC^{r}_{i,j} + OC^{m}_{i,j}) - CC_{i,j} \leq 0$$

Rearranged equation 5.3.7 is as follows:

$$(OC^{r}_{i,j} + OC^{m}_{i,j}) - CC_{i,j} \leq 0$$

LINDO form of equation 5.3.7 is as follows:

$$KKBOCR + KKBOCM - KKBCC \leq 0$$

LIMITS:

$CC_{i,j} \leq$, i.e., $KKBCC \leq$

IV.9 LAND USE CONSTRAINTS

Equation 5.3.8

Original equation 5.3.8 is as follows:

$$\lambda^{k}_{i,j,t} * A^{k}_{i,j} \leq TA_{i,j}$$

Rearranged equation 5.3.8 is as follows:

$$\lambda^{k}_{i,j,t} * A^{k}_{i,j} - TA_{i,j} \leq 0$$

LINDO form of equation 5.3.8 is as follows:

$$\lambda^{k}_{i,j,t} * KKBA^{k}_{i,j} - KKBTA_{i,j} \leq 0$$

IV.10 CROP WATER REQUIREMENT CONSTRAINTS

Equation 5.3.9

Original equation 5.3.9 is as follows:

$$W^{k}_{i,j,t} * A^{k}_{i,j} \leq K_{i,j,t} * Ir'_{i,j}$$

Rearranged equation 5.3.9 is as follows:

$$W^{k}_{i,j,t} * A^{k}_{i,j} - K_{i,j,t} * Ir'_{i,j} \leq 0$$

LINDO form of equation 5.3.9 is as follows:

$$W^{k}_{i,j,t} * KKBA - K_{i,j,t} * KKBIRD \leq 0$$

PUBLICATION

A paper presented during the present study is reported as follows :

Patil, M. D., Sharma, N. and Ojha, C.S.P., "A Case Study of Transbasin Water Transfers Possibilities Between the Godavari and the Krishna Basin in India", presented at *USCID International Conference on Transbasin Water Transfers, conducted by UNITED STATES COMMITTEE ON IRRIGATION AND DRAINAGE (USCID)*, 1616 Seventeenth Street, Suite 483, Denver, Colorado, U.S.A. June 26-30, 2001.