STUDY OF WATER DEMAND IN A RIVER BASIN - A CASE STUDY

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree

of

MASTER OF TECHNOLOGY

in

IRRIGATION WATER MANAGEMENT

By

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the dissertation entitled **"STUDY OF WATER DEMAND IN A RIVER BASIN – A CASE STUDY"**, in partial fulfillment of the requirement for the award of degree of Master of Technology in Irrigation Water Management is an authentic record of my own work carried out under guidance and supervision of DR.U.C CHAUBE. This is to further certify that I have worked for the period from July 2003 to June 2004 for the preparation of this dissertation.

The matter embodied in this dissertation has not been submitted for the award of any other Degree.

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

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Date : 14. June, 2004

ABSTRACT

A river basin is a natural unit of water availability, its assessment and development to meet demand for various purposes. Need for adopting basin as an unit of planning is emphasized with supporting recommendations by various agencies and examples from various countries. Based on study of country practices, some important guidelines for basin water balance studies have been proposed for adherence, reference and use by those involved in river basin planning and management.

A simple method for characterisation of a basin has been developed and applied in the study of Ciujung basin in Indonesia. Emphasis in this study is on estimation of basin water demand for various purposes. Scientific methods in estimation of non-agriculture water demands (domestic and industrial use, minimum flow requirements for river maintenance, livestock water demand and fish pond water demand) and for estimation of irrigation demand have been applied in the study of Ciujung basin. Practices followed in India and Indonesia have been compiled and compared by making extensive literature survey.

Irrigation development potential in a basin depends on Water Potential Area (WPA) or Irrigation and Land Potential Area (LPA). LPA and WPA are the critical limiting factors of irrigation development in a basin. The irrigation potential area derived from water potential analysis are compared with those from land suitability and land availability analysis. The smaller of the two indicates irrigation development potential in a basin. Such study requires detailed analyses of water availability which is beyond the scope of this dissertation work. However procedure for estimation of irrigation development potential has been discussed based on practice followed in Indonesia. Such type of analysis is generally not carried out in India in the basin water balance studies as seen from the reports of NWDA (NWDA 1993, NWDA 1996). Therefore the approach and procedure discussed in this dissertation report can serve as an useful reference for water balance study in a more scientific manner.

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AD	= Agriculture Development
CCA	= Culturable Command Area
CGWB	= Central Ground Water Board
CBS	= Central Bureau of Statistics
CEC	= Cation Exchange Capacity
CWC	= Central Water Commission
DAB	= Directorate of water Supply
DMI	= Domestic, Municipal Industrial
DGWRD	= Directorate General of water Resources Development
ESCAP	= Economic and Social Commision for Asia Pacific
ESCAFE	= Economic and Social Commision for Asia and Far East
ET	= Evapotranspiration
FAO	= Food and Agriculture Organization of the United Nation
FIDP	= Formulation of Irrigation Development Program
GIR	= Gross Irrigation Requirements
G and D	= Gauge and Discharge
HPB	= Hutan Produksi Biasa (Normal Production Forest)
HPT	= Hutan Produksi Terbatas (Limited Production Forest)
HL	= Hutan Lindung (Protection Forest)
HPK	= Hutan Produksi Konversi (Convertion Forest)
IDR	= Irrigation Diversion Requirement
IWRD	= Integrated Water Resources Development
JICA	= Japan International Cooperation Agency
Kc	= Crop Coefficient
LPCD	= Litre/Capita/day
NWDA	= National Water Development Agency
PET	= Potential Evapotranspiration
Palawija	= Secondary food crops (grown mainly in dry season)
PPA/HSA	= Hutan Sifat Alam (Nature Reserve)
RePPProT	= Regional Physical Planning Program for Transmigration
TVA	= Tennessee Valley Authority
TPI	= Tata Penebangan Indonesia (Indonesia Selective Felling System)
TGHK	= Tata Guna Hutan Kesepakatan (Consensus Forest Land Use Plane
TAC	= Technical Advisory Committee
USA	= United State of America
UK	= United Kingdom
USDA	= United State Department of Agriculture
WR	= Water Requirement

CHAPTER - 1

INTRODUCTION

1.1 GENERAL

The primary resources of a country are her people, her land, and her water. Only with water do the other two resources become fully productive. Social and economic development of a country is very much dependent upon development and multi-purpose utilization of surface and ground water resources. Accordingly, water has received high priority in the development plans of India and Indonesia. Water resources projects have been and continue to be planned on project-to-project basis by separate departments and agencies to meet immediate and short term needs for which pressures exist. In view of this approach, total water resources of a basin are not being put to economic use. Also, full potential of many a beneficial projects can not harnessed in future and it becomes a loss for ever to the society.

In course of time, concept of water resource development has changed from single purpose, single source, adhoc development to integrated development of large multipurpose projects. Now emphasis is on environmentally sound development and management of river basin wherein exists the joint pool of water resources (rainfall, groundwater, surface flow in rivers and tributaries, water in lakes, reservoirs, soil moisture etc).

The aim of all water resource projects is to conserve and improve our physical environment for permanent human benefits. Man has inevitably to interfere with nature. Several water related human activities such as flood control, irrigation, hydropower generation, navigation, municipal and industrial water supply, waste water treatment and disposal, inter basin transfer, recreation, watershed management etc. occur simultaneously in a river basin. Figure 1.1 depicts the scenario of water related development activities and resource conservation measures in a basin. The inter-relation and the consequences of various development activities and need for resource conservation is evident.

The higher the scale of interference with nature, the more important is it to ensure that planning, design and construction of the undertaking are carried out under expert supervision, on the basis of all relevant data and taking into account various physical, social, economical inter-linkages among projects, among project components and between projects and environment.

The Indonesia is endowed with rich rainfall and fertile land for paddy cultivation. This good circumstance for paddy planting is not uniform over whole Indonesia. Fertile land area may not receive enough rainfall and much precipitation zone may not have good soil for planting. While planning for basin development water potential area and irrigation potential area also need to be analysed. Irrigation potential area is derived from balance land potential area and water potential area. Water potential area can be estimated from available water for irrigation and unit irrigation water requirement.

1.2 STUDY AREA

The purpose of this study is to illustrate scientific procedure for estimation of water demand for 1). Domestic Municipal and Industry (DMI), 2). River Maintenance, 3). Fish Pond, 4). Livestock and 5). Irrigation in Ciujung basin. Demand estimation are based on the various available data and information. For analysis of temporal variation, all demands should be estimated on monthly basis in a river basin. Ciujung river basin in Indonesia is the study area for this dissertation work.

The Ciujung river is one of the important river in West Java Province (Figure 1.2). Ciujung river with catchment area (from mouth) of 1,850 km^2 flows across four regencies namely Pandeglang, Bogor,Serang and Lebak. Ciujung river has length of about 106 km and it has 24 minor tributaries.and 2 major tributaries namely Ciseumeut and Cibeurang. Pamarayan Weir is located on Ciujung river for Ciujung Irrigation Scheme.

Directorate of Planning and Programming under Directorate General of Water Resources Development Ministry of Public Works Indonesia has carried out water demand estimation of Ciujung Basin in 1993 (JICA 1993). In this study water assessment has been carried out for the monsoon season and in annual basis. This was a preliminary study. As per this study the 75 % and 50 % dependable annual yield in the basin are 2,172 M cumec and 1,448 M cumec respectively. For proper planning, monthwise water demand study is also required. Therefore, in this dissertation, water demand study has been carried out on monthly basis.

1.3 OBJECTIVE AND SCOPE OF STUDY

1.3.1 Objective

The objective of this dissertation work is to study country practices for basin study and identify and illustrate (through a case study) appropriate scientific procedures for assessing multipurpose water demands (DMI, River Maintenance, Irrigation, Fishpond, Livestock, etc) and irrigation development potential in a river basin.

1.3.2 Scope

(i) Need and importance of adopting basin as unit for water planning. Recommendation by various agencies.

(ii) Literature review on practices followed in India, Indonesia and other countries to provide guidelines for demand estimation in a river basin.

(iii) Description of development condition in Ciujung basin.

(iv) Analysis of water demands for different purposes on monthly basis.

(v) Discussion of procedure for estimation of irrigation development potential in a basin and

(vi) Conclusions on the basis of country practices and case study of Ciujung basis.

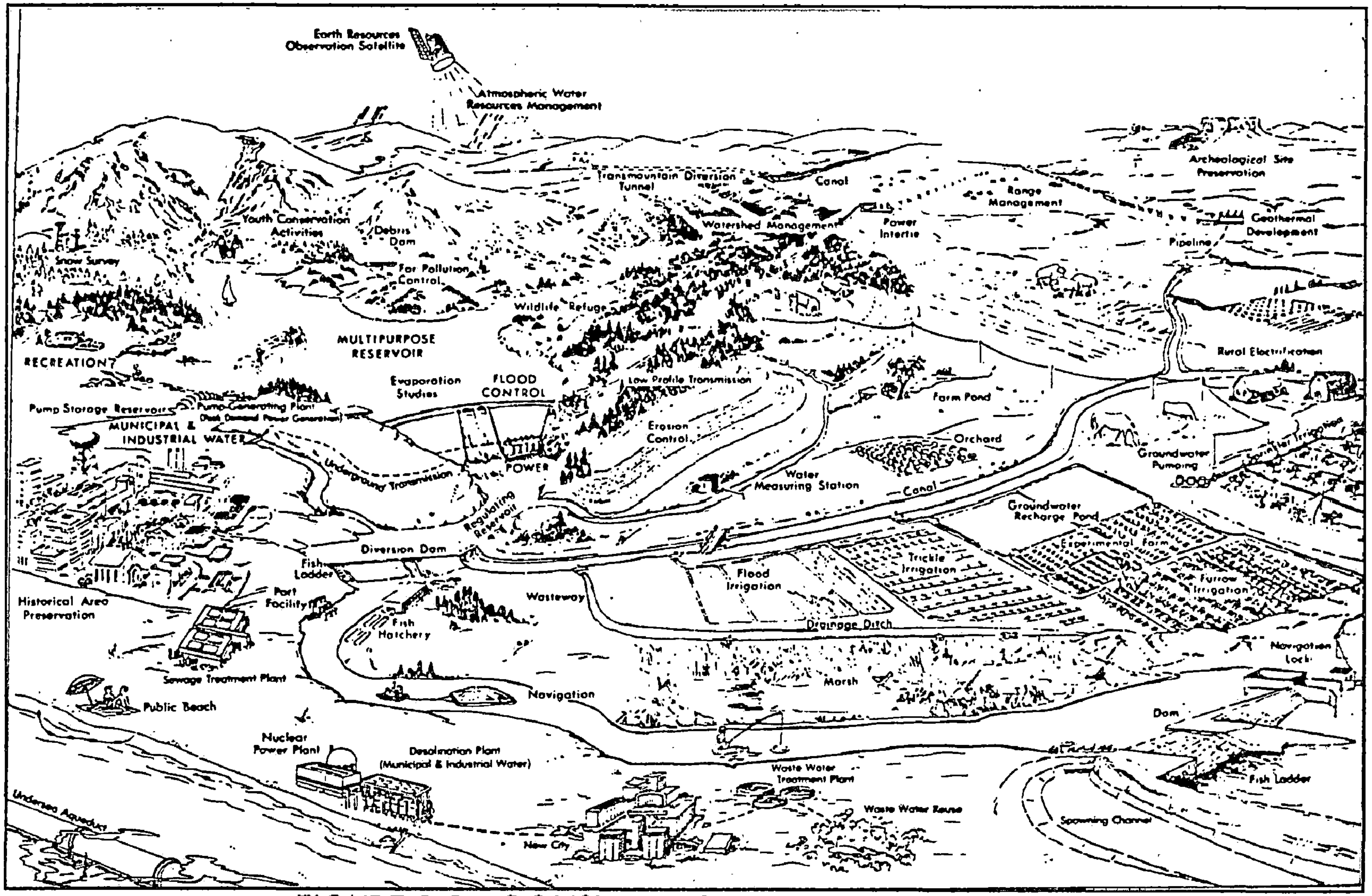


FIGURE 1.1. CONSERVATION AND FULL UTILIZATION OF WATER
(Source : Chaube 2003)

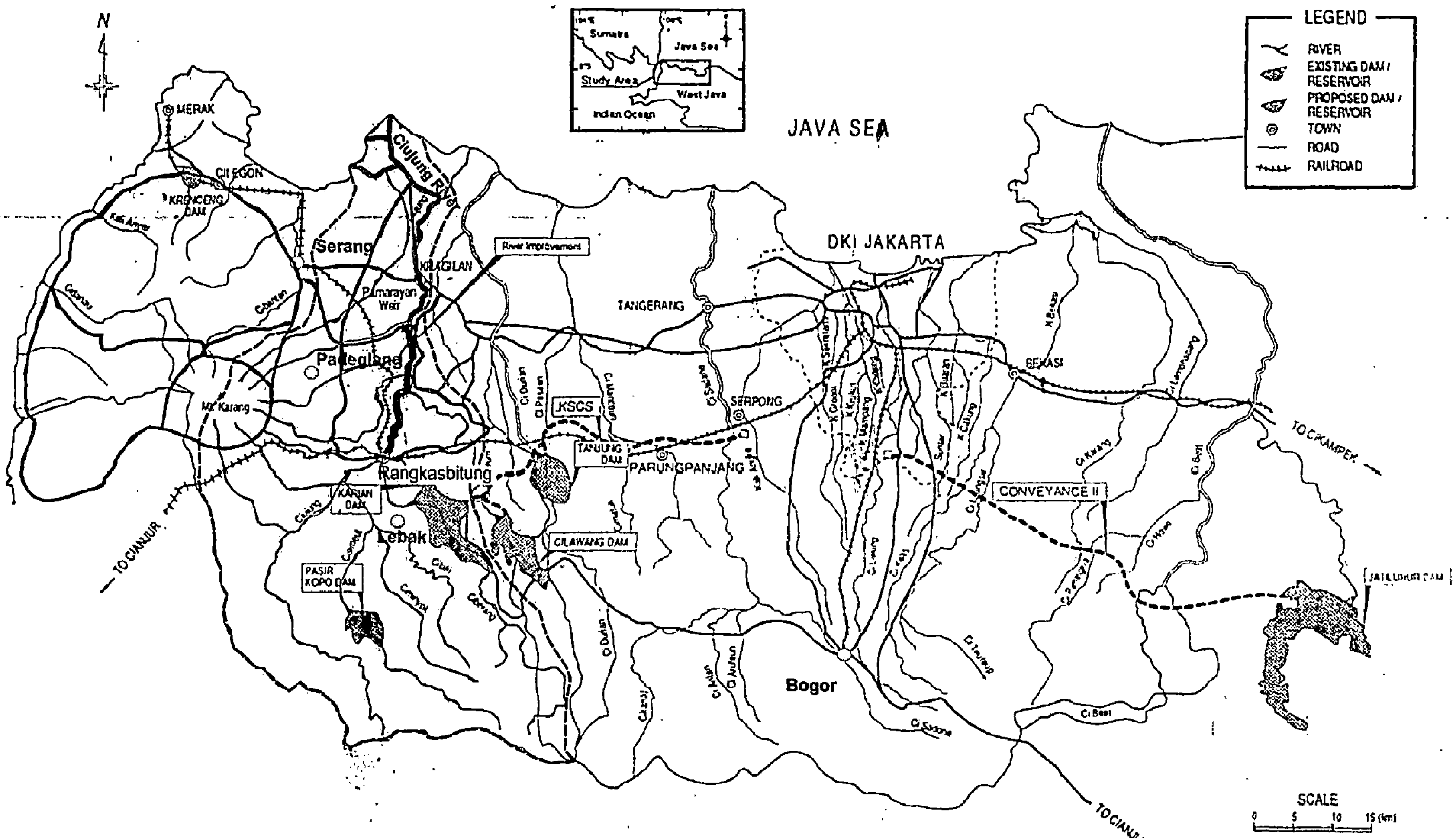


FIGURE 1.2. STUDY AREA

CHAPTER –2

NEED, IMPORTANCE AND TECHNICAL CONSIDERATIONS IN BASIN STUDY

2.1 GENERAL

Sustainable and integrated development and management of fresh water resources has to be related to a specific region. River basin is a natural hydrologic unit of water availability, its assessment and development. Basin is also a natural habitat for human beings and other species. This chapter defines a river basin and explains the need and importance of considering a river basin as the planning unit. Some important technical considerations and assumptions are required to be made in basin study. Based on literature review some useful guidelines for basin water balance study have been compiled in this chapter.

2.2 RIVER BASIN DEFINITION

A river basin is defined as an area from which a natural lake, stream or waterway and man-made reservoir receives surface flow which originates as precipitation. Such an area is called 'watershed' in American usage. In English usage 'watershed' means boundary line or divide separating the adjacent drainage basin. Watershed of a river basin may not co-incide with phreatic divide which fixes the boundary of an area that contributes ground water to each stream system.

The geological formation under many river basins is such that precipitation falling on one basin finds its way underground through fissures and water bearing strata to an outlet either in a nearby or a remote drainage basin or directly to the sea. This is called watershed leakage.

A river basin is also viewed as an eco- system and natural habitat for a variety of species. Species are defined as groups of individuals who can survive only in populations and through interbreeding with similar kind of individuals. Thus we have plant, animal and human species. River basin provides home (space) and life resources for these species and is therefore a natural habitat. River basin development usually implies conversion of natural habitats to other uses, depriving some biological species of their homes and life resources.

2.3 RIVER BASIN AS UNIT OF PLANNING

It came to be appreciated by 1930s that only coordinated planning for a river basin, as a whole, for multiple benefits can lead to optimum economic results for the region and the country. It is not that the entire basin must be developed at one time - only each new work of development from a river must take due note of the requirements of other works already built, or to be built, above or below the new work. In other words, an outline Master Plan of development of every river basin has to be prepared, as early as possible, and all works on the river system must be built in accordance therewith.

A basin plan should show not only the extent and the nature of developments proposed in it but also the extent of irrigable areas for which adequate irrigation supplies could not be provided, and have therefore to be imported, as well as the quantum of surplus water if any remaining unutilized and thus available for development outside the river basin.

In initial stages of water resources development in India, large projects in a number of river valley's were taken up by the States to boost up agricultural production to achieve self sufficiency in food. The easier sites for putting up storage structure have already been exploited by many States. The future major water resources projects have to be taken up at rather difficult locations. The new projects are more likely to be inter-State in nature. Also, as the demand on available water resources increases with developmental activities, interactions between projects come into play and multi-State interests may have to be taken care of. All these factors point to the necessity of moving beyond the limited interests of a State alone in dealing with water resources and underline the need for development and management on the river basin level.

A river basin has a defined watershed boundary and within it there is inter relationship between the surface water, groundwater and the supporting natural environment. Several water related human activities occur simultaneously in a river basin. There are temporal and spatial variations in water availability and in water demand. There are competing and conflicting demands for water. As discussed in following section it is well recognized World wide that only a holistic approach to planning, development and management with basin as an unit can address all water related issues successfully.

2.4 RECOMMENDATIONS BY VARIOUS AGENCIES

Importance of river basin as an unit of planning has been stressed from time to time by various agencies. Based review of literature some of the relevant recommendations are quoted below:

Irrigation Commission of Government of India(1972)

"5.7 The Planning of water resources has to be related to a defined area or region, with due regard to inter-regional needs. A river basin, and in the case of large rivers, a sub-basin is a natural unit. It has a defined watershed boundary, and within it there is an inter-relationship between the surface and groundwater resources. A river basin, therefore, becomes a suitable unit of planning".

"5.13 ...In formulating schemes, the States have not always paid due attention to the overall needs of river basins. In the absence of coordinated plans for the development of the basin as a whole the available water resources cannot be put to the best use".

"5.9...There should be for each basin, a water budget of all sources of water, surface and subsurface ".

National Commission of Agriculture of Government of India (1976)

"7.3.31 ... Comprehensive river basin plans should be drawn up for the proper development of the land and water resources of the basins ".

National Commission on Floods of Government of India (1980)

"15.2.5... A river basin is the most suitable and proper unit for preparation of water and flood plans".

"15.2.1. ... Floods should find a place in the comprehensive planning for water resources development. The first choice should therefore, be to undertake comprehensive water resources development in a river".

"15.2.4 .... Flood Master Plans should not in any way vitiate or conflict with future comprehensive plans for water resource development".

The United Nations Water Conference held in Mar-del Plata, Argentina in 1977 recommended the formulation of master plan for countries and river basins to provide a long term perspective for planning, including resource conservation using techniques like system analysis and mathematical modeling as planning tools, wherever applicable.

The International Conference on Managing Water Resources for Large Cities and Towns, held in Beijing on 18.21 March 1996 also recommended that the basic unit of water resources management is the river basin. Effective implementation of an integrated water resources management plan would benefit from the establishment of a public or semi-public autonomous basin organization.

National Water Policy adopted by Government of India in 1987 states: "Resource planning in the case of water has to be done for a hydrologic unit such as a drainage basin as a whole or for a sub-basin. All individual developmental projects and proposals should be formulated by the States and considered within the framework of such a overall plan for a basin or sub-basin, so that the best possible combination of options can be made".

2.5 COUNTRY PRACTICES ON BASIN PLANNING

Several countries have successfully adopted the concept of basin as an unit for planning and development of water resources. Chaube (1993) has compiled the practices followed in various countries. Tennessee Valley Authority (TVA) in 1934 in the United States was initially evolved in 1934, to perform not only a specified number of engineering tasks but also to deal with large social issues.

In the early years of the TVA, a wide range of regional planning activities were initiated and carried out which included a forestation, extension programmers for better land use and soil management and a variety of community development programmers. These activities were soon relegated to the periphery and the Authority functioned more like a power production and flood control corporation. In the united States, the idea of river basin planning and management gradually took shape into an operational concept through a progressive synthesization of their inter-related but separately evolved concepts of multipurpose projects, unity of drainage basin and the acceptance of the Government's intervention in the promotion of social welfare. Over the years, despite the criticism against the working of TVA, the concept of river basin planning and management has survived in the USA.

In United Kingdom in 1973, under the water act based on the principle that a single authority should plan and control all uses of water in each river basin, nine English Regional Water Authorities assumed responsibility for water supply, sewerage and sewage disposal, as well as for water resources planning, pollution control, fisheries, flood protection, navigation, water recreation and environmental conservation. Over the years, it has been found the these water authorities worked well in practice.

Among the ten water authorities in U. K, the Thames Water Authority is a classic example of integrated river basin management. The basin supports 3500 abstractions 1200 for agriculture, 500 for domestic water supplies and 1800 for industrial and other uses. The river receives industrial effluents at 6500 locations and effluents from sewage treatment works at 450 locations. Besides, the river is used for fishing and boating. The river flows are regulated and managed to ensure that discharges do not pollute water supplies and abstractions do not effect the level of the river to the extent that it put at risk natural life or the enjoyment of those who use the river for recreation.

In France, the 1992 law recognizes water as a single unitary resource irrespective of its physical and geographical distinctions. The management of water is done in the framework of a river basin.

The French system basically consists of setting up a river Basin Committee (comprising about 100 members) with roughly one-third of the members from elected representatives, one-third of the members representing the different water users identified and the remaining one-third socio-economic professionals and administrators. The River Basin Committee is a small Parliament for water at basin level; it is also the policy making body for each river basin, decides broadly on the development plans to be taken up and gives an agreement on the level of financial charges collected by the River basin Agency which is the executive limb of the River Basin Committee. After being voted by the River Basin Committee, the level of the financial charges must be ratified by the Central Government. The River Basin Agency's Board of directors consists of 26 members (one third elected representatives, one-third water users representatives and one-third representatives from the various institutes involved in water resources management).The Chairman of the Board of Directors is nominated by the Central government. The River Basin Agency is financially self-sustaining.

French system is, thus basically founded on the following features:

(i) Water user pays for the water he is using and polluter pays for the water quality deterioration he is causing. The system is structured in such a way that it takes into account the capacity to pay for each category of users (domestic, industrial and farmers for irrigation).

(ii) The water resources development and management is financially self-sustaining. The water charges are proposed by the Agency's Board of directors and later on agreed upon by the River Basin Committee. Since elected representatives are also members of the river Basin committee, there is general consensus on the water charges and recovery of water charges is very satisfactory.

(iii) More than 90 per cent of the money collected is afterwards redistributed under the form of financial assistance (loans and grants) either for pollution control actions or for the development of water resources and their sustainability.

The French system is more independent and transparent in nature

In Asian region, the Mekong river covering the whole of the Lao PDR and Kampuchea, one third of Thailand and two-fifth of Vietnam, is under a Mekong Committee established by the ESCAFE now ESCAP (Economic & Social Commission for Asia and pacific) in 1957 with secretariat office at Bangkok which co-ordinates the work of collection of basic data and river basin planning.

- In China, the 1988 water law requires that basin plans should serve as the basis for water development, utilization and prevention of damage. There are seven Commissions covering the six major river basins and one lake basin. These are the central agencies having planning and regulatory functions under the Ministry of Water. The Yellow river conservancy Commission has additional responsibility of flood management in lower Yellow river and the operation of all reservoirs. It has considerable financial strength and autonomy as a consequence of water and power receipts from the operation of projects. However, major basins are not managed by a single agency.
- Indonesia has also created several basin agencies with power which include planning regulation and management of major facilities.There are a large number of islands each having several drainage basins with direct outlets to ocean. Regional plans causing several smell basins have been

prepared focusing on a particular aspect such as flood control, rice crop production.

- In Sri Lanka, The Mahaweli Authority has been a powerful body for both development and management of major storage and irrigation projects. It also provides secretariat for planning and other water management activities.
- The Philippines has also accepted the concept of planned development of water resources on the basis of basins. The 36 basin plans prepared in the country provide the basin for all water licensing the project clearance.

Problem of International Shared Basins

Nearly 47% of the area of world falls within shared rivers and lake basins. Nearly 60% of Africa and South America are within shared basins. There are 44 countries in the world where atleast 80% of the total areas lie within international basins.

An analysis shows that there are 214 river and lake basins that are shared by two or more countries. Of these, 156 basins are shared by two countries. There are nine basins which are shared by six or more countries. Any development on an international river is subject to international law. In view of the conflicting interests of the countries, it is very difficult to develop and manage international river basins in an efficient manner. Generally, the issues amongst the countries are politically sensitive. As such, the riparian countries are not able to formulate rights agreements. The impending conflicts resulting from lack of agreements influences basic policy decisions and development strategies. The unilateral exploitation of shared water resources by one country, without the prior agreement of the other co-basin country could lead to serious conflicts and regional instability (Chaube U.C.2003).

2.6 GUIDELINES ON BASIN WATER BALANCE STUDIES

The National Water Development Agency (NWDA) was established by Government of India in July, 1982 as an autonomous society under Ministry of Water Resource.

For the sake of equity and uniformity in water Balance studies for river basins and guidelines have been issued by the Technical Advisory Committee of NWDA on important aspects like working out water availability yields, methodology for working out ultimate water requirements, water surpluses, land uses, ground water requirements for various purposes like drinking, industrial, irrigation and other uses, salinity control etc. NWDA (1996) has compiled such guidelines at one place for facilitating in its adherence, reference and use by those involved in river basin planning and preparation of inter- basin transfer link reports. These are briefly discussed below:

2.6.1 Soil, Land use, Delta and Water Use

1. The permanent pastures and other grazing land need not be included in the culturable area of the basins/ sub-basins and no separate provision would be necessary for irrigating the permanent pastures and the other grazing lands. (9th TAC-Feb, 1987).
2. Fodder crops should be included in the cropping patterns recommended by the NWDA in the water balance studies. (9 th TAC-Feb,1987).
3. The overall delta for major, medium and minor projects should be computed based on climatological data of the station in or adjacent to the basin / sub basin. To work out delta of minor projects, an irrigation efficiency of 80 % and evaporation losses at 10 % of the water withdrawals form the storages may be assumed, (10 th TAC-Oct,1987).
4. The culturable command are (CCA) need not be projected to 2025 AD and it would be adequate to consider the maximum culturable area of the recent years.(11 th TAC - Aug, 1988).
5. It was agreed that in case of such future projects reports which have already been approved by CWC, the cropping pattern will be based on the availability of water and carrying capacity of soils. (15 th TAC- June, 1991).
6. In case of future studies conveyance efficiencies of 65 % for major and medium projects and 80 % for minors projects will be considered while working out gross irrigation requirements (GIR) for paddy crops. The studies already completed by NWDA need not be revised in view of insignificant change with the existing and proposed methods. (17 th TAC- Aug, 1992).
7. The water requirement may be worked out on the basis of suggested cropping pattern and by the climatological approach as per the present practice. (22 nd TAC - June, 1995).

8. The practice of providing 20 % of rabi area with 50 mm for pre-sowing irrigation in future project would be enough for planning purposes. (24 th TAC-June,1996).

2.6.2 Computation of Yields

1. The yield studies by the rainfall-runoff correlation taking monsoon months as a whole be continued. Wherever monthly rainfall-runoff correlations are obtained for any sub- basin,multiple correlation should be considered. (9 th TAC- Feb, 1987).
2. In case where there are no G and D sites or the existing G and D sites cover only a small portion of the catchments, rainfall-runoff relationship obtained for the adjoining hydrometerologically similar basin /sub basin may be adopted.
3. The surface water yield need not be workout at the state boundaries. The existing procedure for deciding the best-fit equations on the minimum standard error of estimate might continue. (11 th TAC- Aug, 1988).
4. Though the computer programmers of all the alternative methods have been developed but for water balance studies linear / non linear type of correlation which have already been used could continue. (18 th TAC- Mach 1993).

2.6.3 Water Availability

1 The water balance study may project availability at both 75 % and 50 % dependability. However, the proposed scheme should provide for a 75 % success rate. (7 th TAC - Nov, 1985).

2 The NWDA reports might consider the water resource available in the basin to be sum of gross monsoon surface water yield and the replenishable ground water potential. For any transfer of surplus water outside the basin, the monsoon flows in the basin will figure in practice.(10 th TAC- Oct,1987).

3 The water balance studies may be updated after a period of 10 years when additional data become available. (7 th TAC- Nov, 1985)

Water availability up to the project site to be checked on the basis of the following:

(i) Flow series are based on observed data and corrected for existing utilization.

(ii) Extended flow series are based on rainfall-runoff correlation for the project site.

(iii) Extended flow series based on rainfall-runoff correlation for the nearest hydrometeorogically similar watershed.

(iv) Prorata basis:

50 % and 75 % yield computed as above may further be adjusted for the ultimate utilization upstream, exports and import to compute 50% and 75 % dependable availability. Water utilization for any project should be restricted to a maximum of 75 % dependable availability in case of diversion. However for storage projects, requirement may exceed 75 % dependable availability with provisions of carry over storage.

2.6.4 Ground Water

1. While the water balance reports may deal with the ground water availability, the existing and projected uses etc in the early reports, data and findings should be presented state-wise and no attempts should be made to assess or identify any surplus or deficit in ground water availability in any basin. The ground water should be left entirely to the concerned states for use. (9th TAC-Feb, 1987).
2. Consider the gross ground water potential of the basin /sub basin assessed from the statistics supplied by the CGBW/ central ground Water Boards and subtract the domestic and industrial use estimated by the NWDA to be met from ground water resources for obtaining the ground water potential available for irrigation use. (10th TAC- Oct, 1987).
3. The ground water should be continued to be indicated as separate resource state-wise. The Water Resource available for estimating surplus/ deficit of any basin /sub basin should be taken only as the monsoon surface flow. For such estimation the award made by various tribunal for concerned basins should also be kept in view. (11 th TAC-Aug, 1988)
4. Water balance studies of deficit sub-basins/ basins should be reviewed by NWDA to count for ground water potential. (15 th TAC-June,1991).

2.6.5 Water Requirements

Domestic and industrial water requirement

1. Consider consumptive use of domestic and industrial use as 20 % and 25 % respectively of the surface water diverted or lifted from the rivers, reservoirs, storages, canals etc. (7 th TAC-Nov,1985).
2. The 50 % of the rural water requirement and entire livestock water requirements is proposed to be met from ground water sources. The urban water requirement in full and 50% of the rural water requirement is to be met form surface water source (11th TAC-Aug, 1988).
3. Entire industrial water requirements are to be met form surface water sources. (11 thTAC-Aug, 1988).
4. The per capita water requirements @ 200 lts. and 70 lts. for urban and rural population adopted in the NWDA studies may be continued for the present as it made better impact on the overall water availability with 80% of the water returning back to the system. (15th TAC- June, 1991).
4. In order to update the water balance studies it was decided that while revising the studies population (Which are presently up to 2025 AD) may be made for 2050 AD.(22th TAC-June, 1995).

2.6.6 Salinity Control

- It was decided as per the clarification of NWDA to Kerala Govt. that a lump sum provision of 10% of the 75% dependable yield will be earmarked for salinity control tentatively pending detailed studies in this area. (14 th TAC-Oct,1990)

Water releases in the river for environment and ecology.

- After meeting downstream requirements a minimum leaned season flow of 10% of the inflow at diversion structure should be maintained for environmental and ecological purposes. With storage, this could be of the order of 10 % of the average lean season nature flow downstream of the storage. (23 rd TAC- Dec, 1995).

2.6.7 Annual Irrigation

1. The intensity of irrigation in the case of existing and on going projects will be as per the present use. Under Peninsular river development component for the future projects, the intensity may assumed as 150 % for major projects, 125% for medium projects and 100 % for minor projects. The studies should also consider possibility of augmentation in the existing storage to increase the present intensity of irrigation, wherever this is less than the percentages indicated above for the future projects. (7 th TAC - Nov,1985).
2. Any surplus surface water for transfer should be assessed only after considering the water needs of the basin for extending irrigation to 60 % of net culturable area. (10 th TAC - Oct, 1987).\

2.6.8 Area to be Brought under Irrigation by 2025 AD

1 In water deficit area, the first attempt should be to cover at least 30 % of the culturable area of the basin/ sub - basin by irrigation from surface water. (9th TAC- Feb,1987).

2 In case of deficit basin /sub-basins where the percentage of existing irrigation from surface water is around 30 % of the culturable area, the NWDA may consider extending irrigation facilities to 60 % of the culturable area where the additional area to be brought under irrigation would be for a single dry crop without considering any high water consuming crop like sugarcane and paddy. (9th TAC - Feb, 1987).

3 Extension of irrigation from 30 % to 60 % of the culturable area in the deficit areas by ways of transfer from other basins should also stand the scrutiny of economic criteria. (9th TAC- Feb,1987).

4 Before diversion of water, irrigation level of at least 60% of the culturable area as annual irrigation as being followed in the NWDA studies as decided by the TAC earlier was in order. (18th TAC - March, 1993).

5 The command area of each proposed project may be examined with regards to availability of culturable area overlap with other projects etc. The time of updating the water balance studies. (22nd TAC- June, 1995)

2.6.9 Seepage and Evaporation Losses

1 The water requirement for irrigation be worked out on climatological approach and reasonable provision made for the field and transmission losses as well as evaporation from the storage. (7th TAC- Nov,1985).

2 It was decided to adopt 20 % if of the withdrawals from the reservoir as evaporation losses in the absence of actual data TAC recommended same figure for minor schemes also. (11th TAC - Aug, 1988).

3 The NWDA might adopt an irrigation efficiency of 55 % for major and medium irrigation projects with a regeneration value of 10 % and an irrigation efficiency of 70 % for minor projects without considering any regeneration. (11th TAC- Aug, 1988).

2.6.10 Regeneration

- Regeneration would be considered as (i) 10% of the net water utilization for irrigation from all the existing, ongoing and future major and medium projects including those from imported water and (ii) 80 % of the domestic and industrial water use met from surface water resource and that no regeneration would be considered from minor irrigation schemes and domestic and industrial use met from ground water. (11th TAC- Aug, 1988).

2.6.11 Technical Points Related To Himalayan Components Studies

i) Intensity of irrigation:

Considering availability of considerable ground water potential in the basins of the Himalayan rivers, it was decided that the areas where existing irrigation intensity is less than 100 %, the same may be increased to level of 100% from surface waters. Where, the existing intensity of irrigation is more than 100 %, the intensity can remain at the same level. Additional intensification over and above those indicated above may be carried out by using ground water to encourage conjunctive use and to avoid the problems of water logging and salinity. (20th TAC- May,1994).

ii) Irrigation in the enroute area:

The areas enroute the link canals not covered by any other irrigation schemes may be provided irrigation to the extent 100 % intensity from the surface water and additional irrigation by ground water.

(20th TAC- May, 1994).

iii) Irrigation in the target area:

The target area should be covered by extensive irritation and an intensity of not more than 100 % should be provided from the transferred water. (20th TAC- May,1994).

iv) Water requirements downstream of diversion points:

While carrying out water balance studies at the point where diversion are contemplated, the water requirements will also included the committed utilizations and additional requirement down stream, which cannot be met from the water available downstream. (20th TAC- May, 1994).

v) Seasonal water balance

Water balance study at diversion points where reservoir is contemplated will be carried out on annual basin as most of the flow can be considered to be regulated. However, at diversion points where reservoirs are not contemplated, water balance study will be carried out on a seasonal basis. (20th TAC-May, 1994).

2.7 GUIDELINES BY NATIONAL COMMISSION FOR INTEGRATED WATER RESOURCES DEVELOPMENT (GOVT OF INDIA)

Report on "Integrated Water Resource Development - A Plan for Action" by the National Commission for Integrated Water Resources Development- Volume I Ministry of Water Resources Government of India September 1999 was reviewed (Govt. of India 1999) and guidelines/norms for estimation of water demand are summarized below.

Natural population growth rate in urban area 2.0 % during 1981-1985 and 1.7% during 1992-1994.

Bovine population growth rate 0.5 % per year.

Table 2.1: Guidelines/ Norms for Estimation of Water Demand

	Unit	2010	2025	2050	
Food Demand	Kg/capita/year	194	218	284	
Rainfed food crop yield	tonnes/ha/year	1.1	1.25	1.5	
Irrigated food crop yield	tonnes/ha/year	3.0	3.4	4.0	
Irrigation efficiency of surface water	Percent	40	50	60	
Irrigation efficiency of ground water	Percent	70	72	75	
Norm for domestic water supply class I city	litre/capita/day	220	220	220	
Other than class I city	do	150	165	220	
Rural	do	55	70	150	
Bovine (cattle)	do	18-30	18-30	18-30	
Norms for water requirement in power sector					
Thermal	.001 km3/year/100mw	2.5	2.1	1.5	
Hydropower	-	-	-	-	
Nuclear	do	3.0	3.0	3.0	
Solar/Wind	do	0.175	0.175	0.175	
Gas based	do	0.47	0.47	0.47	
Water requirement for navigation	Min width (m). Min depth (m)	45 1.5	45 1.5	45 1.5	
Evaporation loss from major reservoirs	% of life storage capacity	15	15	15	
Evaporation loss form minor reservoirs	% of life storage capacity	25	25	25	
Return flow from irrigation (i)Surface water supply (ii) Ground water supply	% of GIR do	36 18	30 17	24 15	GIR: gross Irrigation supply
Return flow from domestic & municipal use	% of supply	50	50	50	Of this 85 %goes surface water source and 15 % to ground water source
Return flow from industrial use	% of supply	50	50	50	Return flow goes to surface water source

Source: Govt of India, 1999

CHAPTER –3
STUDY AREA CHARACTERISTICS

3.1. GENERAL

Proper assessment of multi purpose water demand in a basin is an essential pre-requisite for the efficient planning and development of the resources. River basin being the basic hydrologic unit for planning and development of water resources, it follows that assessment of water demand has necessary to be basin wise.

Indonesia is divided into 90 river territories for the purpose of water demand calculation and assessment of water availability. This river territory system is divided further into 136 river basins. River territory system is based on administrative management boundary rather than on hydrological watershed boundary basis.

River territory is subdivided into river basins if it has :

- Island (s), those island (s) should be one river basin
- In large scale river system, river territory is divided into major tributary river systems
- Different watershed, for which estuary is also different ocean related is a river basin
- Large enough drainage area of a single basin is divided into two river basin i.e. upper river basin and lower river basin.

80 % dependable river runoff is assumed to be natural river run off (without any deduction of water demands) for further calculation of water balance. Table 3.1. shows estimated water availability in Indonesia.

Table 3.1. Estimated Surface Water Resource

Region	*MCM/Year*	*Percent*
Sumatera	482,173	26 %
Jawa	122,699	7 %
Bali & Nusa Tenggara	45,909	2 %
Kalimantan	556,700	30 %
Sulawesi	143,343	8 %
Maluku & Irian Jaya	496,422	27 %
INDONESIA	1,849,246	100 %

Source : JICA-1993

3.2. BASIN DESCRIPTION

3.2.1 River System

Ciujung River basin area of 2,499 km² lies between 105°61' and 106°56' East Longitude and 5°50' and 7°10' South Latitude, The Northern part is bounded by Java Sea, the Western part by Sunda Strait, the Eastern part by Ciliwung-Cisadane basin and the Southern part is bounded by long line of mountainous region with elevation between 1,300 m till 2,200 m from sea water level. The Ciujung River is one of the important flowing river of West Jawa Province, Indonesia. Ciujung River has a length of about 106 km and has 24 minor tributaries namely Cibeunjar, Cimajang, Cibeureum, Cilisung, Cibiuk, Cimuli, Cipanjangan, Ciliwet, Cilajang, Cinadukapol, Cipamastran, Cioray, Cilancar, Cipanas, Cikeuyeup, Cikupa, Cikambueun, Cisangu, Cikambuy, Cisangumali, Ciasem, Cipari, Cikalitinggal and Cisimet) and 2 major tributaries namely Ciseumeut(CA = 458 km²) and Cibeurang(CA = 305 km²). At the Ciujung River is available Pamarayan Weir Ciujung Irrigation Scheme. The main Ciujung River joints with these tributaries at just upstream of Rangkasbitung and passes through the existing Pamarayan Weir which is an irrigation intake of the Ciujung Irrigation Scheme. The envisaged Karian and Pasir Kopo dam sites are located in the Ciujung River Basin. Basin is nearly tall shaped (medium scale type 1,000 km²~10,000 km²).

3.2.2 Climate

The study area belongs to typical humid tropical zone and the weather patterns are characterized by the monsoons. The wet season is defined as a period from November to April and the dry season from May to October in general. The monthly mean temperature are rather stable throughout a year ranging between 26°and 27°. The monthly mean relative humidity indicates generally high humidity ranging from about 80% in the dry season to 85% in the wet season throughout a year. The monthly mean velocity at Serang range between 4 knots and 5 knots or 2.1 m/sec and 2.6 m/sec. The monthly mean sunshine duration at Serang ranges between 5 and 6 hours per day in the dry season and 3 to 4 hours per day in the wet season. Average potential evapotranspiration in the basin is 137.5 mm/month.

3.2.3 Rainfall

The annual rainfall in the Ciujung river basin ranges from 4,000 mm in the mountainous area to 1,500 mm in the coastal area. The mean annual basin rainfall at the existing water level gauging stations at Rangkasbitung, Pamarayan and Kragilan in the Ciujung river basin, are given in Table 3.2 as follows:

Table.3.2. Annual Basin Mean Rainfall

Water Level Gauging Stations	*Mean Annual Rainfall*
Ciujung River Basin	
- Rangkasbitung	3,005 mm
- Pamarayan	2,970 mm
- Kragilan	2,798 mm

3.3.3 Radar Chart Characterisation

To grasp basins characteristics in view of water resources development and watershed conservation, four major items, namely forest area, rainfall, irrigation area and population are selected to make radar chart for easy understanding (Table 3.3)

Table 3.3. Parameter for Water Resources Development and Watershed Conservation

Parameter	*Description*	*Range*
1. Forest	Ratio of forest area to basin area	13 % ~ 97 %
2. Rainfall	Annual Rainfall	1,277 mm ~ 4,224 mm
3. Irrigation	Ratio of irrigation area to basin area	0 % ~ 35,1 %
4. Population	Population density Rural population are converted to urban population in proportion of water consumption rate	1 ~ 2,757 person / km^2

To make radar chart, above four parameters are divided into following five classes (Table 3.4). Figure 3.1 shows radar charts for these five classes.

Table 3.4 Classes of Parameters

Class	*Forest (%)*	*Irrigation (%)*	*Population (person/km²)*	*Rainfall (mm)*
1	12.5 ~ 30.0	0 ~ 2.5	0 ~ 2.5	< 1,500
2	30.0 ~ 46.0	2.5 ~ 5.0	25 ~ 75	1,500 ~ 2,000
3	46.0 ~ 63.0	5.0 ~ 10.0	75 ~ 150	2,000 ~ 2,500
4	63.0 ~ 80.0	10.0 ~ 15.0	150 ~ 250	2,500 ~ 3,000
5	> 80.0	> 15.0	> 250	> 3,000

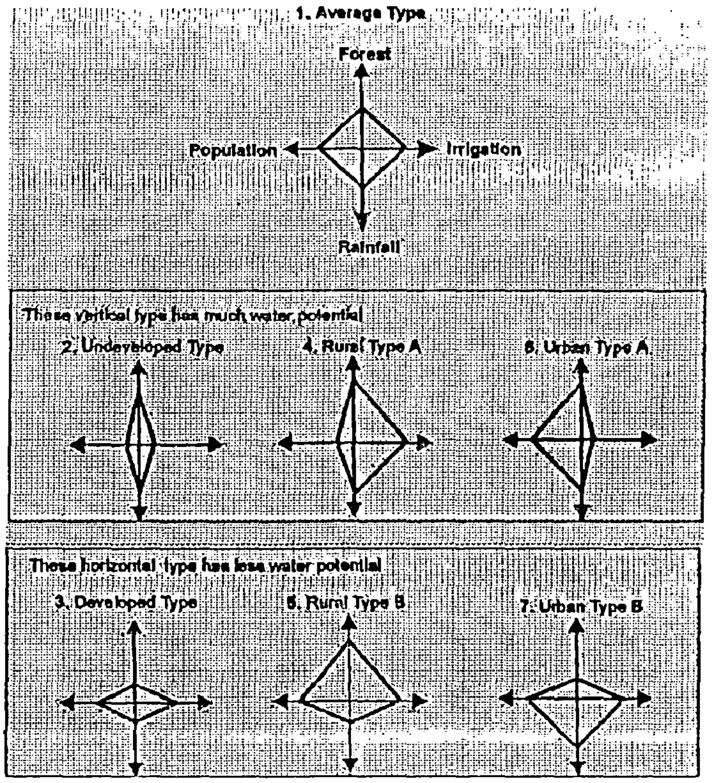


Figure 3.1 Seven types of radar charts depicting different basin characteristics

In view of irrigation development, a river basin is evaluated and categorized into one of the following three development type for deciding further development direction taking into account basin characteristic (radar chart) and other information (rainfall information, total population, vegetation)

1. **Development Basin** has much development potential. Basin authority should pay attention to basin environment and conservation
2. **Conservation Basin** can be developed if basin environment and conservation assessment results allow to develop
3. **Management Basin** should be developed under the control of overall water resource development management

Development type of Ciujung river basin is categorized as conservation type.

3.4 CONDITION of CIUJUNG BASIN and BASIN MAP

The Ciujung river basin (CA 2,499 km ^{2}) is in the west Java Province of Indonesia (Figure 3.2).

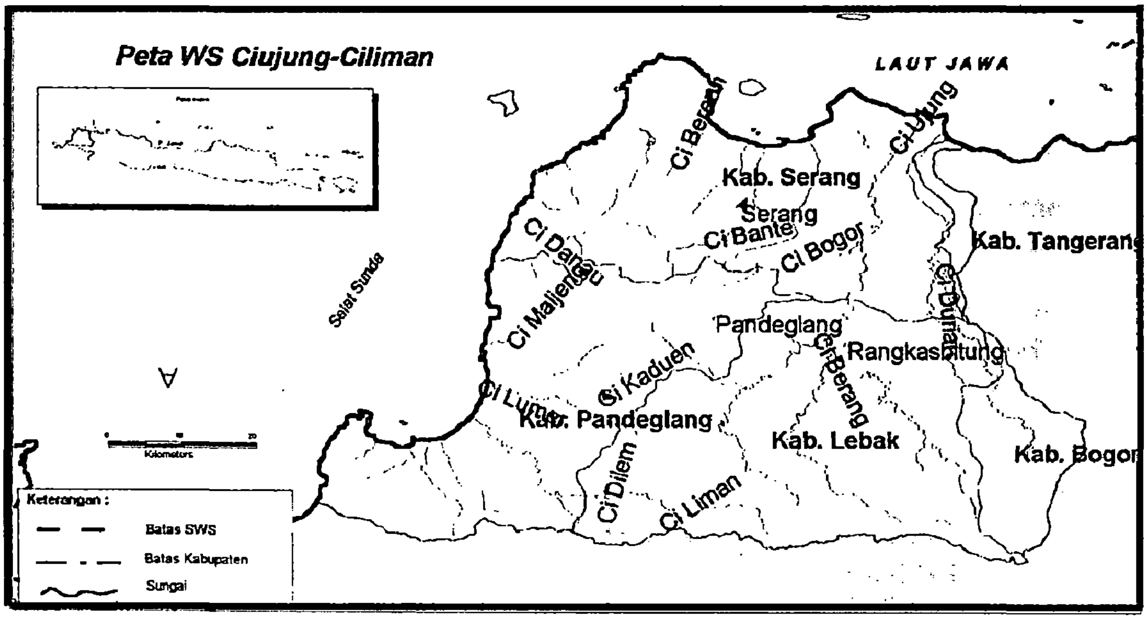


Figure 3.2 Ciujung river basin map

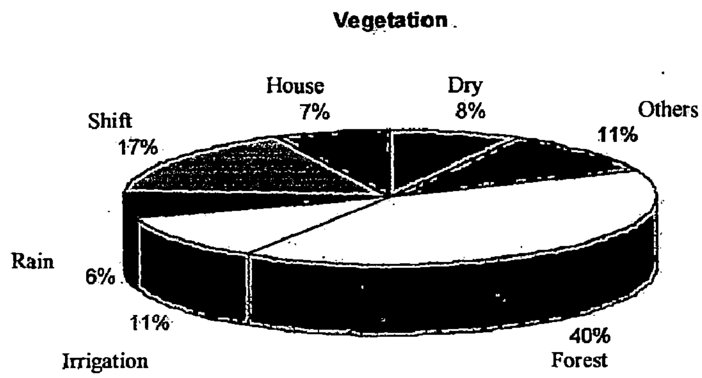
Different regencies covered in the Ciujung basin are given below

Padeglang	220 km ^{2}
Lebak	1,207 km ^{2}
Bogor	64 km ^{2}
Serang	972 km ^{2}

Average annual rainfall is 3083 mm with a 28 % coefficient of variation. Land use pattern is given below

Forested Land		1,053 km ^{2}
Wet paddy field Irrigation		302 km ^{2}
	Rainfed/Tidal/Swamp	171 km ^{2}

Upland field	Garden/ Dry field	211 km^2
	Shifting cultivation	463 km^2
	Grass Land	177 km^2
	House Compound	8 km^2
	Swamps/Dyke/Pond	45 km^2
	Fallow Land	68 km^2



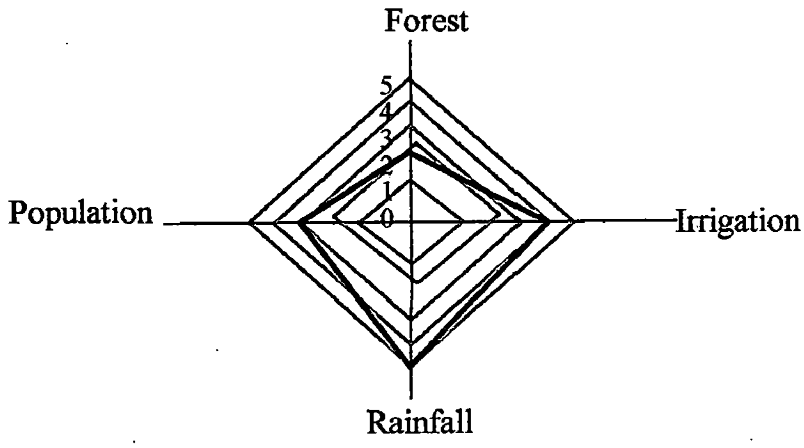
Human Population : Basin has a population density of 480/sq.km.

Urban	220,346
Rural	977,999
Total	1,198,345

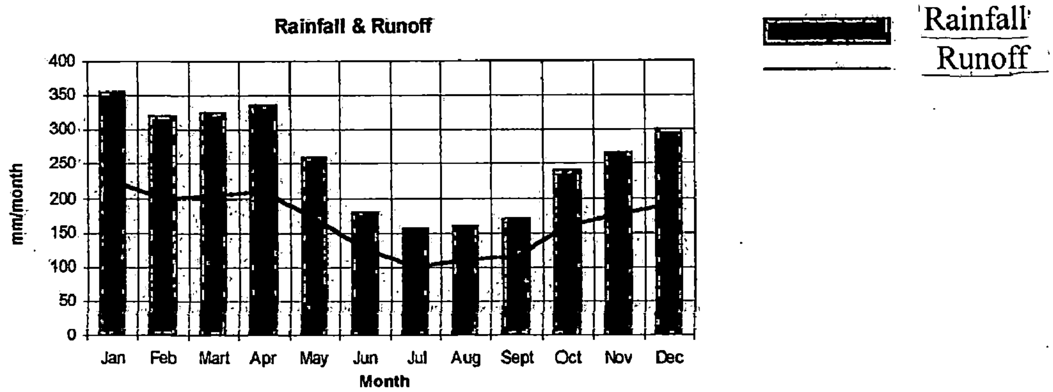
Live Stock Population :

Cattle /Buffalo	40,500 heads
Sheep/Goat	252,500 heads
Pig	2,000 heads
Poultry	2,389,500 heads

The radar chart of Ciujung basin is shown below. Development of basin can be characterised as conservation type



Monthly variation of rainfall and runoff is depicted in following figure.



CHAPTER –4

THE BASIN WATER DEMAND ESTIMATION (NON AGRICULTURAL)

4.1. FORECAST of POPULATION

Forecast of population is required for estimation of food demand and for estimation of water requirement for various purposes (domestic, municipal, industrial, river maintenance, livestock). Demographers are the expects who make forecast of population taking into consideration various factors such as life styles in urban and rural areas changes in urban and rural population, rate of population growth and trend in the rate of growth, high, low and average rate growth etc. An area may be classified as urban based on following three criteria.

- Population density exceeds 5,000 persons per km^2
- Less than 25 % of households are engaged primarily in agriculture
- Three are more than eight urban facilities including primary school, secondary school, cinema, hospital, clinic, bank, road accessible by three/ four wheel vehicles, public electric city and others.

It may happen that an area which was classified as rural in earlier study is classified as urban in next study and food demand.

Alternate scenarios of population growth /need to be examined

(i) Higher population growth scenario (population)

(ii) Lower income elasticity scenario (per capita food requirement)

(iii) Decelerated economic growth scenario (per capita food requirement)

(iv) Higher population growth and lower economic growth ratio

This would produce the highest projection for food demand

Accuracy in forecast of food demand and basin water demands depends on population projection. Therefore close monitoring on the change in population growth rate is required. A variety of population forecast models here been proposed by various agencies including United Nations.

For this study data on population forecast is taken from FIDP study (FIDP- Nov 1993). Population growth rate are taken as 1.5 % before 2000 and 1 % to 1.2 after 2000. Population forecast per regency in Ciujung River basin is given below.

Population is estimated based on the results of population projection. Population projection by Regency is calculated by multiplying a coefficient with population projection by FIDP study. The coefficient is estimated based on the projection population of Regency and Province. The calculation of population for urban and rural is shown in Table 4.1

Table 4.1. Projection of Urban and Rural Population

Projection Year	1990	1995	2000	2005	2010	2015	2020
Urban	240,306	313,048	392,721	459,921	535,756	626,148	723,030
Rural	1,289,649	1,312,596	1,299,258	1,317,815	1,297,663	1,229,071	1,151,816

4.2 DMI WATER DEMAND

4.2.1 Domestic and Industrial Use

Assessment of future demand for domestic water supply has to be based on the growth of population in the area to be served and its likely consumption of water per capita. There per capita consumption of water will depend on standard of living of the people, social customs and habits, accessibility of supply, quality available, climate, tariffs and economic and educational back ground. The National Master Plan for water supply and sanitation prepared by the Ministry of Works and Housing Govt. of India, has indicated the per capita requirement of domestic water urban population as to 70 to 250 lit/capita/day (lpcd) with an average 40 lpcd. These rates may be used a guidance along with the projected population figures for estimating the domestic water needs.

Industrial water use varies widely among industries. Statistics on average production may be available with industries or concerned Government departments. Efforts should be made to collect such data at least for these industries which are water intensive such as paper and newsprint, coal mining, petrochemical etc. Water demand projection for industries should be coordinated with studies of anticipated industrial expansion and should indicate the location, type of use as well as the amount, quality and location of effluent discharge. Industries when set up will also create and accompanying demand of domestic supply to cater to the needs of new concentration of workers and their colonies. This demand should also be taken into the availability of cheap raw material and labor, transport facilities to demand centers and the general industrial policy of Stage Govt. information available with industry department and national plan document will provide some idea of the regional industrial growth prospects which may be utilized.

4.2.2 Minimum Flow Requirement

Maintenance of minimum flow in river is also to be considered as a water use since it restricts the quantity of water that can be diverted for other uses. Necessity to maintain water quality, river regime, maintenance of river eco- system or other public necessity such as bathing, drinking water for cattle's etc. Minimum flow requirements at different points in the river system should be assessed and adequate provision should be made in the master plan to ensure this.

(1) Per-capita Water Consumption

Projection of per capita water consumption (Table 4.2) is estimated based on the National Water Resources Policy by FAO and on a review of considering next water supply targets by the Directorate of Water Supply (DAB), Directorate General of Human Settlement

Table 4.2 Projection of Per Capita Water Consumption

(Unit = lit/capita/day)

City Size Category	*1990-2000*	*2000-2015*	*2015-2020*
Urban >1,000,000	250	270	280
Urban <1,000,000	150	170	180
Rural	30	38	40

(2) Water Demand

Total DMI water demand is estimated by multiplying projected population by per capita water consumption rate, as shown in the following formula :

$$Q(DMI) = 365 \text{ days} \times \left(\frac{q(u)}{1000} \times P(u) + \frac{q(r)}{1000} \times P(r) \right)$$

Where :

Q(DMI) = DMI Water Demand (m^3/year)

q(u) = Water Consumption of Urban Area (lit/capita/day)

q(r) = Water Consumption of Rural Area (lit/capita/day)

P(u) = Urban Population

P(r) = Rural Population

The results of DMI water demands by projection year are shown in the Table 4.3

Table 4.3 DMI Water Demand Projection for Ciujung

Unit : MCM/year

Year	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
Population urban	*240,306*	*313,048*	*392,721*	*459,921*	*535,756*	*626,148*	*723,030*
Population Rural	*1,289,649*	*1,312,596*	*1,299,258*	*1,317,815*	*1,297,663*	*1,229.071*	*1,151,816*
DMI demand	*27.3*	*31.5*	*43.1*	*47.7*	*52.2*	*59.1*	*64.3*

Example : Year 1990

Q (DMI) =365x (q(u)/1000 x P(u)+q(r)/1000xP(r))

=365x(150/1000x240306+30/1000x1289649)

= 27,278410 m3 =27.3Mm3/year

4.3 RIVER MAINTENANCE FLOW REQUIREMENT

4.3.1 Recreation

The water resource planner is interested in outdoor recreation activities associated with the presence or proximity of water, particularly reservoirs. Activities which require direct use of water include boating, ice skating, swimming, water skiing and fishing. Shoreline activities such as picnicking do not use water directly.

Many times, navigable water ways also can be developed for pleasure boating and in such cases the maintenance of navigable depth also serves for recreation.

4.3.2 Aquatic and Wild Life

A survey should be carried out for planned as well as existing and under construction projects to study the possible effects of planned development on the different species of fish and wild life in the basin. If the study indicates any adverse effects, remedial measures should be incorporated in the plan to offset such adverse effects. The remedial measure may be in the form of providing fish ways and fish ladders, controlled release of water downstream, restriction in the drawdown of storage etc.

Apart form protecting the species, fish culture may be a commercially viable proposition in many reservoirs. The master plan should include an evaluation of the potential of inland water bodies for fisheries development. The factors influencing fish reserves and fish catch potential should be presented and discussed. Similarly, the local market demand for fish and export possibilities to other areas should also be discussed side by side.

(1) Water Consumption

According to the IWRD (1991), the present per capita flushing water requirement of urban areas was estimated at 330 lit/day, for 2000 it was expected to be 360 lit/day and in 2015 it is expected to reduce to 330 lit/ day since by then more people are expected to be connected to a sewerage system. Projection of per capita flushing water requirement is assumed with as follows:

Table 4.4 Projection of Per Capita Flushing Water Requirement

Projection	*Water Requirement*
1990 – 2000	330 lit/capita/day
2000 – 2015	360 lit/capita/day
2015 – 2020	300/lit/capita/day

(2) Water Demand

River maintenance water demand is estimated by multiplying projected urban population by per capita flushing water requirement, as shown in the following formula :

$$Q(RM) = 365 \text{ days} \times \frac{q(f)}{1000} \times P(u)$$

Where :

Q(RM) = River Maintenance Water Demand (m^3/year)

q(f) = Flushing Water Requirement (lit/capita/day)

P(u) = Urban Population

The results of river maintenance water demands by projection year are shown in the Table 4.5 Water demand is estimated at 79.2. billion m^3 in Ciujung River Basin in year of 2020 as nearly same as DMI water demand.

Table 4.5 River Maintenance Water Demand Projection for Ciujung

Unit : MCM/year

Year	1990	1995	2000	2005	2010	2015	2020
River Maintenance demand	28.9	37.7	51.6	60.4	70.4	68.6	79.2

Example Year 1990

Q(RM) = 365x q(f)/1000x P(u)

=365x330/1000x240306

=28944857.7 m3=28.9Mm3/Year

4.4 LIVESTOCK WATER DEMAND

(1) Water Consumption

A water consumption rate of livestock unit per day is assumed as follows :

Table 4.6 Unit Water Requirement for Livestock

Unit : liters/head/day

Livestock	*Water Consumption*
Cattle/ Buffalo	40
Sheep/ Goat	5
Pig	6
Poultry	0.6

(2) Livestock Population

Livestock population projection is estimated based on the tendency of livestock population from 1984 to 1989 (JICA 1993). Table 4.7 and Shows livestock population

(3) Water Demand

Livestock water demand is estimated by multiplying heads of livestock by water consumption rate, as shown in the following formula :

$$Q(L) = \frac{365}{1000} \times \{q(c/b) \times P(c/b) + q(s/g) \times P(s/g) + q(pi) \times P(pi) + q(po) \times P(po)\}$$

Where :

- Q(L) = Livestock Water Demand (m^3/year)
- q(c/b) = Water Requirement for Cattle/ Buffalo (lit/head/day)
- q(s/g) = Water Requirement for Sheep/ Goat (lit/head/day)
- q(pi) = Water Requirement for Pig (lit/head/day)
- q(po) = Water Requirement for Poultry (lit/head/day)
- P(c/b) = Cattle/ Buffalo Population
- P(s/g) = Sheep/ Goat Population
- P(pi) = Pig Population
- P(po) = Poultry Population

The calculation of livestock water demand for Ciujung River Basin is shown in Table 4.7

Table 4.7 Livestock Water Demand

Unit : MCM/year

Livestock	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*	*2020*
Cattle Buffalo/Horse ('000 heads)	41.9	44.5	47.2	49.8	52.5	55.2	57.8
Sheep/Goat ('000 heads)	265.7	351.8	437.9	523.9	610.0	696.1	782.2
Pig ('000 heads)	1.9	1.7	1.4	1.2	1.0	0.7	0.5
Poultry ('000 heads)	2,496.6	3,042.0	3,587.3	4,132.7	4,678.1	5,223.5	5,768.9
Water demand (million m3)	1.6	2.0	2.3	2.6	2.9	3.2	3.5

Example year 1990

Q(L)= 365/1000(40x41900+5x265700+6x1900+0,6x2496600

= 1649558 M3 =1.6 Mm3

4.5. FISHPOND WATER DEMAND

(1) Water Consumption

According to the JICA (1993), at a pond of 70 cm the net water demand for flushing would thus 35 to 40 mm/day, or about 5 to 6 times as for irrigated paddy. Water used for flushing however returns entirely into the system, usually at a short distance downstream of the intakes of freshwater ponds. The actual net freshwater consumption of fishpond is therefore of the same order of magnitude as for irrigated paddy

(2) Fishpond Area

Future fishpond area is estimated from past trend. Table 4.8 presents estimated fishpond area in Ciujung River Basin based on the CBS survey results.

(3) Water Demand

Fishpond water demand is calculated by multiplying projected fishpond area by water consumption rate, as shown in the following formula and results for Ciujung river Basin are Shown in Table 4.8

$$Q(FP) = 365 \times \frac{q(f)}{1000} \times A(FP) \times 1{,}000$$

Where :

Q(FP) = Fishpond Water Demand (m^3/year)

q(f) = Flushing Water Requirement (mm/day) = 7 mm/day

A(FP) = Fishpond Area (ha)

Table 4.8 Fishpond Water Demand

Fishpond	1990	1995	2000	2005	2010	2015	2020
Area (ha)	333	333	333	333	333	333	333
Water demand (million m3)	8.5	8.5	8.5	8.5	8.5	8.5	8.5

Example Year 1990

Q(FP) = 365x q(f)/1000 x A(FP) x1000

=365x(7mm/day/1000)x333x1000

=8508150 m3 = 8.5Mm3

CHAPTER –5
BASIN IRRIGATION WATER DEMAND

5.1 GENERAL

Cropping pattern : The existing cropping pattern may undergo changes with the introduction of irrigation. The projected cropping pattern should take into account the agricultural productivity of land, climate and above all the farmer's choice. Experience in areas with similar characteristics will be a guidance in this regard. The cropping pattern is also likely to change with changing market condition over the life of the project or over the planning period.

Such possible changes should be visualized and incorporated. In a large basin, different cropping patterns may have to be adopted for different regions or sub basins. It may even vary from project to project.

Crop water requirement: The term water requirement of crops implies the total amount of water required at the field to mature the crop. It includes evapo-transpiration (ET),application losses and special needs and does not included transit losses. Special needs include requirement for puddling , transplanting, leaching salts etc.

The crop water requirement may be determined from data collected on yield vs. applied water from fields or experimental plots for specific crops in a specific locality having characteristic values of consumptive use and effective precipitation. If such data are available at field experiment station in the basin or nearby areas with comparable characteristics, these should be used.

In the absence of such data, crop water requirement may be estimated from ET values. The ET may be measured directly by soil moisture depletion studies by conducting field experiment. Alternately , many formulae are available for computing potential evapotranspiration (PET). Some of the more commonly used formulae are the Blaney-Criddel, Christianson's and Penman's methods. The modified Penman method which is based on energy concept and aerodynamic principle, is considered more reliable. However this requires a large number of weather parameters such as humidity, wind velocity, radiation, sunshine hours etc. ministry of Water Resource Publication.

Practice in India is to follow either Christianson's method or Modified Penman method depending upon data availability.

The net irrigation water requirement is obtained by deducting effective rainfall and soil moisture contributing from water requirement. This is the irrigation water to be supplied at the head of field channel. The gross irrigation water requirement will include the seepage and other losses during conveyance. The conveyance losses will mainly depend on soil through which the canal runs and whether the canal is lined or unlined.

The conveyance losses may amount to 30 % to 40 % of the water released at canal head and the total losses including field losses may be as high as 50% to 80%. Therefore, the master plan should critically discuss this issue and suggest suitable measure to reduce losses and increase irrigation efficiency. Lining of canals and alternate methods of irrigation like sprinkler irrigation may be costly proposition, but are worth studying for their economics.

5.2 IRRIGATION WATER DEMAND

Irrigation water demand calculation is rather complicated than other water demand calculation. First, typical cropping pattern for the basin is established based on the past three or four years cropping pattern and trend in the change of cropping pattern. Second, water demand calculation is made based on the established cropping pattern. Water demand is estimated by following formula

Irrigation water demand $= (E_{tc} + IR + RW + P - ER) / IE \times A$

Where :

Etc = crop consumptive use = $E_{to} \times k_c$

Eto = evapo - transpiration

kc = crop coefficient

IR = land preparation water

RW = layer replacement water

P = percolation loss

ER = effective rainfall

IE = irrigation efficiency

A = irrigation area

(1) Cropping Pattern

General cropping pattern for Ciujung basin is illustrated in Figure 5.1 .Assumptions and information is as given below

- Average monthly planted area for 3-4 year are calculated using statistic data on planted area for paddy and Palawija published by Biro Pusat Statistik (BPS 1990).
- Dry season cultivation and wet season cultivation are defined based on average monthly planted area and average rainfall pattern in the basin.
- Estimated planted area (per 100 ha) is applied for estimation.
- The upper limit of cropping intensity is to be 2.0.
- During wet season, 100 % of paddy is to be planted, while during dry season, paddy and Palawija are to be planted.
- Crop growing period for wet and dry paddy and palawija is 90 days.
- Crop growing period for palawija is 90 days.

(2) Crop Consumptive use

The crop consumptive use is calculated as

$$E_{tc} = kc \times E_{to}$$

Where:

Etc = crop consumptive use (mm/day)

Eto = evapotranspiration (mm/day)

k_c = crop coefficient

The crop coefficient for paddy and upland crop are given in Table 5.1 (DGWRD 1986).

Table 5.1: Crop coefficients for Paddy and Palawija

Growth	Crop Coefficient (kc) Paddy	Crop Coefficient (kc) Palawija
First month	1.10	0.67
Second month	1.05	1.00
Third month	0.95	0.75

(3) Evapotranspiration

Monthly evapotranspiration is obtained from the report of Regional Physical Planning Project for Transmigration (RePPProT) study (RePPProT 1989). Monthly evapotranspiration has been calculated using the data in and around the area as shown in Table 5.2. Mean,maximum and minimum values of evapotranspiration are given below

Evapotranspiration for Java and Bali by Penman Method

Mean Monthly Eto (mm/month)	Mean Daily Eto (mm/day)	Max Monthly Eto (mm/month)	Min Monthly Eto (mm/month)
128	4.3	209	70

(4) Land Preparation Water Requirement

The land preparation period is assumed to be 30 days. Water requirement for land preparation of paddy fields are taken at 250 mm, including presaturation of the soil, puddling of soil, and water requirement for nurseries. Above 250 mm figure assumes fine texture soil.

For the calculation of the irrigation requirements during land preparation ,***van de goor and zijlstra's*** formula is used (DGWRD 1986)

$$IR = M(e^k/e^{k-1})$$

Where :

IR = Irrigation requirement at field level (mm/day)

M = Water requirements to compensate for evaporation and percolation of the fields already saturated (mm/day).

$M = Eo + p$

$Eo = 1.1\ Eto$ (mm/day)

Eto = evapotranspiration (mm/day)

p = percolation (mm/day)

$k = MT/S$

Where:

T = land preparation period (days)

S = presaturation requirements (mm/day)

The monthly land preparation water requirement is shown in Table 5.2

Table 5.2 Reference Crop Evapotranspiration and Land Preparation Requirement in Ciujung River Basin (unit mm/month)

ETO		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Serang	120	115	128	125	119	111	121	133	138	141	130	125	126
	Kemayoran	124	122	142	142	136	125	141	153	156	165	145	139	141
	Curug-Tangerang	123	121	137	135	134	122	134	147	148	156	140	138	136
	Atang sanjay-Bogor	132	125	139	134	125	109	130	142	151	160	144	135	136
	Average	126	123	139	137	132	119	135	147	152	160	143	137	138
Land Preparation		372	375	381	382	375	369	378	386	393	396	387	379	

(5) **Percolation**

The percolation rate is assumed to be 2 mm/day, as per design practice and guidelines given in DGWRD (1986)

(6) **Water Layer Replacement**

Twice water layer replacements, each of 50 mm at about 1 month and 2 months after transplanting, are considered according to irrigation design standard (DGWRD 1986).

(7) **Effective Rainfall**

Monthly effective rainfall for Ciujung river basin is calculated by multiplying proportion coefficient (effective rainfall/mean rainfall) with monthly mean rainfall .The proportion coefficient(FAO Report no 25) is considered according to guidelines , published by FAO (refer to Table 5.3).

Table 5.3 Proportion of Monthly Mean Rainfall to Effective Rainfall

	Paddy			Palawija	
Monthly Mean Rainfall (mm)	Monthly Effective Rainfall (mm)	Proportion	Monthly Mean Rainfall (mm)	Monthly Effective Rainfall (mm)	Proportion
(1)	(2)	(2)/(1)	(1)	(2)	(2)/(1)
12.5	10.5	84%	12.5	9.0	72%
25.0	20.5	82%	25.0	18.0	72%
37.5	30.5	81%	37.5	27.5	73%
50.5	40.5	81%	50.0	35.7	71%
62.5	50.5	81%	62.5	44.5	71%
75.0	60.2	80%	75.0	52.7	70%
87.5	69.7	80%	87.5	60.2	69%
100.0	78.7	79%	100.0	67.7	68%
112.5	87.2	78%	112.5	75.0	67%
125.0	95.7	77%	125.0	81.5	65%
137.5	104.0	76%	137.5	88.7	65%
150.0	112.0	75%	150.0	95.2	63%
162.5	120.0	74%	>160	100.0	-
175.0	127.0	73%	-	-	-
187.5	134.0	71%	-	-	-
200.0	140.0	70%	-	-	-
225.0	151.0	67%	-	-	-
250.0	161.0	64%	-	-	-
275.0	171.0	62%	-	-	-
>300	175.0	-	-	-	-

Table 5.4 shows monthly effective rainfall for paddy and Palawija

Table 5.4 Mean Monthly rainfall and Effective Rainfall in Ciujung Basin (unit mm/month)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean monthly rainfall	357	319	321	331	264	182	156	168	175	245	265	300	3083
Rainfall With 20 % non - exceedance Probability	220	191	192	200	148	85	65	75	80	134	149	176	1695
Effective Rainfall for paddy	140	134	134	140	104	60	51	60	60	96	104	127	1210
Effective rainfall for palawija	100	100	100	100	89	53	45	53	53	82	89	100	962

(8) **Irrigation Efficiency**

Irrigation diversion requirements are calculated by considering operation loss and conveyance loss. For this study, the following irrigation efficiency are adopted (Table 5.5) from DGWRD (1986):

Table 5.5 Irrigation Efficiency

Canal	*Irrigation Efficiency*
Headreach and main canal	90 %
Secondary Canal	90 %
Tertiary system	70 %
Over all	*56.7 %*

Irrigation efficiency of 55 % for paddy has been assumed with reference to the above figures. As for irrigation efficiency for palawija, it is assumed to be 50 % as the percolation loss is accounted for in the irrigation efficiency.

5.3 PLANTED AREA OF CROPS

As shown in crop calender (Figure 5.1), land preparation is carried out over 30 days for paddy and paddy crop growth period 90 days. This paddy occupies a land area for 120 days. Palawija occupies a land area for 90 days. Paddy is grown in dry season only.

Data on planted area under different crops in different months was collected for four years. Average planted area of crops in wet season and dry season are shown in Table 5.6 and Figure 5.1

These average values were used to estimated planted area per 100 ha of land and cropping intensity in wet and dry season as shown in Table 5.6

Table 5.6 Planted Area and Cropping Intesity in Ciujung Basin

Land Parcel	Wet Season Paddy			Dry Season					CI Paddy	CI Paddy & Palawija
	Month	Av.Planted Area	Percent Area	Month	Paddy Planted Area	Paddy %	Palawija Area	Palawija %		
1	2	3	4	5	6	7	8	9	10	11
1st	Oct	48.2	4.7	Apr	192.9	18.9	18.0	5.1	0.236	0.287
2nd	Nov	172.5	16.9	May	288.0	28.2	10.4	2.9	0.415	0.480
3rd	Dec	372.0	36.4	Jun	201.9	19.8	10.8	3.0	0.562	0.592
4th	Jan	279.1	27.3	Jul	77.1	7.6	9.7	2.7	0.349	0.376
5th	Feb	104.2	10.2	Aug	50.1	4.9	9.6	2.7	0.151	0.178
6th	Mar	44.7	4.4	Sep	28.9	2.8	5.3	1.5	0.072	0.087
Total		1,020.7	99.9		838.9	82.2	63.8	17.9	1.821	2.000

5.4 IRRIGATION DIVERSION REQUIREMENTS

(a) Paddy in Wet Season :

There are six parcel of land in which wet season paddy plantation study different months from October to March . The planted area of these parcels per 100 ha of land area 4.7 ha/100ha (planted in October), 16.9 ha/100 ha (planted in November), 36.4 ha/100ha (planted in December), 27.3 ha/100ha (planted in January), 10.2 ha/100ha (planted in February), 4.4 ha/100ha (planted in March).Calculation of monthly irrigation diversion requirements for wet season paddy in the six parcels of land are shown in Table 5.7

Example: Calculation of Irrigation diversion requirement on October

Eto Oct = 160 mm/month

Kc = crop coefficient--→ 1^{st}=1.10

2^{nd}= 1.05

3^{rd} = 0.95

season for planted October to march

Etc=Kc x Eto

= 1.10 x 160 =176 mm/month

Replacement 50 mm one and two month after planted (Nop-Dec)

Land Preparation one month before starting planted season namely September = 393 mm/month

Percolation 2mm x total day on month Start planted

=2 x 31= 62 mm/month

Effective Rainfall start one month before planted season. Estimated non-exceedance 20 % rainfall conversi to table 5.3 = 60mm/month

Sub total = 393-60 mm/month

=333 mm/month

Net WR = 333/1000x 4.7x10000 =15651 mm/month

Total Net WR =15651 mm/month

Net WR =15651/1000 =15.7 mm/month/100ha

IDR = Net WR/Irr Eff
= 15.7/0.55
=28 mm/month/100ha

(b) Paddy in Dry Season

Dry season paddy planted area per 100 ha of land are 18.9 ha/100 ha (starting April), 28.2 ha/100 ha (starting May), 19.8 ha/100 ha (starting June), 7.6 ha/100 ha (starting July), 4.9 ha/ 100ha (starting August), 2.8 ha/100 ha (starting September). Calculation of monthly irrigation diversion requirements for dry season paddy in the six parcels of land area shown in Table 5.8

(c) Palawija in Dry Season

Palawija sown area per 100 ha of land area 5.1 ha/ 100 ha (starting April), 2.9 ha/100 ha (starting May), 3.0 ha/ 100 ha (starting June), 2.7 ha/ 100 ha (starting July) 2.7 ha / 100ha (starting August), 1.5 ha /100 ha (starting September). Calculation of monthly irrigation diversion requirements for dry season palawija in the six parcels of land area shown in Table 5.9.

Total unit monthly irrigation water requirements for the river basin can be estimated by summation of those wet and dry paddy requirement and palawija requirement, namely :

Total Unit Irrigation Diversion Requirements =Table 5.7 +Table 5.8+Table 5.9

Table 5.10 shows calculation result of total unit irrigation water requirement for Ciujung River Basin.

(9) Irrigation Water Demand

Irrigation water demand is estimated by multiplying irrigation area by irrigation diversion requirement, as shown in the following formula :

$$Q_{(IR)} = \frac{q_{(IR)}}{1,000} \times [A_{(IR)} \times 10,000]$$

Where :

$Q_{(IR)}$ = Irrigation Water Demand (m³/month)

$q_{(IR)}$ = Unit Irrigation Diversion Requirement (mm/month)

$A_{(IR)}$ = Irrigation Area (ha)

The result of irrigation water demand for Ciujung River Basin are shown in the Table 5.10

Table 5.10 Irrigation Demand Ciujung Basin

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Irrigation Diversion Requirement (i) Wet Season Paddy (mm/month)	170	140	84	28	11	0	0	0	28	104	235	231	1031
(ii) Dry Season Paddy (mm/month)	0	0	85	148	200	234	221	128	54	24	7	0	1101
(iii) Palawija (mm/month)	0	0	0	0	4	8	11	9	7	7	3	0	49
Unit Irr Diversion Requirement Q(IR) mm/month (Total of (I+ii+iii)	170	140	169	176	215	242	232	137	89	135	245	231	2181
Irrigation Area (ha) A (IR)	30254	30254	30254	30254	30254	30254	30254	30254	30254	30254	30254	30254	
Irrigation Water Demand Q (IR) m3/month	51.4	42.4	51.0	53.2	65.0	73.4	70.2	41.4	27.0	40.9	74.0	70.0	659.8

Example : Month January

$Q(IR) = 302549(ha)x\ 170/1000x10^4/10^6$

$=51.4\ m^3/monthh$

Total Annual Water Demand

Total annual water demand in Ciujung River Basin in year of 2020 is shown in Table 5.11. Out of available water about 815.3 billion m³ of water will be used for DMI, Irrigation, Livestock etc. Balanced water is available for new irrigation but not all of them, since wet season surplus water can not be used for dry season irrigation without creation of water reservoirs.

Tabel 5.11 Annual Water Demand in 2020

Unit : MCM m'

River Basin	*DMI*	*River Maintenance*	*Irrigation*	*Fishpond*	*Livestock*	*Total*
Ciujung	*64.3*	*79.2*	*659.8*	*8.5*	*3.5*	*815.3*

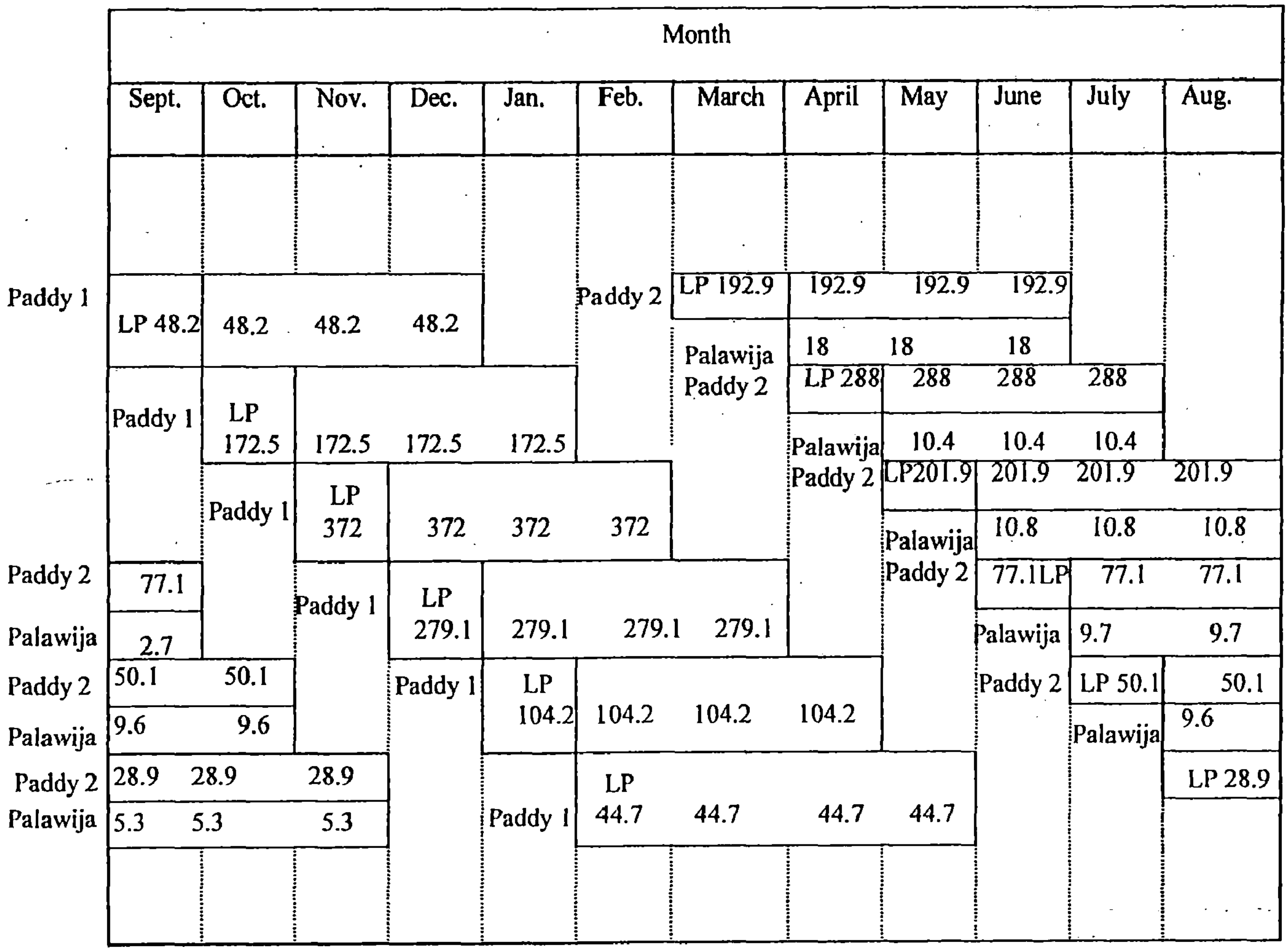
5.5 WATER POTENTIAL FOR IRRIGATION

Water potential for irrigation in Ciujung River Basin is estimated by subtracting all the water demands from the available water resources. This balance calculation is made assuming that ;

- no reservoir or pond for water storage
- no return flow
- no basin transfer water
- priority order for water demand is DMI first and followed by river maintenance, fish/ livestock and then irrigation

Monthly water balance in 2020 calculated based on the result of available water resources and water demands in previous sections. Monthly water potential in terms of irrigable area is calculated by dividing water balance results by unit monthly irrigation water requirements as discussed in next chapter.

This dissertation study is limited to analysis of demand estimation. Therefore water potential and water balance study has not been carried out as it would require detailed analysis of water availability.



Note: LP = Land Preparation
Paddy 1 is wet season crop (100% density)
Paddy 2 + Palawija is dry season crop. (Variable density)

Figure 5.1 Typical Cropping Pattern

TABLE 5.7. Calculation of Irrigation Diversion Requirement for Ciujung River Basin
(Paddy On Wet Season)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nop	Des
Eto	(mm/month)	126	123	139	137	132	119	135	147	152	160	143	137
kc		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	1.05	0.95
Etc = kc*Eto	(mm/month)	0	0	0	0	0	0	0	0	0	176	150	130
Replacement	(mm/month)	0	0	0	0	0	0	0	0	0	0	50	50
Land Preparation	(mm/month)	0	0	0	0	0	0	0	0	393	0	0	0
Percolation	(mm/month)	0	0	0	0	0	0	0	0	0	62	60	62
Effective Rainfall	(mm/month)	0	0	0	0	0	0	0	0	60	96	104	127
Sub-Total	(mm/month)	0	0	0	0	0	0	0	0	333	143	156	115
Net WR *4.7	(m3/month)	0	0	0	0	0	0	0	0	15604	6674	7332	5405
kc		0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	1.05
Etc	(mm/month)	120	0	0	0	0	0	0	0	0	0	157	144
Replacement	(mm/month)	50	0	0	0	0	0	0	0	0	0	0	50
Land Preparation	(mm/month)	0	0	0	0	0	0	0	0	0	396	0	0
Percolation	(mm/month)	62	0	0	0	0	0	0	0	0	0	60	62
Effective Rainfall	(mm/month)	140	0	0	0	0	0	0	0	0	96	104	127
Sub-Total	(mm/month)	92	0	0	0	0	0	0	0	0	300	113	129
Net WR *16.9	(m3/month)	15548	0	0	0	0	0	0	0	0	50531	19097	21801
kc		1.05	0.95	0	0	0	0	0	0	0	0	0	1.1
Etc	(mm/month)	133	117	0	0	0	0	0	0	0	0	0	151
Replacement	(mm/month)	50	50	0	0	0	0	0	0	0	0	0	0
Land Preparation	(mm/month)	0	0	0	0	0	0	0	0	0	0	387	0
Percolation	(mm/month)	62	58	0	0	0	0	0	0	0	0	0	62
Effective Rainfall	(mm/month)	140	134	0	0	0	0	0	0	0	0	104	127
Sub-Total	(mm/month)	105	91	0	0	0	0	0	0	0	0	283	86
Net WR *36.4	(m3/month)	37856	32760	0	0	0	0	0	0	0	0	102648	31304
kc		1.10	1.05	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Etc	(mm/month)	139	129	132	0	0	0	0	0	0	0	0	0
Replacement	(mm/month)	0	50	50	0	0	0	0	0	0	0	0	0
Land Preparation	(mm/month)	0	0	0	0	0	0	0	0	0	0	0	379
Percolation	(mm/month)	62	58	62	0	0	0	0	0	0	0	0	0
Effective Rainfall	(mm/month)	140	134	134	0	0	0	0	0	0	0	0	127
Sub-Total	(mm/month)	61	103	110	0	0	0	0	0	0	0	0	252
Net WR *27.3	(m3/month)	16380	27846	30030	0	0	0	0	0	0	0	0	68796
kc		0.00	1.10	1.05	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Etc	(mm/month)	0	135	146	130	0	0	0	0	0	0	0	0
Replacement	(mm/month)	0	0	50	50	0	0	0	0	0	0	0	0
Land Preparation	(mm/month)	372	0	0	0	0	0	0	0	0	0	0	0
Percolation	(mm/month)	0	58	62	60	0	0	0	0	0	0	0	0
Effective Rainfall	(mm/month)	140	134	134	140	0	0	0	0	0	0	0	0
Sub-Total	(mm/month)	232	59	124	100	0	0	0	0	0	0	0	0
Net WR *10.2	(m3/month)	23562	59196	12648	10200	0	0	0	0	0	0	0	0
kc		0.00	0.00	1.10	1.05	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Etc	(mm/month)	0	0	153	144	125	0	0	0	0	0	0	0
Replacement	(mm/month)	0	0	0	50	50	0	0	0	0	0	0	0
Land Preparation	(mm/month)	0	375	0	0	0	0	0	0	0	0	0	0
Percolation	(mm/month)	0	0	62	60	62	0	0	0	0	0	0	0
Effective Rainfall	(mm/month)	0	134	134	140	104	0	0	0	0	0	0	0
Sub-Total	(mm/month)	0	241	81	114	133	0	0	0	0	0	0	0
Net WR *4.4	(m3/month)	0	10604	3564	4972	5852	0	0	0	0	0	0	0
Total Net WR	(m3/month)	93346	77126	46242	15172	5852	0	0	0	15604	57205	129077	127306
Net WR	(mm/month/100 h	93.3	77.1	46.2	15.2	5.9	0.0	0.0	0.0	15.6	57.2	129.1	127.3
IDR	(mm/month/100 h	170	140	84	28	11	0	0	0	28	104	235	231

***Remarks :** Eto = Reference Crop Evapotranspiration, kc = Crop Coefficient, Etc = Crop Evapotranspiration, WR = Water Requirement*
*IDR = Irrigation Diversion Requirement, Irrigation Efficiency = 55 %, Percolation = 2 mm/ day, * = Planted Area (ha)/ 100 ha*

TABLE 5.8. Calculation of Irrigation Diversion Requirement for Ciujung River Basin
(Paddy On Dry Season)

		Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Okt*	*Nop*	*Des*
Eto	(mm/month)	126	123	139	137	132	119	135	147	152	160	143	137
kc		0.00	0.00	0.00	1.10	1.05	0.95	0.00	0.00	0.00	0.00	0.00	0.00
Etc	(mm/month)	0	0	0	151	138	113	0	0	0	0	0	0
Replacement	(mm/month)	0	0	0	0	50	50	0	0	0	0	0	0
Land Preparation	(mm/month)	0	0	381	0	0	0	0	0	0	0	0	0
Percolation	(mm/month)	0	0	0	60	62	60	0	0	0	0	0	0
Effective Rainfall	(mm/month)	0	0	134	140	104	60	0	0	0	0	0	0
Sub-Total	(mm/month)	0	0	247	71	146	163	0	0	0	0	0	0
Net WR *18.9	(m3/month)	0	0	46494	13230	27594	30618	0	0	0	0	0	0
kc		0.00	0.00	0.00	0.00	1.10	1.05	0.95	0.00	0.00	0.00	0.00	0.00
Etc	(mm/month)	0	0	0	0	145	125	128	0	0	0	0	0
Replacement	(mm/month)	0	0	0	0	0	50	50	0	0	0	0	0
Land Preparation	(mm/month)	0	0	0	382	0	0	0	0	0	0	0	0
Percolation	(mm/month)	0	0	0	0	62	60	62	0	0	0	0	0
Effective Rainfall	(mm/month)	0	0	0	140	104	60	51	0	0	0	0	0
Sub-Total	(mm/month)	0	0	0	242	103	174	190	0	0	0	0	0
Net WR *28.2	(m3/month)	0	0	0	68244	28764	49068	53298	0	0	0	0	0
kc		0.00	0.00	0.00	0.00	0.00	1.10	1.05	0.95	0.00	0.00	0.00	0.00
Etc	(mm/month)	0	0	0	0	0	131	142	140	0	0	0	0
Replacement	(mm/month)	0	0	0	0	0	0	50	50	0	0	0	0
Land Preparation	(mm/month)	0	0	0	0	375	0	0	0	0	0	0	0
Percolation	(mm/month)	0	0	0	0	0	60	62	62	0	0	0	0
Effective Rainfall	(mm/month)	0	0	0	0	104	60	51	60	0	0	0	0
Sub-Total	(mm/month)	0	0	0	0	271	130	203	192	0	0	0	0
Net WR *19.8	(m3/month)	0	0	0	0	53658	25740	40194	37818	0	0	0	0
kc		0.00	0.00	0.00	0.00	0.00	0.00	1.10	1.05	0.95	0.00	0.00	0.00
Etc	(mm/month)	0	0	0	0	0	0	149	155	144	0	0	0
Replacement	(mm/month)	0	0	0	0	0	0	0	50	50	0	0	0
Land Preparation	(mm/month)	0	0	0	0	0	369	0	0	0	0	0	0
Percolation	(mm/month)	0	0	0	0	0	0	62	62	60	0	0	0
Effective Rainfall	(mm/month)	0	0	0	0	0	60	51	60	60	0	0	0
Sub-Total	(mm/month)	0	0	0	0	0	309	60	207	194	0	0	0
Net WR *7.6	(m3/month)	0	0	0	0	0	23408	12160	15656	14668	0	0	0
kc		0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	1.05	0.95	0.00	0.00
Etc	(mm/month)	0	0	0	0	0	0	0	162	159	152	0	0
Replacement	(mm/month)	0	0	0	0	0	0	0	0	50	50	0	0
Land Preparation	(mm/month)	0	0	0	0	0	0	378	0	0	0	0	0
Percolation	(mm/month)	0	0	0	0	0	0	0	62	60	62	0	0
Effective Rainfall	(mm/month)	0	0	0	0	0	0	51	60	60	96	0	0
Sub-Total	(mm/month)	0	0	0	0	0	0	327	164	209	169	0	0
Net WR *4.9	(m3/month)	0	0	0	0	0	0	16023	7987	10241	8232	0	0
kc		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	1.05	0.95	0.00
Etc	(mm/month)	0	0	0	0	0	0	0	0	167	168	136	0
Replacement	(mm/month)	0	0	0	0	0	0	0	0	0	50	50	0
Land Preparation	(mm/month)	0	0	0	0	0	0	0	386	0	0	0	0
Percolation	(mm/month)	0	0	0	0	0	0	0	0	60	62	60	0
Effective Rainfall	(mm/month)	0	0	0	0	0	0	0	60	60	96	104	0
Sub-Total	(mm/month)	0	0	0	0	0	0	0	326	167	185	142	0
Net WR *2.8	(m3/month)	0	0	0	0	0	0	0	9128	4648	5152	3948	0
Total Net WR	(m3/month)	0	0	46494	81474	110016	128834	121675	70589	29557	13384	3948	0
Net WR	(mm/month/100 h	0.0	0.0	46.5	81.5	110.0	128.8	121.7	70.6	29.6	13.4	3.9	0.0
IDR	(mm/month/100 h	0	0	85	148	200	234	221	128	54	24	7	0

Remarks : Eto = Reference Crop Evapotranspiration, kc = Crop Coefficient, Etc = Crop Evapotranspiration, WR = Water Requirement
*IDR = Irrigation Diversion Requirement, Irrigation Efficiency = 55 %, Percolation = 2 mm/ day, * = Planted Area (ha)/ 100 ha*

TABLE 5.9. Calculation of Irrigation Diversion Requirement for Ciujung River Basin
(Palawija On Dry Season)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Okt	Nop	Des
Eto	(mm/month)	126	123	139	137	132	119	135	147	152	160	143	137
kc		0.00	0.00	0.00	0.67	1.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00
Etc	(mm/month)	0	0	0	92	132	83	0	0	0	0	0	0
Effective Rainfall	(mm/month)	0	0	0	100	89	53	0	0	0	0	0	0
Sub-Total	(mm/month)	0	0	0	-	43	30	0	0	0	0	0	0
Net WR *5.1	(m3/month)	0	0	0	0	2142	1530	0	0	0	0	0	0
kc		0.00	0.00	0.00	0.00	0.67	1.00	0.71	0.00	0.00	0.00	0.00	0.00
Etc	(mm/month)	0	0	0	0	88	119	95	0	0	0	0	0
Effective Rainfall	(mm/month)	0	0	0	0	89	53	45	0	0	0	0	0
Sub-Total	(mm/month)	0	0	0	0	-	66	50	0	0	0	0	0
Net WR *2.9	(m3/month)	0	0	0	0	0	1885	1450	0	0	0	0	0
kc		0.00	0.00	0.00	0.00	0.00	0.67	1.00	0.70	0.00	0.00	0.00	0.00
Etc	(mm/month)	0	0	0	0	0	80	135	103	0	0	0	0
Effective Rainfall	(mm/month)	0	0	0	0	0	53	45	53	0	0	0	0
Sub-Total	(mm/month)	0	0	0	0	0	27	91	50	0	0	0	0
Net WR *3	(m3/month)	0	0	0	0	0	780	2700	1500	0	0	0	0
kc		0.00	0.00	0.00	0.00	0.00	0.00	0.67	1.00	0.70	0.00	0.00	0.00
Etc	(mm/month)	0	0	0	0	0	0	90	147	106	0	0	0
Effective Rainfall	(mm/month)	0	0	0	0	0	0	45	53	53	0	0	0
Sub-Total	(mm/month)	0	0	0	0	0	0	45	53	53	0	0	0
Net WR *2.7	(m3/month)	0	0	0	0	0	0	1188	1404	1404	0	0	0
kc		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	1.00	0.70	0.00	0.00
Etc	(mm/month)	0	0	0	0	0	0	0	99	152	112	0	0
Effective Rainfall	(mm/month)	0	0	0	0	0	0	0	53	53	82	0	0
Sub-Total	(mm/month)	0	0	0	0	0	0	0	53	53	82	0	0
Net WR *2.7	(m3/month)	0	0	0	0	0	0	0	1404	1404	2187	0	0
kc		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	1.00	0.70	0.00
Etc	(mm/month)	0	0	0	0	0	0	0	0	102	160	100	0
Effective Rainfall	(mm/month)	0	0	0	0	0	0	0	0	53	82	89	0
Sub-Total	(mm/month)	0	0	0	0	0	0	0	0	53	82	81	0
Net WR *1.5	(m3/month)	0	0	0	0	0	0	0	0	780	1215	1320	0
Total Net WR	(m3/month)	0	0	0	0	2142	4195	5338	4308	3588	3402	1320	0
Net WR	(mm/month/100 h	0	0	0	0.0	2.1	4.2	5.3	4.3	3.6	3.4	1.3	0
IDR	(mm/month/100 h	0	0	0	0	4	8	11	9	7	7	3	0

Remarks : Eto = Reference Crop Evapotranspiration, kc = Crop Coefficient, Etc = Crop Evapotranspiration, WR = Water Requirement
*IDR = Irrigation Diversion Requirement, Irrigation Efficiency = 50 %, Percolation = 2 mm/ day, * = Planted Area (ha)/ 100 ha*

CHAPTER -6

IRRIGATION DEVELOPMENT POTENTIAL

6.1 GENERAL

To assess irrigation development potential in a region , river basin approach from both aspects of water and land potential need to be adopted. Water availability is a crucial factor that limits extensive irrigation development. However this dissertation work is limited to study of basin water demand only. The approach followed in assessment of irrigation development potential in a basin is described in this chapter. Such type of analysis is generally not carried out in India in basin water balance studies as seen from the reports of NWDA (NWDA 1993, NWDA 1996). Therefore the approach explained in this chapter can serve as guideline for a scientific study.

Time interval : one month; Area : a river basin

AWS : Available water resource

AIW : Available irrigation water = AWS- non agricultural water demand

UIW : Unit irrigation water requirement

WPA : Water potential area = AIW/UIW

LPA : Land potential area based on land suitability and land availability.

IPA : Irrigation potential area =LPA-WPA

Land potential area (LPA) : It- is obtained from land suitability analysis and, land availability analysis (present land use and land statis). Generally land which is suitable for paddy cultivation and available for field extension is defined as potential land for paddy field extension. The land Potential area indicates further potential of wet land agriculture development from view point of physical land condition. The estimation of land resources potential for wet land cultivation is essential for assessment of irrigation development potential. Both LPA and WPA are the critical limiting factors of irrigation development in a basin.

Approach for Estimation of Land Potential Area

The estimation procedure requires many kinds and large amount of information. Air photographs, satellite imageries and existing many kinds of topographic maps are used to derive information on physiographic geographic and vegetation aspects. For climate and hydrology study rainfall and runoff data are the basic data. The methodology and data source are briefly summarized in the Table 6.1

Table 6.1 Methodology and original data/ source

Item	Methodology/Source
Approach	Integrated Land unit ...FAO, (1981) The Land Unit Approach to Land Resources Surveys for Land Use Planning, with Particular Reference to the Sekampung Watershed, Lampung Province, Sumatra, Indonesia
Identification unit of Land Systems	Average : more than 400,000 ha. Minimum : about 50 ha, based on 1/250,000 maps
Number of Land Systems	414 Land Systems in Indonesia
Land System areas	Measured on 1/250,000 maps and summarized by map sheet and Province
Land Suitability Criteria	FAO (1976) Framework for land evaluation . A standard set of principles and concepts on land evaluation system.
Geology	Existing maps at 1/100,000-1/1,000,000 by Geological Research and Development Center.Photogeological land system maps at 1/1,000,000. Other survey results
Climate	Climatic records by Agency for Meteorology and Geophysics
Hydrology	River gauging and hydrological records
Physiography	Airphotography for basic information; Recent Landsat,SPOT and radar imagery to fill in gaps.
Soil (Source/ Classification)	Landforms on imagery. USDA Soil Taxonomy (1985).. One of world standard soil classification system
Land Cover (Land Use)	Airphotography for basic information; Recent Landsat, SPOT and radar imagery to fill in gaps and up to update forest boundary.
Forest Category	Consensus Forest Land Use Plan
Swamp (Inland)	Adopted by suitability criteria for wetland arable. Total area and suitability can be identified by Land System descriptions, but availability can not be identified.
Swamp (Tidal)	Adopted by suitability criteria for tidal Irrigation. Total Area and Suitability can be identified by land system description, but availability can not be identified

Source:RePPProT (1989)

6.2. AGROCLIMATIC ZONES

Climatic conditions, such as rainfall, temperature and sunshine, vary significantly in Indonesia. This variation affects relationship in moisture regime soil and plants. These different soil moisture regimes create distinctive soil types, which help to define land system. Moisture regime also determines the types of plant that can survive in an area under natural conditions, and to enhance the area's agricultural potential.

Monthly rainfall conditions determine four agroclimatic zones; aridic, ustic, udic and perhumid, and also temperature conditions affected by altitude divide these zones into two groups.

6.2.1 Aridic or Permanently Dry Zone

Severe limitations to plant growth are imposed by the climatic conditions of semi-permanent dry season which create the aridic soil type; this is designated as the aridic or permanently dry zone, and is defined as having nine or more months with an average rainfall of less than 100 mm. It occupies 0.34 million ha or 0.2 % of country area.

6.2.2 Ustic or Seasonally Dry Zone

Less severe but still difficult conditions are found in the ustic or seasonally dry zone, defined as having five to eight months with an average rainfall of less than 100 mm. It occupies 14.3 million ha or 7.5% of the country area.

6.2.3. Udic or Seasonal Wet Zone

Most of Indonesia lies within the udic or seasonally dry zone, defined as having up to four months with an average rainfall of less than 100 mm. This zone occupies 134.0 million ha or 70.1 % of country area. Rainfed agriculture is possible in much of this zone, but yields are higher and multiple cropping is possible where the effort has been made to provide supplementary irrigation water.

6.2.4 Perhumid or Permanently wet zone

Perhumid or permanently wet zone is defined as having 12 wet months (mean monthly rainfall exceeding 200 mm), and covers 20.6 million ha or 10.8 % of country area. . This zone is particularly suitable for such trees as oil palm and sago, but is too wet for most other crops.

6.2.5 Highland or Permanently Cool Zone

This cool zone is defined in terms of altitude and includes all land above the 1,000 m contour. It therefore overlaps with wet, moist and dry zones (though not with the aridic zone). These cover 21.9 million ha or 11.5 % of the country area. Highland agriculture as practiced in most areas involves such crops as maize, wheat, sorghum, soybean, groundnut, banana, arabica coffee and a range of temperate latitude vegetables and market garden produce particularly near the major cities of Java and Sumatra. This form of agriculture is found in the submontane sub zone, between 1,000 and 2,000m.

The areas of Indonesia found in the respective zones are given in following table.

Table 6.2 Areas of Agroclimatic Zones by Region in Indonesia

(million ha)

Region	Hot				Highland (Permanently Cool)		
	Permanently Wet	Seasonal wet	Seasonal dry	Permanently dry	Wet	Moist	Dry
Sumatra	0.82	41.70	0.16	0.00	0.21	4.64	0.00
Java & Bali	0.10	6.10	5.27	0.00	0.09	2.02	0.24
Kalimantan	10.51	41.01	0.02	0.00	1.26	0.78	0.00
Sulawesi	0.00	13.90	0.90	0.02	0.00	3.78	0.02
Maluku & NTT	0.00	8.93	5.86	0.31	0.00	0.64	0.12
Irian Jaya	9.12	22.25	2.04	0.00	5.99	2.08	0.00
Indonesia	20.55	133.89	14.26	0.34	7.55	13.94	0.38

Source: JICA 1993

6.3 ROCEDURE FOR LAND SUITABILITY ANALYSIS

Land suitability for wetland agriculture development (paddy cultivation) is assessed on the basis of nine suitability criteria. The nine suitability factors define the land suitability class of each land system. Each factor is classified into three suitability classes by certain criteria ; suitable (S), conditionally suitable ($) and unsuitable for its difficulty of development (N). The concept of the land suitability analysis is illustrated in the following figure 6.1, and the criteria and evaluation process are explained in this section.

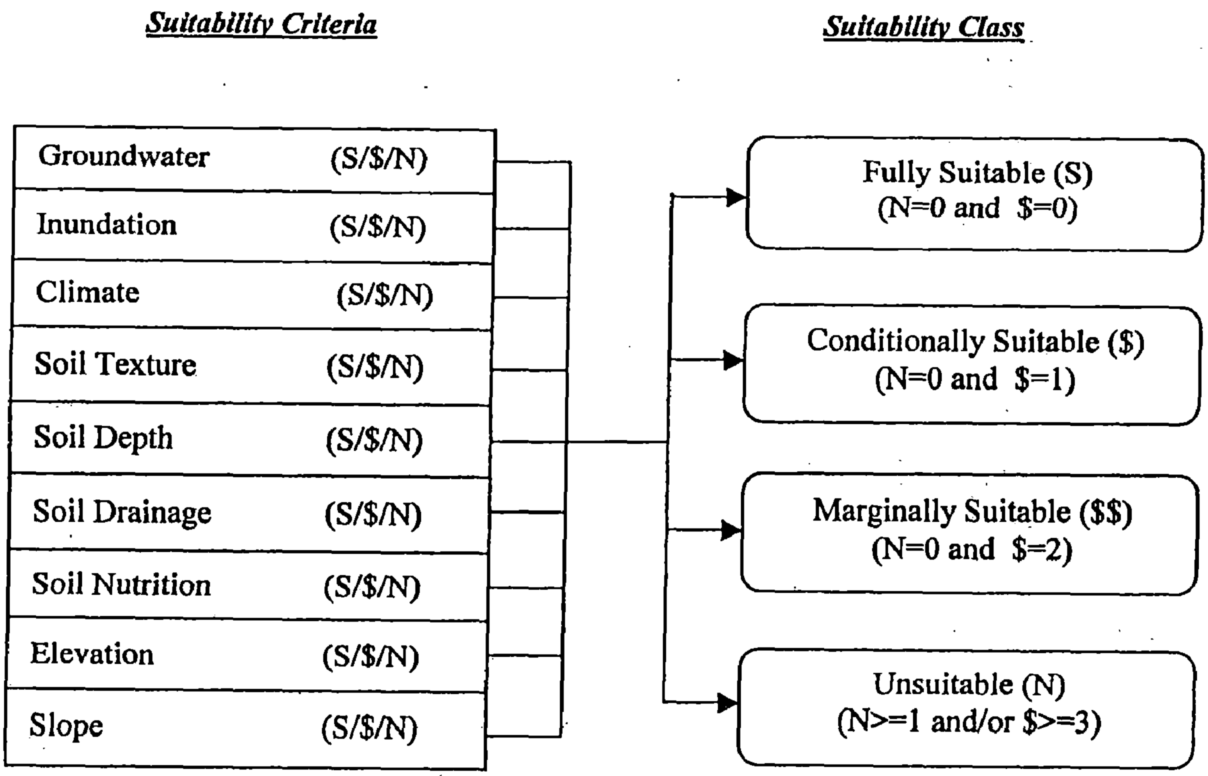


Figure 6.1 General Concept of Land Suitability Analysis

Items and limitation of land suitability criteria are briefly described as follows. The items of Potable water and Fragmentation, which are used for specified development potential analyses are excluded from the criteria as this study is focused on irrigation development and those two criteria are not important factors.

Ground water quality (G):

A distinction is made between : not available, fresh, brackish/sulphurous and saline. Presence of brackish/sulphurous or saline groundwater is considered to limit the suitability of the land system for paddy cultivation for its excessive salinity.

Inundated land (I):

The parameters are given in the data sets : the risk of flooding, the sediment load of the flood water and the risk of inundation. Areas commonly or frequently flooded by waters containing high sediment loads or subject to permanent or tidal inundation are thought to be unsuitable for paddy cultivation.

Climate (C) :

The climate classification is based on the average annual amount of rainfall and the number of wet (>200mm) and dry (<100mm) months, in combination with the length of the growing period and the minimum and maximum temperature. Paddy cultivation is possible if the average annual rainfall ranges between 1,000 and 5,000 mm. The dry period should be no more than 7 months and there have to be at least 4 wet months. The growing period has to be more than 100 days and the temperature is allowed to range among 15 and 34 C^{0}.

Soil texture (T) :

Six soil texture classes of the top 25 cm of the soil are distinguished, which are fine, moderately fine, medium, moderately coarse, coarse, and organic texture. Only soils having a coarse texture are considered not suitable for paddy cultivation in relation to excessive drainage and low nutrient holding capacity.

Soil depth (D) :

Although both peat and mineral soil are classified according to their depth for the suitability assessment , separate criteria are used for the two types of soil. Peat soils deeper than 75 cm from surface are considered unsuitable for paddy cultivation because of formidable difficulties to be reclaimed. Mineral soils less than 25 cm deep are considered unsuitable because such shallow rooting zone often cause water and nutrition stresses.

Soil drainage (W) :

A distinction between excessively, well to moderately well, imperfectly, poorly and very poorly drained soils is made. For paddy cultivation soils have to be imperfectly to very poorly drained.

Soil nutrition (N) :

The soil nutrient status of the top 25 cm of the soil is described with the following parameters: exchangeable potassium (K), available and total phosphorus (P) and the cation exchange capacity (CEC). Furthermore a number of potentially limiting soil chemical characteristics is given : the pH(H2O) value, Aluminum (Al) saturation, the depth to acid sulphate layer, the salinity of the soil and whether or not the parent material of the soil is ultrabasic. Land system suitable for paddy cultivation should have CEC value higher than 5 meq/100g soil, pH values lower than 7.9 and a salinity (EC) below 4.0 mS/cm. The presence of an acid sulphate layer within 25 cm from the soil surface,and quartzic or ultrabasic parent material makes the soil unsuitable for paddy cultivation. Land system with low exchangeable K, available P or total P or with high Al saturation or exchangeable Al are considered as conditionally suitable.

Elevation (L) :

Elevation above 1500m (annual average temperature below 18.7 C^0) are though to be unsuitable for paddy cultivation for its cool.

Slope (S) :

Land slope classes are distinguished as flat (<2 %), very gentle (2-8 %) gentle (9-15 %), moderately steep (16-25 %), steep (26-40 %), Very steep (41-60 %) and extremely steep (>60 %). Only flat areas are considered to be suitable for paddy cultivation . Very gentle to moderately steep areas are considered as conditionally suitable areas. As for volcanic in Java, even steep and very steep areas are also included in conditionally suitable areas because high population pressure has already enforced cultivation on some parts of such lands.

The nine characteristic of each land system are examined and categorized as suitable (S), conditionally suitable ($), unsuitable (N) or not relevant (#). After that, each land system is classified into four groups, i.e., fully suitable (S), conditionally suitable ($), marginally suitable ($$) and unsuitable (N).

As a result of combination of the nine suitability examinations, land suitability orders on land systems are defined as follows.

Fully suitable (S):

Land on which sustained use of the type considered is expected to yield benefits sufficient to justify the required inputs without unacceptable risk of damage to land resources. "Suitable" indicates that 60 to 100 % of the land systems is suitable for the specified land utilization type. Suitable land systems may include up to 40 % of unsuitable land.The type of land systems does not have any N or $ factors within the nine suitability criteria.

Conditionally suitable ($) :

Land which requires additional inputs to make it suitable for sustained use of the types under consideration inputs may include soil and water conservation measures, bench terracing, water control, estate management, fertilizer, infrastructure etc. Conditionally suitable land systems may also include up to 40 % of unsuitable land. The land systems are distinguished as one $ character of the nine suitability criteria.

Marginally suitable ($$) :

Land which requires more inputs to solve double constraints for wetland arable agriculture development. Marginally suitable land systems may also included up to 40 % of unsuitable land. The land systems distinguished as two $ factors of the nine suitability criteria.

Unsuitable (N) :

Land with qualities that appear to preclude sustained use types under consideration."Unsuitable" indicates that 60 % to 100% of the land system is unsuitable for the specified land utilization type. Unsuitable land systems may include up 40 % of suitable land. In the land system, at least one N factor and/or more than three $ factors are founded out.

Conditionally suitable land systems can be divided into four sub-classes by a kind of conditionally suitable factors, which are inundation (i), drainage (w), soil nutritions (n) and slope (s). The sub - division roughly shows amounts of land with moderate constraints for wetland agriculture development.

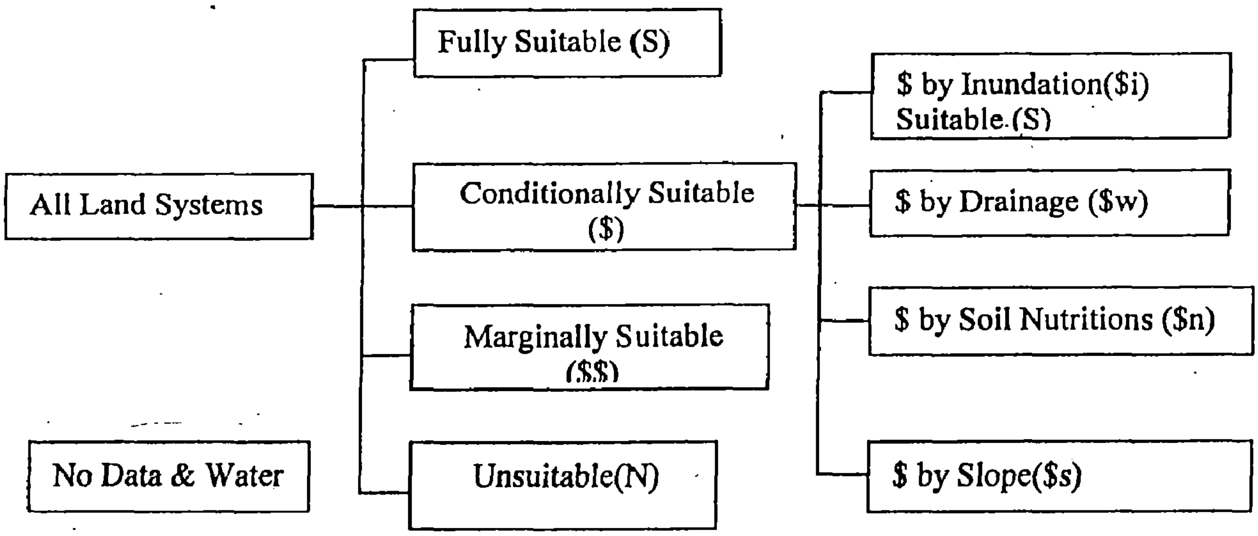


Figure 6.2 Schematic of Land Suitability Classes

Result of Land Suitability Analysis for Ciujung Basin

Rainfall (mm/month)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
220	191	192	200	148	85	65	75	80	134	149	176	1,715

Table 6.3 Land Suitability for Wetland Agriculture Development by Province

('000 ha)

Province	Area by Land Suitability		Subdivision of $ Land	
West Java	Total	4,645		
	S	779	$I	0
	$	299	$w	0
	$$	2,891	$n	0
	N	654	$s	299
	Unclass	22		

Source : JICA 1993

6.4 PROCEDURE FOR LAND AVAILABILITY ANALYSIS

6.4.1 Land Availability Analysis

Available land area for new wetland development is derived by subtracting current used land area from each land system area, based on matrix data of land system area and specified land use area. The land use types consist of 12 great categories, which are forest, bush/scrub, grassland, shifting cultivation, upland permanent cultivation, wetland cultivation, tree crops/estates, agroforestry, reforestation, water (river, lake,etc.), unvegetated and settlements. Lands which are currently used as lowland paddy field (sawah) and other specified purposes are considered as no potential area for wetland extension development. Current used areas and still available areas are distinguished as follows.

Land Use Types and Classification of Land Availability

Available Land for Field Extension	Not Available Land for Field Extension
Conversion Forest Bush/Scrub Grassland Shifting cultivation Upland	Present Paddy Field Forest excl. Conversion Forest Estate Agroforestry Reforestation Water Unvegetated Land Settlement No Data

In planning land conversion to paddy fields, environmental aspects should be concerned sensitively. In this study forest areas are divided into two groups, i.e., conservation forest and convertable forest. The classification method of forest land is described in following section.

6.4.2 Forest Classification

Forest lands in Indonesia are classified by a method known as consensus Forest Land Use Plan (Tata Guna Hutan Kesepakatan, TGHK).

A land is classified into five TGHK categories by using of site index. Classification index of forest land consists of three identification items, which are land slope, soil erodibility and rainfall intensity. A rainfall intensity index comprises the mean annual rainfall (mm) divided by mean annual raindays.

Table 6.4 Forest Land Classification Index

Land slope		Soil erodibility		Rainfall intensity	
Class	Point	Class	Point	Class	Point
0-8 %	20	None	15	<13.6	10
9-15 %	40	Low	30	13.6-20.7	20
16-25 %	60	Medium	45	20.8-27.7	30
26-45 %	80	High	60	27.8-34.8	40
> 45 %	100	Very High	75	>34.8	50

Source: JICA 1993

This site index is calculated by summing the number of points attributable in respect of each of the three criteria and is used to determine the forest land category as follows:

Site Index	Forest Land Category
< 125	Normal Production Forest (HPB) or Conversion Forest (HPK)
125-147	Limited Production Forest (HPT)
>175	Protection Forest (HL)

Furthermore, all land above 45 % slope is classified as Protection Forest, also land which has a Soil Erodibility of Very High and a slope that exceeds 15 %. In addition, provincial authorities may restrict normal logging activities to areas where the slope is less than 25 % and the altitude is below 500 m.

TGHK category consists of following five, each having its own purpose and permitted form of exploitation.

Table 6.5 Forest Use Category, Purpose and Permitted Exploitation

Category	Symbol	Purpose	Permitted exploitation
Nature reserve	PPA/HAS	Gene conservation	None
Protection Forest	HL	Watershed protection	None
Limited Production Forest	HPT	Timber production	Selective felling
Normal Production Forest	HPB	Timber production	Selective or clear felling
Conversion Forest	HPK	Conversion to agriculture	Clear felling

Normal Production Forest area is managed under the Indonesian Selective Felling System (TPI). The cutting cycle is set at 35 years and the minimum log diameter is 50 cm. In those areas classified as Limited Production Forest, the minimum diameter of the logs extracted is raised to 60 cm. For Protection Forest no felling is allowed. On the other hand, Conversion Forest can be included within the area of a concessionaire. The above diameter restrictions do not apply and complete clearing of the site is allowed.

Only Conversion Forest is considered to be convertible to paddy field in future planning . For Java and Bali , this TGHK classification is not applied because almost all forest area in these island is considered to be developed for specified purposes. Therefore, all forest areas in Java and Bali are determined to be impossible to convert to paddy fields.

Table 6.6 Result of Land Availability Analysis For Ciujung Basin

	Gross total area ('000 ha)	Actually used area for sawah ('000) (%)	Actually used area for other purposes ('000 ha)(%)	Gross available area for wetland development ('000 ha)(%)	Net available area ("000 ha)
All Suitability Classes	4,644.6	923.5 (20%)	2,078.5 (45%)	1,642.6 (35%)	591.3
Fully Suitable Land	778.6	515.8 (66%)	240.6 (31%)	22.2 (3%)	8.0
Conditionally Suitable Land	298.8	141.8 (47%)	110.8 (37%)	46.2 (15%)	16.6
Marginally Suitable Land	2,890.9	245.6 (8%)	1,435.0 (50%)	1,210.3 (42%)	435.7
Unsuitable Land	653.9	20.3 (3%)	269.7 (41%)	363.9 (56%)	131.0
Fully and Conditional Suitable Land	1,077.4	657.6 (61%)	351.4 (33%)	68.4 (6%)	24.6

Source :JICA 1993

6.5 LAND POTENTIAL FOR AGRICULTURE DEVELOPMENT

Land which is suitable for paddy cultivation and convertible to paddy field is defined as land potential the net land potential with land suitability classes is summarized Table 6.6

6.6 LAND POTENTIAL FOR IRRIGATION DEVELOPMENT

Irrigation development potential is physically limited not only by land availability but also irrigation water availability. Irrigation water availability analysis takes into account many factors such as monthly rainfall amount and distribution, river discharge, water consumption for other purpose and so on. On the other hand water demand of irrigated paddy field is also computed on the basis of present (irrigated) paddy field area and a typical cropping pattern. Maximum irrigable area is determined by river basin from a view point physical water availability.

Water used for irrigation is primarily consumed in present irrigation field. Surplus water can irrigate rainfed paddy field at a certain portion. Ratio of irrigable rainfed field is assumed to be the ratio of paddy field with suitable condition (S + $) to total paddy field.

The irrigation potential areas derived from water potential analysis are compared with those from land suitability and availability analyses. The smaller area of two should be irrigation development potential for the basin.

CHAPTER –7

CONCLUSIONS

With availability of modern analytical tools as well as detailed data and information on natural resources and demand for these, it is now possible to adopt a comprehensive approach for water resource development and management in a basin.

In developing countries such as Indonesia and India, irrigation continues to be major sector of water resource development. Therefore, while preparing master plan for a basin, estimation of irrigation water demand and irrigation development potential has to be done in a realistic manner.

A river basin is a natural unit of water availability, its assessment and development. It is also natural habitat for human beings and other species. Thus it is a natural eco-system. Need for adopting basin as an unit of planning has been strongly advocted at various forums and by various agencies all over the world. There are now several examples of such basin developments which have been given in chapter 2. Practices vary from country to country. Each region/ country will have to adopt specific development policy and provide standard guidelines.

For the sake of equity and uniformity in water balance studies for river basins, procedures and guidelines have been issued by the Technical Advisory Committee of National Water Development agency (Govt of India) on important aspects like (i) working out water unavailability yields, (ii)methodology for working out ultimate water requirements and water surpluses,(iii) land uses (iv) ground water requirements for various purposes like drinking, industrial, irrigation and other uses, (v)salinity control etc. NWDA (1996) has compiled such guidelines at one place for facilitating in its adherence, reference and use by those involved in river basin planning and preparation of inter- basin transfer link reports.

Emphasis in this dissertation work is on estimation of basin water demand for various purposes. National Commission for Integrated Water Resource Development (Govt of India 1999) has recommended basic unit parameters. These have been compiled by reviewing the report.

Four items (forest area, rainfall, irrigation area and population) can be used to characterize a basin. Radar chart is an useful tool for graphic presentation of basin characteristics and for visual comparison of characteristics of different basins. Following this procedure, Ciujung river basin is characterised as conservation type.

Unit water demand for urban and rural population are different. Further it is necessary to classify area as urban or rural for which an appropriate criteria is needed. Further present rural area may become urban area in future. Alternate scenarios of population growth in future need to be evolved as accuracy in forecast of food demand and basin water demands depends on reliable population projection.

Variety of population forecast models have been proposed by various agencies including United Nations. Population forecast for Ciujung basin has been made assuming growth rate of 1.5% before 2000 and 1% to 1.2% after 2000.

Non agricultural water demand in a basin comprises of demand for domestic and industrial use, minimum flow requirements for river maintenance, live stock water demand and fish pond water demand. Unit water requirements and population estimates form the basis for estimation of non agricultural water demands. Domestic water requirement in urban and rural area in India and Indonesia are compared below

Domestic requirement litre/capita/day

City size	Present		Mid Future		Planning Horizon	
	Indonesia	India	Indonesia	India	Indonesia	India
	2000	2010	2015	2025	2020	2050
Urban > 1,000.000	250	220	270	220	280	220
Urban < 1,000.000	50	150	170	165	180	220
Rural	30	55	38	70	40	150

As seen from above table, domestic water requirement in rural area of India are higher than in Indonesia whereas urban area requirements are higher in Indonesia than in India. In Indonesia there is more annual rainfall compared to India and there are two rainy seasons in Indonesia. Further in India daily bath and daily washing of clothes as well life style require more use of water for domestic purpose.

River maintenance flow requirement in Indonesia is estimated in a more scientific basis. It is particularly important for urban area adjacent to rivers. Govt of

India(1996) provides min flow requirements based on ecological consideration. It prescribes a minimum lean season flow of 10% of inflow at diversion structure and with storage it could be of the order of 10% of average lean season natural flow downstream of the storage.

Live stock unit water demand in India is assumed to be 18 to 30 litre/head/day whereas in Indonesia it varies from 6 litre/head /day for pig to 40 litre/head/day for cattle/ buffalo.

Whereas Govt. of India (1999) prescribes unit water requirements for hydro, thermal, nuclear, solar/wind and gas based power plants, no such guidelines are available in Indonesia. It is recommended that water demand for power sector in Ciujung basin should be worked out assuming unit requirements as used in India.

In Indonesia, main crop is paddy and therefore irrigation water demand is mainly governed by rice crop water requirements and rice crop areas unlike in India where a variety of crops are grown. Procedure as followed in Indonesia for estimation of irrigation demand has been developed on a scientific basis. It takes into account golongan system of irrigation, and staggered crop calendar.

In India, irrigation efficiency for canal water is 40-60% and it is 70-75% for ground water. In Indonesia irrigation efficiency is 56.7% for paddy and 50% of Palawija crops.

Irrigation development potential in a basin depends on water potential for irrigation and Land Potential Area (LPA). Water potential for irrigation can be obtained by subtracting all non agricultural water demands from the available water resources. Water Potential Area (WPA) is obtained from available irrigation water divided by unit irrigation requirement. Land potential area is based on land suitability analysis and land availability analysis. The land potential area indicates further potential for wet land agricultural development from view point physical land condition. LPA and WPA are the critical limiting factors of irrigation development in a basin. Such type of analysis is generally not carried out in India in the basin water balance studies as seen from the reports of NWDA (NWDA 1993, NWDA 1996). Therefore the approach discussed in this dissertation report can serve as guideline for water balance study in a more scientific manner.

The scope of this dissertation work has been limited to analysis of basin water demand. During the dissertation study, extensive literature survey has been carried out on the practices followed in India and Indonesia. It is hoped that this dissertation study would serve as useful reference for basin studies on a more scientific and realistic basis.

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