ANALYSIS OF CROPPING PATTERN AND WATER UTILIZATION IN CHAMBAL COMMAND

A DISSERTATION

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By

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(JAYA SAMPURNA)

Place : Roorkee
Date : December , 2002

ABSTRACT

The work on the Chambal Project was started in 1953. The main storage dam is Gandhi Sagar and a diversionary barrage at Kota together with the principal canals were constructed and irrigation was started in year 1960 but project construction was completed in 1971.

The project was scheduled to provide full benefits by 1968. Very shortly after the commencement of irrigation, the Chambal Command faced many problems and irrigation potential could not be utilized as planned. Agriculture production in Chambal project area has not increased as envisaged at the time of construction of the irrigation project.

This dissertation work was taken up with the following objectives:

- Analysis of agroclimatic characteristics of the command area as relevant to irrigated agriculture.
- Analysis of changes in cropping pattern and growth of irrigation water demand over different period.
- Analysis of irrigation demand and water utilization.

The main findings of the study are:

1. Monthly rainfall in the command area have high coefficient of variability in all months (more than 80 %).

2. The area is classified as semi arid with moderately deficit moisture availability. Rice and sugarcane crops are not suitable for the area. These high water consuming crops should not be grown in the command area.

3. Design cropping patterns have been revised several times having been influenced by actual development of cropping pattern. Actual cropping pattern as witnessed

over the past 40 years also show wide variation. It is necessary to critically examine such wide variation. Target crop areas are high but actual achievement are low.

4. The area under paddy and sugarcane have not achieved design target. Sorghum and maize have disappeared in recent years. Kharif cropping pattern has shown major short full in entire span of 40 years. Wheat area has shown rising trend from 1993-1994 onward, Soyabean in kharif and mustard in rabi are the major oilseed crops showing rising trend from 1982-1983 to 1993-1996 but declining afterward.

5. With change in cropping pattern, irrigation water demand has also been changing.

   - Water demand in recent years has significantly increased in all months particularly in rabi season.

   - Whereas RBC has adequate canal capacity, the capacity of LBC is found to be inadequate mainly in October.

   - Compared to available design capacity of RBC, the demand has been significantly low resulting in poor utilization of capacity.

6. Water availability at Kota barrage is governed by releases from upstream "carry over" reservoir. These releases are according to power generation schedule. Low water utilization in kharif and spillage occurring downstream of Kota barrage suggest that in certain critical months of kharif season (May,June) water available at Kota barrage is not as per irrigation requirement particularly in RBC resulting in decrease in paddy area.

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AD	= Agriculture Development
C	= Celsuis
CA	= Command Area
CCA	= Culturable Command Area
CWPRS	= Central Power Research Station
CSWCR & IT	= Central Soil & Water Conservation Research & Training Institute
CV	= Coefficient of Variation
CAD	= Command Area Development
CBIP	= Central Board of Irrigation and Power
CADA	= Command Area Development Authority
Cu	= Consumptive Use
ea	= Saturation Vapour Pressure
ed	= Actual Vapour Pressure
ETo	= Evapotranspiration
f(U)	= Wind function
FIR	= Field Irrigation Requirement
GIR	= Gross Irrigation Requirement
ha	= Hectare
Km	= Kilometre
LAT	= Latitude
LON	= Longitude
LBC	= Left Bank Canal
MCM or Mm^3	= Million Cubic Metre
MAI	= Moisture Adequacy Index
n	= Sunshine Duration
OFD	= On Farm Development
PET	= Annual Potential Evapotranspiration per month
P	= Annual Precipitation

Rs	= Radiation
Rn	= Equivalent Evaporation
RBC	= Right Bank Canal
RH	= Relative Humidity
T	= Temperature
U	= Wind Speed at 2 m height

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Irrigation projects are planned and constructed with the objective to encourage efficient use of scarce water and to deliver fair, reliable and adequate supplies at the outlet. Supplying adequate water to meet the optimal crop water requirement for each farmer below outlet may appear desirable, but it is not always feasible.

It is diffucult to manage water distribution in irrigation system. Typically, systems are large and made up of many structures, controls and people. There are complex and dynamic interaction among the physical nature of the resource and the elements of the system. Between these and the environment, farmers and irrigation engineers who make formal and informal decisions at various levels, further influence these interactions. People are often uncertain about how much water is available which generates competition in sharing it. This leads to conflicts and some time malpractices.

1.2 CHAMBAL COMMAND AREA

The Chambal irrigation project is one of the major irrigation projects to have been built in India on priority basis soon after independence. Project construction began in 1953 and irrigation water was made available to farmers in 1960. The main features of the system (Shah 1990) are as under (Fig. 1.1).

- Gandhi Sagar Dam : a masonry structure 64 meters high with a reservoir storage capacity of 7.595 MCM and a reservoir area of 690 sq.km, the second largest in INDIA. The power station has a generation capacity of 120 megawatts
- Ranapratap Sagar Dam : a masonry structure 54 meters high with a live storage capacity of 1.556 MCM and an installed capacity of 172 megawatts. The water of Ranapratap Sagar are also used to cool the reactors of Rajasthan Atomic Power Project at Rawatbhata which has a generation capacity of 400 megawatts.

- Jawahar Sagar Dam: a 45 metre high concrete gravity structure with little storage and 100 megawatts of installed capacity.
- Kota Barrage : an earthen dam with masonry gated spillway about 30 metre high with canal gates on either side to regulate water into the canal system.
- Canal Network: The canal system comprises of two main canals, which take off from the barrage. The Right Bank Canal (RBC) which runs for 124 km. In Rajasthan and further 179 km. in Madhya Pradesh to serve 127,000 ha and 280,000 ha respectively. The two main branches of the Left Bank Canal (LBC) total 168 km. In length and serve 102,000 ha in Rajasthan.

Command Area forms part of the South Eastern Plateau region of the state being situated 25.04^0 N to 25.50^0N latitude and above mean sea level and is an elongated basin in the former alluvial plain of Chambal River. The area is nearly flat plain which slopes (above 0.08 %) gently to the north west direction. The general layout and salient features are shown in Fig. 1.2 and Table 1.1 respectively.

Intensive ravines have cropped up adjacent to the Chambal river and its major tributaries. Gully and sheet erosion is mostly common near the river and about 20 % of the area affected by it, is gradually becoming unproductive.

1.3 BACKGRAOUND OF STUDY

The work on the Chambal Project was started in 1953. The main storage dam is Gandhi Sagar and a diversionary barrage at Kota together with the principal canals were constructed and irrigation was started in year 1960 but project construction was completed in 1971.

The project was scheduled to provide full benefits by 1968. Very shortly after the commencement of irrigation, the Chambal Command faced many problems and irrigation potential could not be utilized as planned. Agriculture production in Chambal project area has not increased as envisaged at the time of construction of the irrigation project, for the following major reasons (CBIP 1987).

- Lack of irrigation distribution methodology and policy (operational plan & warabandi not implemented).

- Poor drainage condition arising out of over irrigation leading to water logging, flooding, yield reduction and a loss of some production land (presently 20,000 ha)
- A lack of on farm development, resulting in low yields and inefficient water use.
- In adequate road network, causing high transport costs (low kharif utilization).
- Gully erosion along banks of Chambal River which causes a loss of land estimated at about 1000 ha per year.
- In adequate service which is only partly effective, due to organizational problem and lack of training.
- Unsatisfactory maintenance of canal and drains, including severe problem of aquatic weed control.
- Shortage of essential farm inputs, mainly fertilizers.
- A lack of coordination between the government agencies responsible for the services to agriculture.

It was initially thought that by creating multidisciplinary infrastructure like systematic construction of water courses, and field channel, drainage, road mandis, extension services, credit societies etc. under one umbrella of Command Area Development Authority (CADA) is the best way to improve the performance of irrigation system. CADA were established in Rajasthan for major projects like, Chambal and Indira Gandhi Nahar Project in mid seventies. Intensive command area development works were taken up under internationally assisted and monitored programmes (CAD Chambal 1972-73). Improvements were noticed and On Farm Development (OFD) work were taken up in some problematic areas of old established of Ganga and Bhakra System. Under this programme huge amounts were spent on Chambal project to construct canal capacity works, outlets (APM'S) Warabandi was introduced for equitable distribution of water. Tall claims were made for successful adoption of warabandi. Financial allocations were also made in the five-year plans for construction of field channels and watercourses upto 6-8 ha blocks and introduction of warabandi in new area. Wide gap in yield were observed from head to tail area served by surface water schemes, and many of the problems stated earlier including malpractices in distribution of water still exist.

1.4 OBJECTIVES OF STUDY

The general objective of this study is to evaluate the progress and performance of irrigation in Chambal Command Area in different period of development such as period before Command Area Development Phase I and Command Area Phase II or post CAD period.

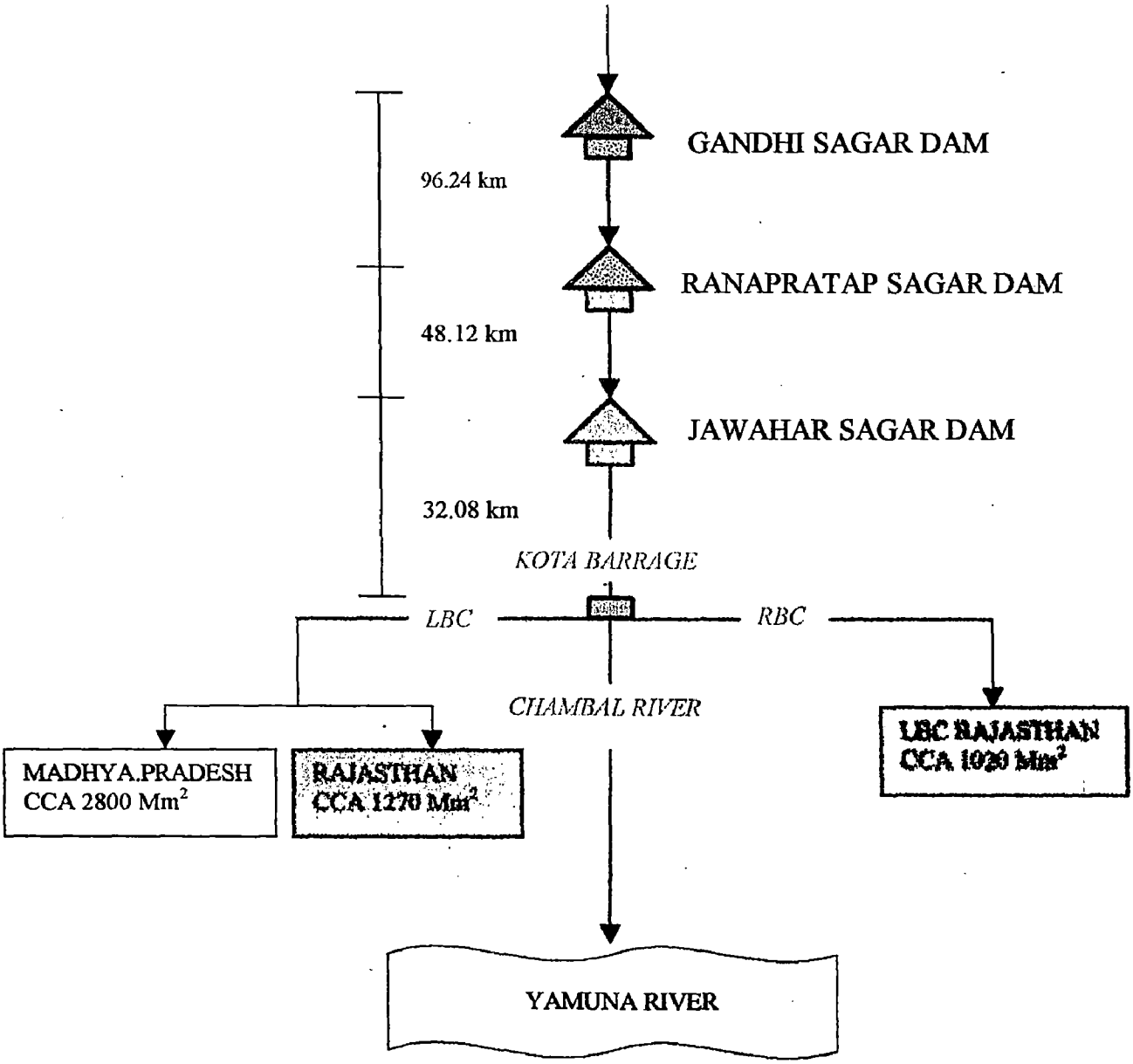
The specific objective of the study are :

- Analysis of agroclimatic characteristics of the command area as relevant to irrigated agriculture.
- Analysis of changes in cropping pattern and growth of irrigation water demand over different period.
- Analysis of irrigation water supply and water utilization.

Tabel 2.1 : THE CHAMBAL CANAL IRRIGATION SYSTEM RAJASTHAN SALIENT FEATURES

1	**Sources of Water Supply**	: Kota Barrage	: FRL 260,36 (854') : SILL 254,88 (836')
2	**Area (Rajasthan)**		
	Service Area	: Left Bank	: 102,000 ha
		Right Bank	: 127,000 ha Total 229,000 ha
	Additional Area	: Left Bank	: 4,840 ha
		Right Bank	: 35,500 ha
3	**Canal Network**		
	Canal Length	: Left Bank	: 168 km
		Right Bank	: 124 km (common carrier) : 179 km (Madhya Pradesh portion)
	Canal Network	: Left Bank	: 1,060 km
		Right Bank	: 1,455 km
		Drains Approximate	: 3,000 km
		5 tank also exist within Right Bank service area	
4	**Design Flow**	: Left Bank	: 42.50 m^3/sec (1,500 cusec)
		Right Bank	: 188.62 m^3/sec (6,656 cusec)
		RB. At Madya Pradesh	: 110.52 m^3/sec (3,900 cusec)
	Manning's (n)	:	: 0,02 unlined (as per original design) : 0,018 lined (as per original design) : 0.026 - 0.044 (actual in lined)
	Velocity	:	: 0,9 m/sec (unlined) : 2,1 m/sec to 1,5 m/sec (lined)
	Bed Slope	: Right Bank	: 1 in 12,000 (unlined) : 1 in 3,800 and 1 in 5,280 (lined)
		Left Bank	: 1 in 5,600
	Full Supply Depth	: Left Bank	: 3.15 m for unlined
		Right Bank	: 2.89 m (head portion)
	Free Board	: Left Bank	: 1.20 m in tank portion
		Right Bank	: 0.90 m in other portion
		LBC	: 0.55 m (at head)
5	**Water Allowance**	: at head	: 6 cusec/400 ha - pre CAD : 7 cusec/400 ha - post CAD
	Water Quality	: Low turbidity (sediment removal in U/S strorage)	
6	**Canal Capacity Factor in Original Design**	: Oct	: 0.9
		Nov	: 0.8
		Dec	: 0.5
		Jan	: 0.5
		Feb	: 0.7
		Mar	: 0.5
		Apr	: 0.4
		May	: 0.6
		Jun	: 0.6
		jul	: 0.2
		Aug	: 0.2
		Sep	: 0.5

Figure. 1.1: SCEMATIC DIAGRAM OF MAJOR PROJECTS IN CHAMBAL BASIN



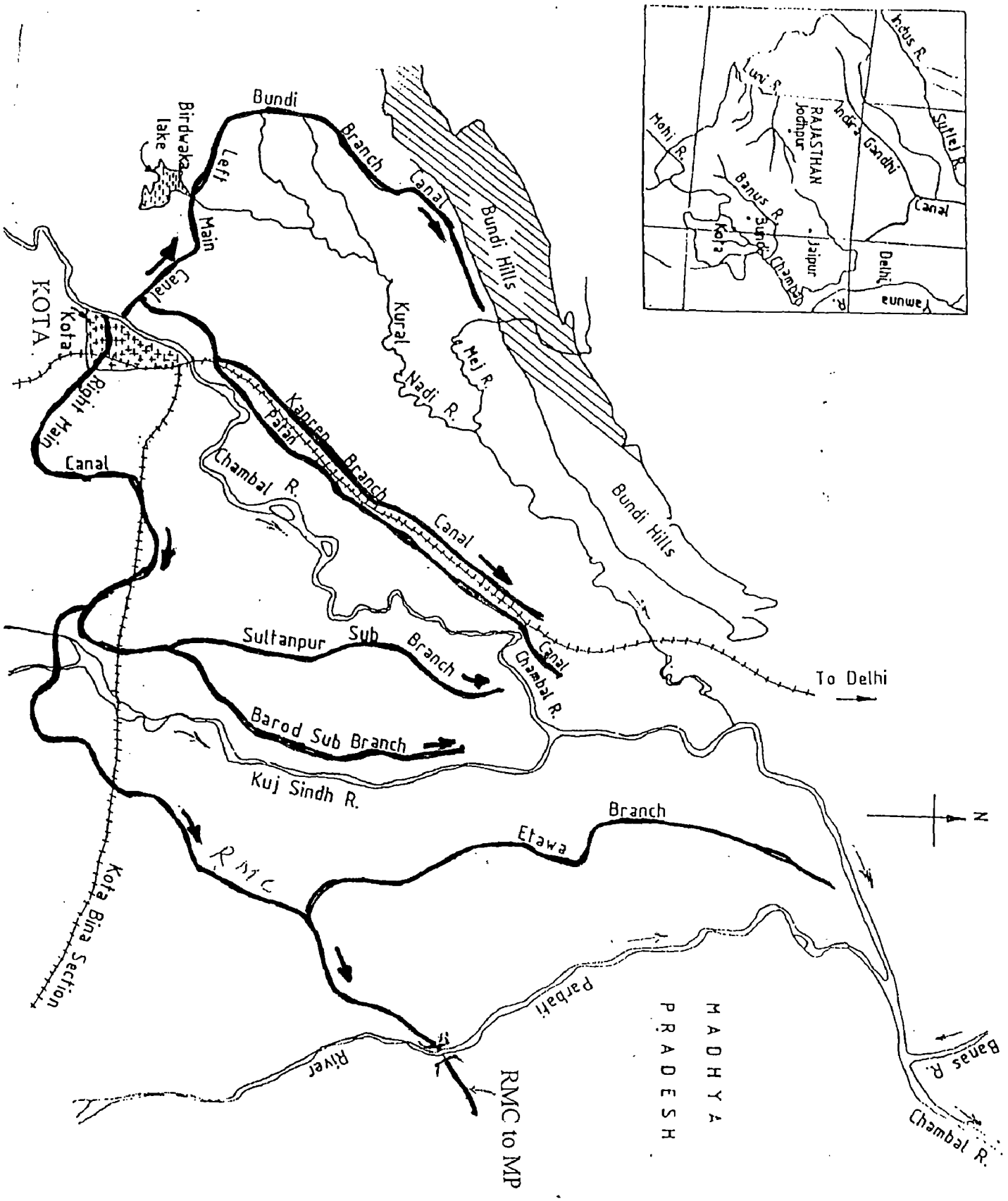
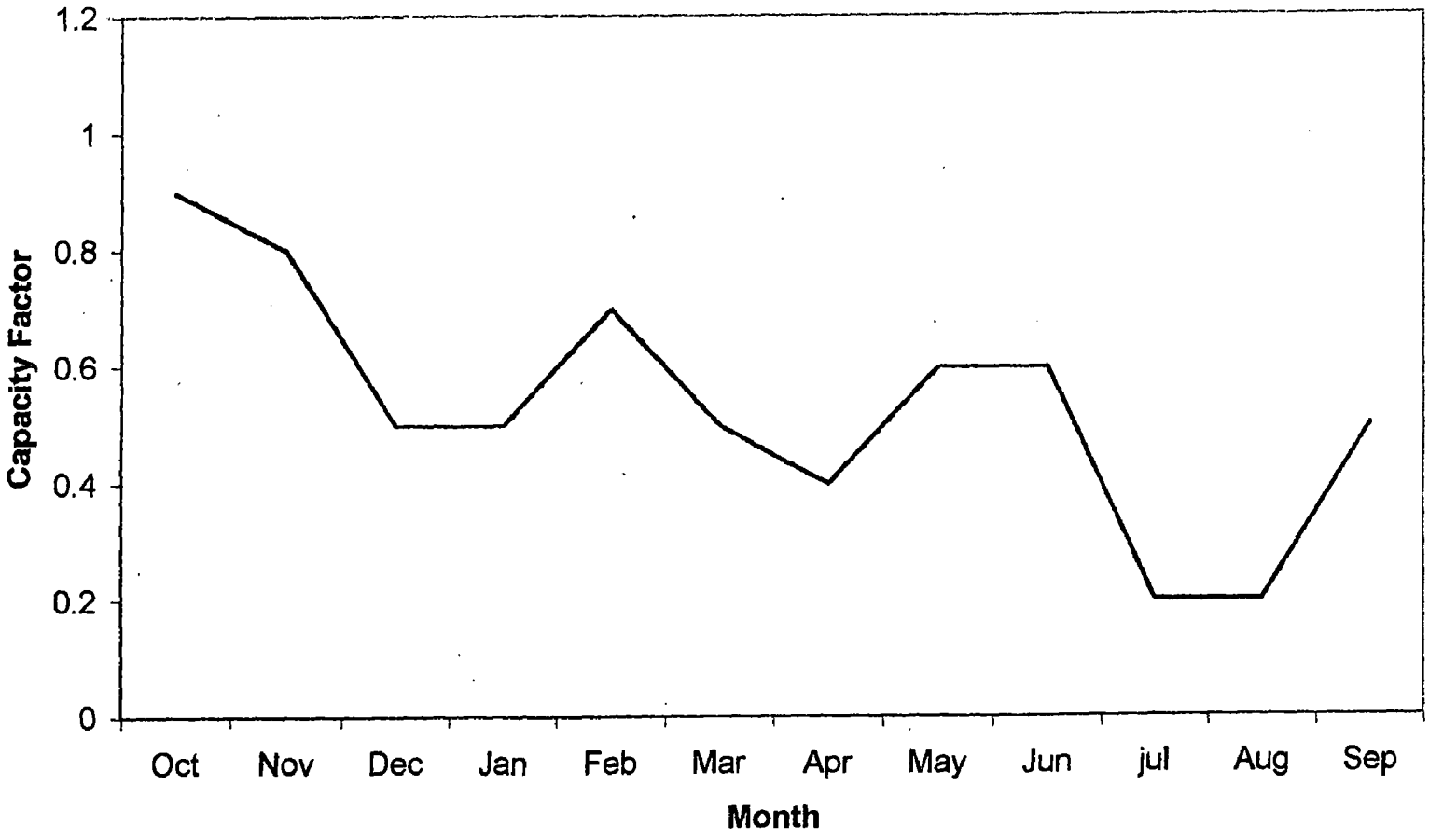


Fig. 1.2 : Chambal Command Area, Kota,Rajasthan,INDIA

Fig.1.3: Canal Capacity Factor in Original Design



CHAPTER 2

ANALYSIS OF AGROCLIMATIC CHARACTERISTICS

2.1 GENERAL

The climate of the Chambal commond area is subtropical semi arid. The average annual rainfall is about 850 mm (1931-1961), 808 mm (1961-1985). About 90 % of this occur in the June-September monsoon season. There is high degree of variability from year to year. Short period high rainfall may be expected during the monsoon. For example in 1986, 195 mm rainfall in a 24 hour period of July and in the same week 631 mm rainfall was occurred. The total of entire season was 1,376 mm. The consequence of this was severe local flooding. There is no estimate available on the frequency and magnitude of flood events.

The air temperature varies from a maximum of 40 ^{0} C or more in May and June to a minimum of 4 ^{0} C in December and January. The climate provides 12 month growing season.

The kharif (wet crop season) spreads from May to October, Rabi (winter crop season) from November to April. Hot crop season or Zaid is from April to June but it is of little consequence in the Chambal Area.

The soil of the project area are fairly uniform clay loams (black cotton soils) and are classified as vertisols, which crack deeply into hard angular clods when dry. When wet they are plastic with very low infiltration rates and considerable swelling. Below 1,5 to 2 m, this soil merges with a yellowish brown heavy clay layer 10 to 30 cm in thickness, partly cemented with sodium carbonate.

Below that is a yellow silt clay (the murrum layer) continuing 20 m to 30 m to bed rock. The murrum layer has relatively high lateral permeability and often acts as a semi-confined aquifer.

The soils of the command area contain 50 % porosity, while moisture holding capacity varies from 35 % to 40 % and wilting point 17 % to 18 %. The permeability is from 1 cm to 5 cm. There is very low percentage (nearly 1.0%) of organic matter. Lime contents in the soils range between 1 % to 5 %.

Ground water table rose sharply from 1960 to create about 20.000 ha of water logged and saline alkaline soil. This area increased to 167.000 ha by the year 1973 and had a water table within 3 m of the surface. This rise was attributed to canal seepage and over irrigation. Generally these shallow ground water have Ec values greater than 1,5 mmhos/cm with recorded values as high as 20 mmhos/cm to 25 mmhos/cm. From a general description of the geology of the area, deep permeable quifers are not likely present. The 20 m to 30 m thickness of alluvium, overlying shale and Shaley lime stone, is composed of sand and silty clays and loams with lenses of sand and kanker. Gravel is seldom present and then only in thin lenses

2.2 CLIMATIC CHARACTERISTICS

Table 2.1 shows average monthly values of :

- Maximum, Minimum, Mean Temperature
- Maximum and Minimum relative humidity
- Pan Evaporation
- Rainfall
- Daily Sunshine Hours, Wind Speed

Average values are compared for the two periods i.e. average for 1931 to 1960 (Source World Bank Appraisal Report 1974) and for 1960 – 1987 (Source: Central Soil and Water Conservation Research and Training Institute Kota).

In general, there has been increase in monthly evaporation, particularly in the month of April, May and June. Average monthly rainfall in June, July, August, September has decreased, There is no significant change in maximum and minimum temperatures over the two periods of analysis.

2.3 POTENTIAL EVAPOTRANSPIRATION

On the basis of meteorological parameters reference crop evapotranspiration have been computed by five different methods viz. Blaney Criddle, Modified Penman, Radiation, Thornthwite and Pan Evaporation for the Chambal command area.

Data for computation of evaporation is given in Table 2.2 . Eto computation by Modified Penman method is shown in Table 2.3.

Eto and Etcrop for wheat, sugarcane and paddy have been estimated by Modified Penman method, Blaney Criddle method and Pan Evaporimeter method as shown in Table 2.4. These have been compared with figures given in Project Chambal Report . estimate as per report appear to be on higher side and these five in considered in analysis .The Eto values have been calculated by as per the procedure and guidelines laid down by Doorenbos and Pruitt (1977). Penman method is more realistic than other methods as it takes into account all meteorological parameters such as temperature, humidity, wind velocity, energy term. ETo values calculated by Penman and Pan Evaporation are close to each other in all the months. The computed Eto value are used further for computing ET crop values for all crop for determining crop water requirements in chapter III.

All the methods show peak values in the month of May and October (Fig. 2.3).

Computational explanatory notes on table 2.3, Computational explanatory notes on Modified Penman.

2.4 ANALYSIS OF RAINFALL

Rainfall is the parent source of water availability in a geographical region. Storage in reservoir and soil moisture saturation needs depend upon the behavior of rainfall pattern.. By Shah (1990) The range and frequency distribution of various amounts about mean are necessary in planning land use and crop cultivation. The annual normal rainfall of the area is 808 mm, of which 687 mm (85 %) occurs during the south west monsoon season (June – September). During the post monsoon season (October to February) 89 mm (11 % of normal) and during hot weather (March to May) the average rainfall is 32 mm (4 % of normal rainfall). The monthwise distribution of rainfall is shown in Fig. 2.1.

The rainfall pattern in the area is quite erratic having deviation of + 87 % to –45 % of the normal value (Fig. 2.2). the statistical characteristics mean, standard deviation and coefficient of variation (C.V) of rainfall value in Table 2.5 also indicates a 34 % variation in annual rainfall. The coefficient of variability varies from a maximum of 158 % during December to a minimum of 80 % in the month of March.

According to Indian Meteorological Department Criterion if the C.V for any month of monsoon is more than 50% , the rainfall is quite erratic, uncertain in nature. Therefore the rainfall can be classified as erratic in nature.

Dependable precipitation (P 75) is defined here as the 75 percent probability of occurrence. Precipitation probabilities of frequency determination are determined from the available data. The accuracy of the analysis depend upon the length of record than on method used. Various monthly precipitation amounts can be determined by using the ranking method and the equation.

The 75, 95, 50 and 5 percent dependable precipitation based on 25 year record are shown in Table 2.5. A generalized equation developed for estimating 5, 50, 75 and 95 percent probability of assured rainfall have been developed with regression analysis. These equations can be used to estimate probable precipitation, if data series is not know and only mean precipitation is known. The regression equations and corresponding coefficient of determination (R^2) as given by Shah (1990) are :

		R^2 in %
P_{05}	= 148 + 1.36 Pm	86
P_{50}	= -20 + 1.0 Pm	99
P_{75}	= -40 + 0.80 Pm	96
P_{95}	= -63 + 0.62 Pm	91

Where Pm is mean montly precipitation

Frequency in deficit of annual rainfall has been computed according to IMD criteria. The number of years and percentage of years when the annual rainfall is less than normal and less than 75 % dependable shown here.

Frequency in deficit of annual rainfall has been computed according to IMD criteria. The number of years and percentage of years when the annual rainfall is less than normal and less than 75 % dependable shown here.

1.	Normal annual rainfall	808 mm
2.	75 % dependable	515 mm
3.	Total number of Years	25
4.	Number of years having rainfall less than normal	15 nos 60 %
5.	Number of year having rainfall less than 75 % dependable	8 nos 32 %

Thus it is included that rainfall pattern is highly erratic and % failure of normal rainfall is 60 % and % failure of 75 % dependable is 32 %

2.5 AGROCLIMATIC CLASSIFICATION

There are five accepted methods available for climatic classification and suitability of crop.

1. *Thornthwaite's Classification* :

With 75 % probability level of annual rainfall the Moisture Availability Index (MAI) for Thornthwaite's classification is given by :

$$MAI = \left(\frac{P}{PET} - 1\right)100$$

Where :

P = annual precipitation at 75 % dependable level.

PET = annual potential evapotranspiration per month

For chambal command, P=515 mm from table 2.5 ; and PET=1164.26 mm/month from table 2.6

$$= \left(\frac{515}{1164.26} - 1\right)100$$

$$= -55.77 \text{ say } -56$$

Thornthwaite's classification is as follows :

Moisture Availability Index	Climatic Moisture Condition
≥ 100	Per humid
20 to 100	Humid
0 to 20	Moist humid
- 33.1 to 0	Moist sub humid
- 66.7 to – 33.1	Semi arid
- 100 to – 66.7	Arid

2. *Krishnan and Singh Method* :

in INDIA, Krishnan and Singh improved Thornthwaite's method suitable to Indian condition. The classification reads as follows:

ZONES	MOISTURE AVAILABLE INDEX	MOISTURE CONDITION
1	< - 80	Extremely dry
2	- 60 to –80	Semi dry
3	- 40 to –60	Dry
4	- 20 to – 40	Slightly dry
5	0 to – 20	Slightly moist
6	50 to 0	Moist
7	100 to 50	Wet
8	> 100	Extremely wet

TEMPERATURE ZONES	TEMPERATURE (^{o}C)	CONDITION
A	> 28	Very hot
B	25 to 28	Hot

C	20 to 25	Mild
D	10 to 20	Cold
E	< 10	Very cold

3. *Hargreaves Classification* :

Hargreaves has classified the moisture condition in a different way. He has developed Moisture Adequacy Index (MAI) using Thorthwaite's potential evapotranspiration.

$$MAI = \frac{P}{PET}$$

Where P is 75 % dependable rainfall. The classification is as follow :

Moisture Adequacy Index (MAI)	**Moisture Condition**
0 to 0.33	Very deficit
0.34 to 0.67	Moderately deficient
0.68 to 1.00	Some what deficient
1.00 to 1.33	Adequate moisture
> 1.33	Excessive moisture

For Chambal command, $MAI = \frac{515}{1164.26}$

$= 0.44$

(as explained in para 2.5,1)

thus the command falls in category moderately deficient

4. *World Bank's Classification* :

Hargreaves later on improved his own index and also indicated suitability of crop. The classification is as follow :

SI. NO	MOISTURE ADEQUATE INDEX (MAI)	CLIMATIC CONDITION	COMMENT
1	All the months with MAI ranging from 0 to 0.33	Very hot	Not suitable even for rainfall agriculture
2	One or two months with MAI of 0.34 or above	arid	Limited suitability for rainfed crop
3	Three or four consecutive months with MAI of 0.34 or above	Semi arid	Production possible for crops 3 to 4 requiring months duration.
4	Five or more consecutive months with MAI of 0.34 or above	Wet dry	Production possible for crops requiring good supply of water
5	One or two months with MAI above 1.33	Some what wet	Natural or artificial drainage required for cultivation
6	Three to five months with MAI as 1.33 or above	Moderately wet	Good drainage system needed for cultivation
7	Five or more months with MAI above 1.33	Very wet	Very good drainage system required

According to above table, chambal command falls in category number 3

5. *National Commission on Agriculture's classification*:

The National Commission on Agriculture suggested following classification :

1. Rainfall of 30 cm per month for at least three consecutive months, suitable for crops like paddy or high water requiring crop.
2. Rainfall between 20 – 40 cm per month for three consecutive months suitable for rice, maize, sorghum.

3. Rainfall between 10 – 20 cm per month for three consecutive months would be suitable for the cultivation of crop other than paddy.
4. Rainfall between 5 to 10 cm per month for about three months is just suitable for pulses, oilseeds.
5. Rainfall 5 cm per month for about 3 consecutive months not suitable for cultivation.

75 % dependable rainfall of Chambal command is given in table 2.5. according to it, there is no rainfall from January to May, very little in June and very good rainfall in July, Augustus, September and little in October. Therefore the area falls in category 3.

The climatic classification based on computed value of PET and method suggested above are as follows :

1. As per Thornthwaite's	semi arid
2. As per Krishnan and Singh method	semi dry
3. Hargreaves classification	Moderately deficient
4. World Bank method	semi arid
5. National Commission on Agriculture's classification	semi arid (category 3)

As per temperature requirement and National Commission on Agriculture, crop suitable in this type of climatic condition are maize, sorghum, wheat.

Therefore it can be concluded that area can be classified as sub tropic semi arid with moderately deficit moisture available.

The area is agro climatically suitable for crop like sorghum, maize, oilseeds except rice. Therefore rice and sugarcane may not be very much suitable for the area from the agro climatic point of view.

Station - Kota
Lat. - 25°13' N
Long. - 75°52' E
Alt. - 275 m

Table 2.1 : CHAMBAL COMMAND AREA DEVELOPMENT (RAJASTHAN) - CLIMATIC DATA

SI NO	MONTH	DAY	AS PER (1931-1960) AVERAGE						AS PER (1960 - 1987) AVERAGE						AVERAGE DAILY SUNSHINE (hr/day)	AVERAGE WIND VEL. (km/hr)	AV.MONTHLY PAN.EVP. (mm)	MEAN MONTHLY RAINFALL (mm)
			Mean		Mean Rel Humadity		Av.Monthly Pan.Evp.	Mean Monthly Rainfall	Temperature		Relative Humidity							
			Tmax (°C)	Tmin (°C)	RHmax (%)	Rhmin (%)			Tmax (°C)	Tmin (°C)	Tmean (°C)	RHmax (%)	Rhmin (%)	Rhmean (%)				
1	JAN	31	24.5	10.6	64	34	114	9	23.7	6.4	15.05	78	32	55	8.91	2.37	103	13
2	FEB	28	28.5	13.1	51	25	151	4	26.5	9.1	17.8	66	28	47	9.52	3.02	137	8
3	MAR	31	34.1	18.5	34	18	256	5	32.5	14.4	23.45	53	19	36	9.22	3.45	257	7
4	APR	30	39	24.4	24	13	334	5	37.5	21	29.25	35	15	25	10.1	4.44	375	10
5	MAY	31	42.6	29.7	28	16	403	7	41.9	25.3	33.6	35	16	25.5	10.47	6.16	493	11
6	JUN	30	40.3	29.5	47	35	328	79	39.8	27.1	33.45	56	32	44	8.88	8.35	453	67
7	JUL	31	33.3	26.4	74	65	180	309	34.5	25	29.75	76	59	67.5	5.36	6.6	204	259
8	AUG	31	31.7	24.4	81	69	104	268	31.4	23.8	27.6	79	69	74	4.91	4.75	154	249
9	SEP	30	33.1	24.7	73	58	128	132	33.2	22.2	27.7	76	52	64	7.57	3.7	174	114
10	OCT	31	34.5	21	53	34	170	15	34.3	16.8	25.55	69	29	49	9.27	2.17	181	26
11	NOV	30	30.8	14.8	51	29	134	6	29.9	11.2	20.55	74	28	51	9.23	1.72	128	36
12	DEC	31	26.7	11.3	61	35	110	9	25.1	7.2	16.15	81	33	57	8.8	1.78	96	8
AVERAGE			33.26	20.70	53.42	35.92	2412	848									2755	808

SOURCE: (a) World Bank Appraisal report (1974) (b) CSWCR and IT, kota

Table 2.2 : DATA FOR ESTIMATED REFERENCE CROP EVAPOTRANSPIRATION (Eto) FOR KOTA REGION, AVERAGE (1960-1987)

DATA	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Latitude (N)	25.13	25.13	25.13	25.13	25.13	25.13	25.13	25.13	25.13	25.13	25.13	25.13
Altitude (m)	257.00	257.00	257.00	257.00	257.00	257.00	257.00	257.00	257.00	257.00	257.00	257.00
T mean (^{o}C)	15.05	17.80	23.45	29.25	33.60	33.45	29.75	27.60	27.70	25.55	20.55	16.15
RH mean (%)	55.00	47.00	36.00	25.00	25.50	44.00	67.50	74.00	64.00	49.00	51.00	57.00
U mean (km/hr)	2.37	3.02	3.42	4.44	6.16	8.35	6.60	4.75	3.70	2.17	1.72	1.78
n mean (hr/day)	8.91	9.52	9.22	10.10	10.47	8.88	5.36	4.91	7.57	9.27	9.23	8.80
RH max (%)	78.00	66.00	53.00	35.00	35.00	56.00	76.00	79.00	76.00	69.00	74.00	81.00
U day (m/sec)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
U day/U night	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50

Source : Vinod Shah (1990)

Table 2.3 : MODIFIELD PENMAN METHOD

ESTIMATED REFERENCE CROP EVAPOTRANSPIRATION (Eto) FOR KOTA REGION

MONTH	ea table 9 (mbar)	ed = ea.RH/100 (mbar)	ea-ed (mbar)	f(U)=0.27 (1+U/100)	Ra Table 10 (mm/day)	N Table 11 (hr/day)	Rs=(0.25+ 0.5n/N)*Ra (mm/day)	f(T) Table 12	f(ed) Table 13	f(n/N) Table 14	Rn.1=f(T). f(n/N).f(ed) (mm/day)	Rn= 0.75Rs-Rs.1 (mm/day)	W Table 15	c Table 16	Eto=c(W.Rn+(1-W) f(U).(ea-ed) (mm/day)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
JAN	17.10	9.41	7.70	0.42	10.00	10.70	6.66	14.10	0.16	0.18	0.41	4.59	0.63	0.95	2.61
FEB	20.30	9.54	10.76	0.47	11.70	11.30	7.85	14.70	0.17	0.18	0.45	5.44	0.62	0.70	3.69
MAR	28.70	10.33	18.37	0.49	13.80	12.00	8.75	15.20	1.19	0.17	3.07	3.49	0.54	0.94	5.68
APR	40.50	10.13	30.38	0.56	15.35	12.70	9.94	16.60	0.22	0.17	0.62	6.84	0.80	0.88	7.82
MAY	51.90	13.23	38.67	0.67	16.40	13.30	10.56	17.50	0.22	0.17	0.65	7.26	0.82	0.96	10.19
JUN	51.80	22.79	29.01	0.81	16.65	13.70	9.56	17.50	0.18	0.16	0.50	6.66	0.81	0.96	9.45
JULY	41.60	28.08	13.52	0.70	16.55	13.50	7.42	16.60	0.14	0.14	0.33	5.24	0.16	0.99	9.07
AUG	36.40	26.94	9.46	0.58	15.75	13.00	6.91	16.30	0.12	0.14	0.27	4.91	0.56	0.95	4.34
SEP	37.00	23.68	13.32	0.51	14.40	12.30	8.03	16.30	0.14	0.16	0.37	5.66	0.84	0.80	4.67
OCT	32.80	16.07	16.73	0.41	12.45	11.60	8.09	15.70	0.17	0.18	0.48	5.58	0.81	0.85	4.95
NOV	24.50	12.50	12.01	0.38	10.50	10.90	7.07	14.60	0.16	0.18	0.42	4.88	0.82	0.69	3.33
DEC	31.90	18.18	13.72	0.39	9.50	10.60	6.32	13.80	0.15	0.18	0.37	4.37	0.94	0.62	2.74

Computational explanatory notes on Table 2.3

MODIFIELD PENMAN METHOD for month of January

Column 2. ea = Corresponding to T mean in table 2.2, 15.05 °C
= 17.1 mbar from appendix.1a

Column 3. ed = ea*(RH mean/100)
= Corresponding to RH mean in table 2.2, 55 %
= ea*(RH mean/100)
= 17.1*(55/100)
= 9.41 mbar

Column 4 = Col.2-Col.3
= 17.1 – 9.41
= 77 mbar

Column 5. f(U) = 0.27(1+Umean/100)
= Corresponding to U mean in table 2.2, 56.88 km/hr
= 0.27(1+56.88/100)
= 0.42

Column 6. Ra =10 mm/day from appendix.1a
= Corresponding to Altitude table 2.2, 25.13 °N January

Column 7. N =10.7 hr/day from appendix. 1b
= Corresponding to Altitude table 2.2, 25.13 °N January

Column 8. Rs = 0.25 + 0.5*(n/Col.7)*Ra
= Corresponding to n mean in table 2.2, 8.91 hr/day
= 0.25 + 0.5*(8.91/10.7)*10
= 6.66 mm/day

Column 9. f(T) = 14.1 from appendix.1b
= Corresponding to T mean in table 2.2, 15.05 °C

Column 10.f.ed = 0.16 from appendix.1b
= Corresponding to column 3, 9.14 mbar

Column 11 = f(n/N), 0.18 from appendix.1b
= Corresponding to n/N, (8.91/10.7=0.83)

Table 2.4 : MONTHLY CONSUNTIVE USE REQUIREMENT FOR WHEAT CROP USING VARIOUS METHOD

MONTH	BLANEY-CRIDDLE			CLASS 'A' PAN EVAPORATION			MODIFIED PENMAN			** As Per Report
	Eto (mm)	Kc	Cu (mm)	Eto (mm)	Kc	Cu (mm)	Eto (mm)	Kc	Cu (mm)	Cu (mm)
1	2	3	4	5	6	7	8	9	10	11
NOVEMBER	153.00	0.17	**26.01**	108.00	0.16	**17.28**	99.90	0.16	**15.98**	**100**
DECEMBER	141.48	0.49	**69.33**	84.01	0.65	**54.61**	84.90	0.66	**56.03**	**90**
JANUARY	136.09	0.43	**58.52**	80.90	0.62	**50.16**	88.35	0.59	**52.13**	**90**
FEBRUARY	126.00	0.71	**89.46**	108.92	0.70	**76.24**	103.32	0.92	**95.05**	**125**
MARCH	145.00	0.90	**130.50**	160.11	0.69	**124.28**	176.08	0.90	**158.47**	**170**
APRIL*	110.00	0.54	**59.40**	130.50	0.30	**39.15**	117.30	0.50	**58.65**	**50**

* only for two week

MONTHLY CONSUNTIVE USE REQUIREMENT FOR SUGARCANE CROP USING VARIOUS METHOD

MONTH	BLANEY-CRIDDEL			CLASS 'A' PAN EVAPORATION			MODIFIED PENMAN			** As Per Report
	Eto (mm)	Kc	Cu (mm)	Eto (mm)	Kc	Cu (mm)	Eto (mm)	Kc	Cu (mm)	Cu (mm)
1	2	3	4	5	6	7	8	9	10	11
NOVEMBER	153.00	0.43	**65.79**	108.00	0.32	**34.56**	99.90	0.42	**41.96**	**120**
DECEMBER	141.98	0.31	**44.01**	84.01	0.42	**35.28**	84.90	0.42	**35.66**	**90**
JANUARY	136.09	0.32	**43.55**	80.90	0.46	**37.21**	88.35	0.43	**37.99**	**50**
FEBRUARY	126.00	0.38	**47.88**	108.92	0.37	**40.30**	103.32	0.49	**50.63**	**100**
MARCH	145.00	0.32	**46.40**	180.11	0.15	**27.02**	176.08	0.32	**56.35**	**100**
APRIL	220.00	0.62	**68.20**	261.90	0.34	**44.52**	234.60	0.58	**68.03**	**120**
MAY	254.20	0.72	**183.02**	319.92	0.36	**115.17**	292.95	0.70	**205.07**	**195**
JUNE	225.00	0.76	**171.00**	317.10	0.37	**117.33**	272.10	0.85	**231.29**	**210**
JULY	71.30	0.78	**55.61**	187.86	0.56	**105.20**	171.74	0.96	**164.87**	**180**
AUGUST	66.03	0.67	**44.24**	131.13	0.65	**85.23**	134.54	0.91	**122.43**	**150**
SEPTEMBER	104.40	0.57	**59.51**	147.00	0.46	**67.62**	140.10	0.63	**88.26**	**165**
OCTOBER	160.27	0.46	**73.72**	147.87	0.39	**57.67**	153.45	0.53	**81.33**	**160**

MONTHLY CONSUNTIVE USE REQUIREMENT FOR PADDY CROP USING VARIOUS METHOD

MONTH	BLANEY-CRIDDEL			CLASS 'A' PAN EVAPORATION			MODIFIED PENMAN			** As Per Report
	Eto (mm)	Kc	Cu (mm)	Eto (mm)	Kc	Cu (mm)	Eto (mm)	Kc	Cu (mm)	Cu (mm)
1	2	3	4	5	6	7	8	9	10	11
MAY	254.20	1.00	**254.20**	319.92	0.91	**291.13**	292.95	0.94	**275.37**	**300**
JUNE	225.00	1.15	**258.75**	317.10	1.10	**348.81**	272.10	1.10	**299.31**	**275**
JULY	71.30	1.30	**92.69**	187.86	1.22	**229.19**	171.74	1.12	**192.35**	**220**
AUGUST	66.03	1.25	**82.54**	131.13	1.30	**170.47**	134.54	1.30	**174.90**	**180**
SEPTEMBER	104.40	1.10	**114.84**	147.00	1.15	**169.05**	140.10	1.15	**161.12**	**180**
OCTOBER	160.27	0.90	**144.24**	147.87	0.88	**130.13**	153.45	0.88	**135.04**	**160**

Note : ** As per World Bank (1974). The consumptive use requirements as stated in the report are on higher side these applear to include overall losses and are gross irrigation requirements.

Computational explanatory notes on Modified Penman, Table 2.4

CONSUMPTIVE USE for Sugarcane Crop for month of November

Kc = 0.42 from appendix.2b

= Corresponding to table 2.3. Col.16: 3.33 mm/day

Cu = (3.33*no of days)*0.42

= (3.33*30)*0.42

= 41.96 mm

CONSUMPTIVE USE for Wheat Crop for month of November

Kc = 0.16 from appendix.2b

= Corresponding to table 2.3. Col.16: 3.33 mm/day

Cu = (3.33*no of days)*0.16

= (3.33*30)*0.16

= 15.98 mm

CONSUMPTIVE USE for Wheat Crop for month of May

Kc = 0.94 from appendix.2b

= Corresponding to table 2.3. Col.16: 10.19 mm/day

Cu = (10.19*no of days)*0.94

= (10.19*31)*0.94

= 275.37 mm

Notes:

Column 1 = monthly consumptive use

Column 2 = evapotranspiration (Eto) from blaney-criddle

Column 3 = crop coefficient (Kc) from appendix.2c

Column 4 = consumptive use of crop

Column 5 = evapotranspiration (Eto) from pan evaporation

Column 12 = Col. 9*Col.10*Col.11

= 14.1*0.16*0.18

= 0.41 mm/day

Column 13 = 0.75*Col.8-Col.12

= 0.75*6.66-0.41

= 4.59 mm/day

Column 14. W = 0.63 from appendix.1c

= Corresponding to T mean and Altitude in table 2.2

Column 15. C = 0.64 from appendix.1c

= Corresponding to RH max 78 %, Uday/Unight 1,5 Uday 3 table 2.2 and Col.8

Column 16 = Col.15(Col.14*Col.15+(1-Col.14)*Col.5*Col.4)

= 0.95(0.63*0.14+(1-0.63)*0.42*7.7))

= 2.61 mm/day

Table 2.5 : MEAN MONTLY RAINFALL AT KOTA (unit mm)

Station : Kota Long : 75°51' E 25 Year (1960-1985)

Latitude 25°12' N Elev. : 257 m

PROBABILITY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
95	0	0	0	0	0	1	70	42	4	0	0	0	390
75	3	0	0	0	0	16	155	179	42	4	0	0	515
50	5	0	0	0	0	34	230	249	91	9	0	0	666
5	42	22	21	21	45	174	540	438	542	125	24	24	1248
Mean (X)	13	8	7	10	11	67	259	249	114	26	8	8	808
S.D.	15.8	11.21	9.34	13	11.8	58.85	141.2	111	121	36.38	13.3	13.33	247.22
C.V.	1.22	1.4	0.8	1.3	1.7	0.88	0.54	0.44	1.05	1.39	1.58	1.58	0.34

*Source: Basic Rainfall series (1960-1985), Irrigation Departement, Hydrology Wing Jaipur,Rajasthan

Table 2.6 : ESTIMATED REFERENCE CROP EVAPOTRANSPIRATION (Eto) FOR KOTA REGION (Unit: mm)

SI NO	MONTH	BLANEY CRIDDLE		RADIATION		MODIFIED PENMAN		PAN EVAPORATION (Eto)		THORTHWAITE	
		mm/day	mm/Month	mm/day	mm/Month	mm/day	mm/Month	mm/day	mm/Month	mm/day	mm/Month
1	JAN	4.39	136.09	3.19	98.89	2.85	88.35	2.61	80.90	2.75	85.20
2	FEB	4.50	126.00	4.33	121.20	3.69	103.32	3.89	108.92	3.32	92.97
3	MAR	4.68	145.00	4.58	141.98	5.68	176.08	5.81	180.11	3.21	99.55
4	APR	7.33	220.00	7.41	222.30	7.82	234.60	8.73	261.90	4.12	123.67
5	MAY	8.20	254.00	9.03	279.93	9.45	292.95	10.32	319.92	4.60	142.45
6	JUN	7.50	225.00	7.54	226.20	9.07	272.10	10.57	317.10	4.01	120.32
7	JUL	2.30	71.30	4.10	127.10	5.54	171.74	6.06	187.86	2.29	69.09
8	AUG	2.13	66.03	3.68	114.08	4.34	134.54	4.23	131.13	1.87	58.07
9	SEP	3.48	104.40	4.34	130.20	4.67	140.10	4.90	147.00	2.98	89.50
10	OCT	5.17	160.27	3.23	100.13	4.95	153.45	4.77	147.87	3.38	104.65
11	NOV	5.10	153.00	4.52	135.50	3.33	99.90	3.60	108.00	3.15	94.47
12	DEC	4.58	141.98	2.74	85.00	2.74	84.90	2.71	84.01	2.72	84.32
	Total		1803.00		1783.00		1952.00		2073.00		1164.26

Note : This table is based in table 2.4

Fig.21 Mean Monthly Rainfall at Kota (1960-1985)

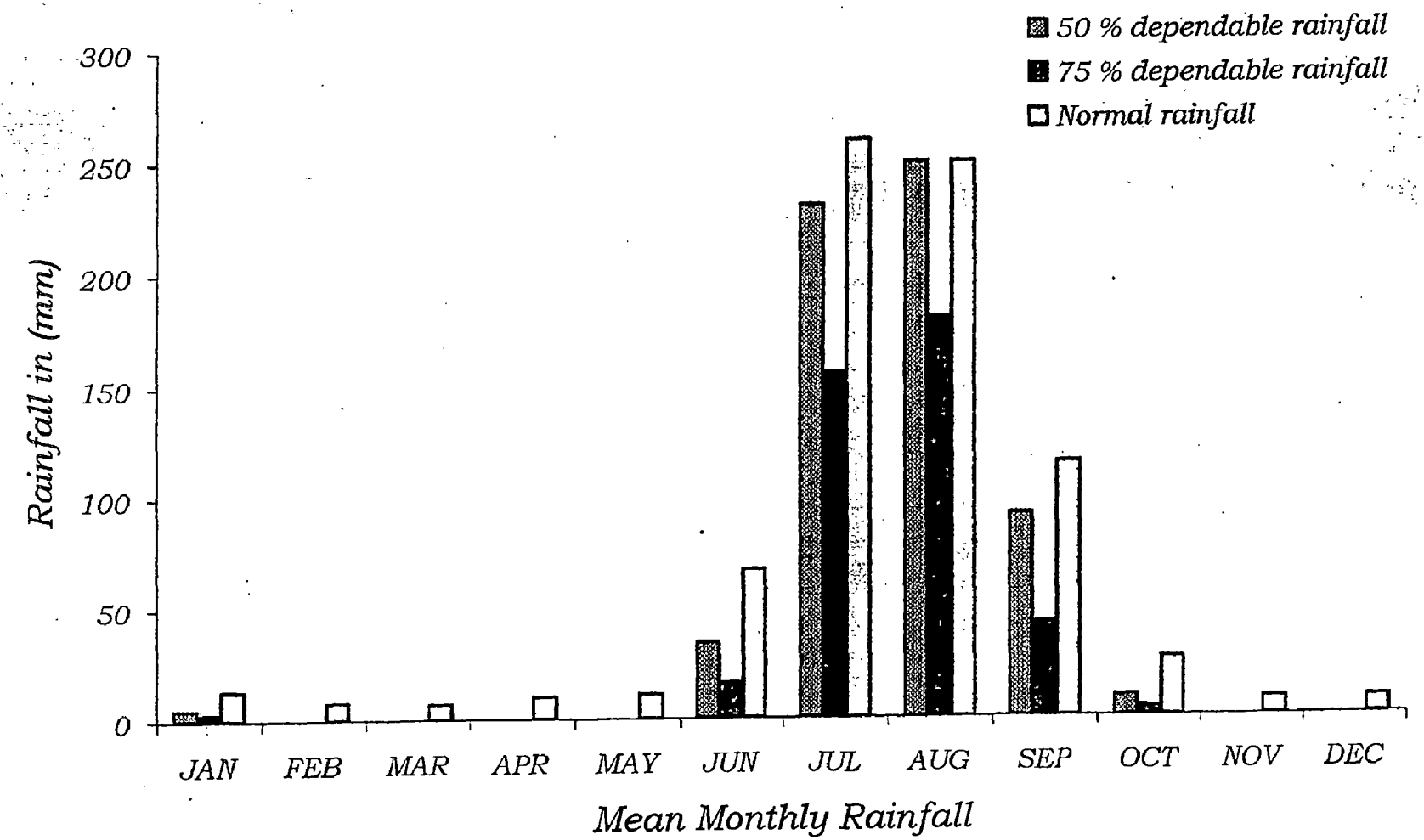
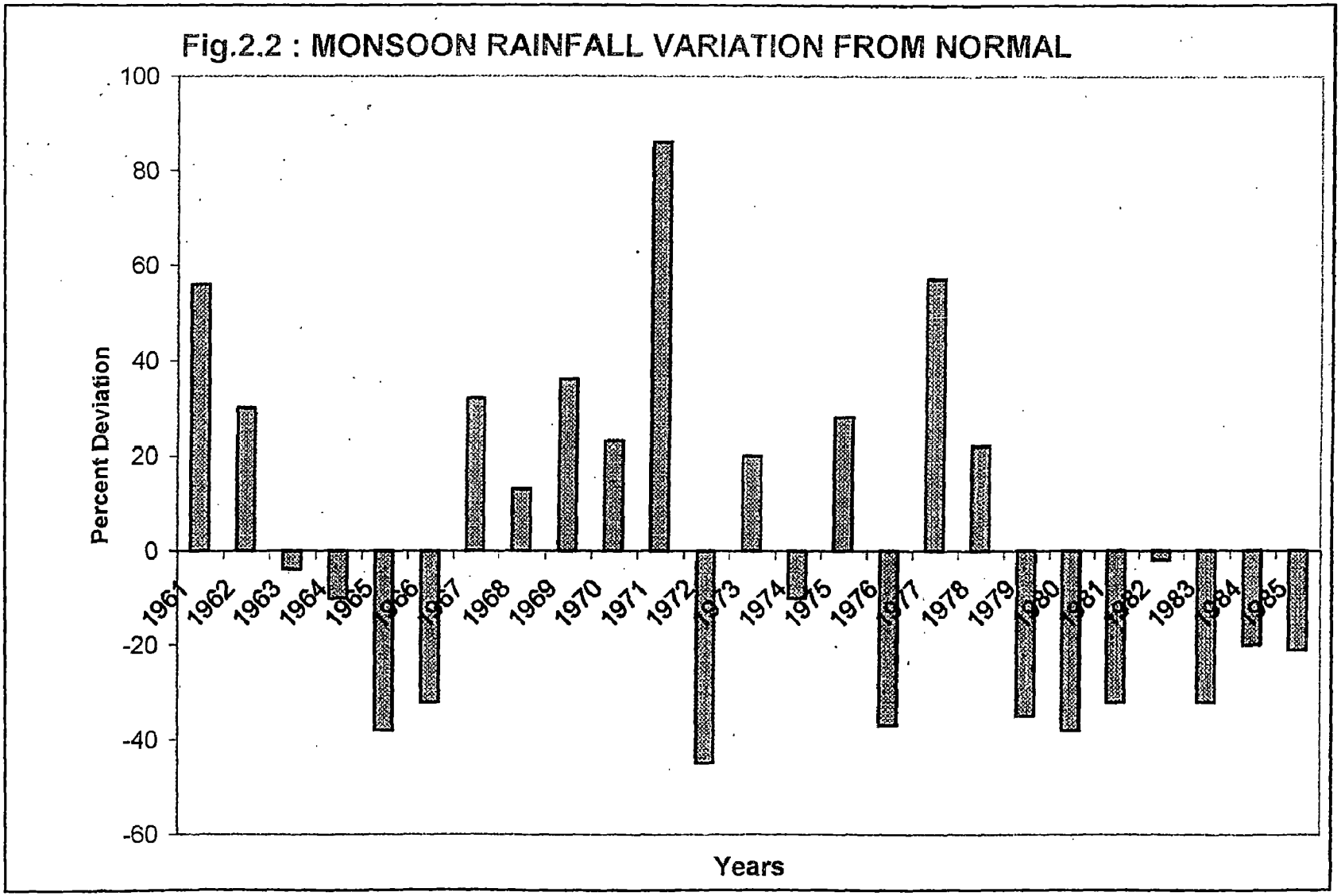


Fig.2.2 : MONSOON RAINFALL VARIATION FROM NORMAL



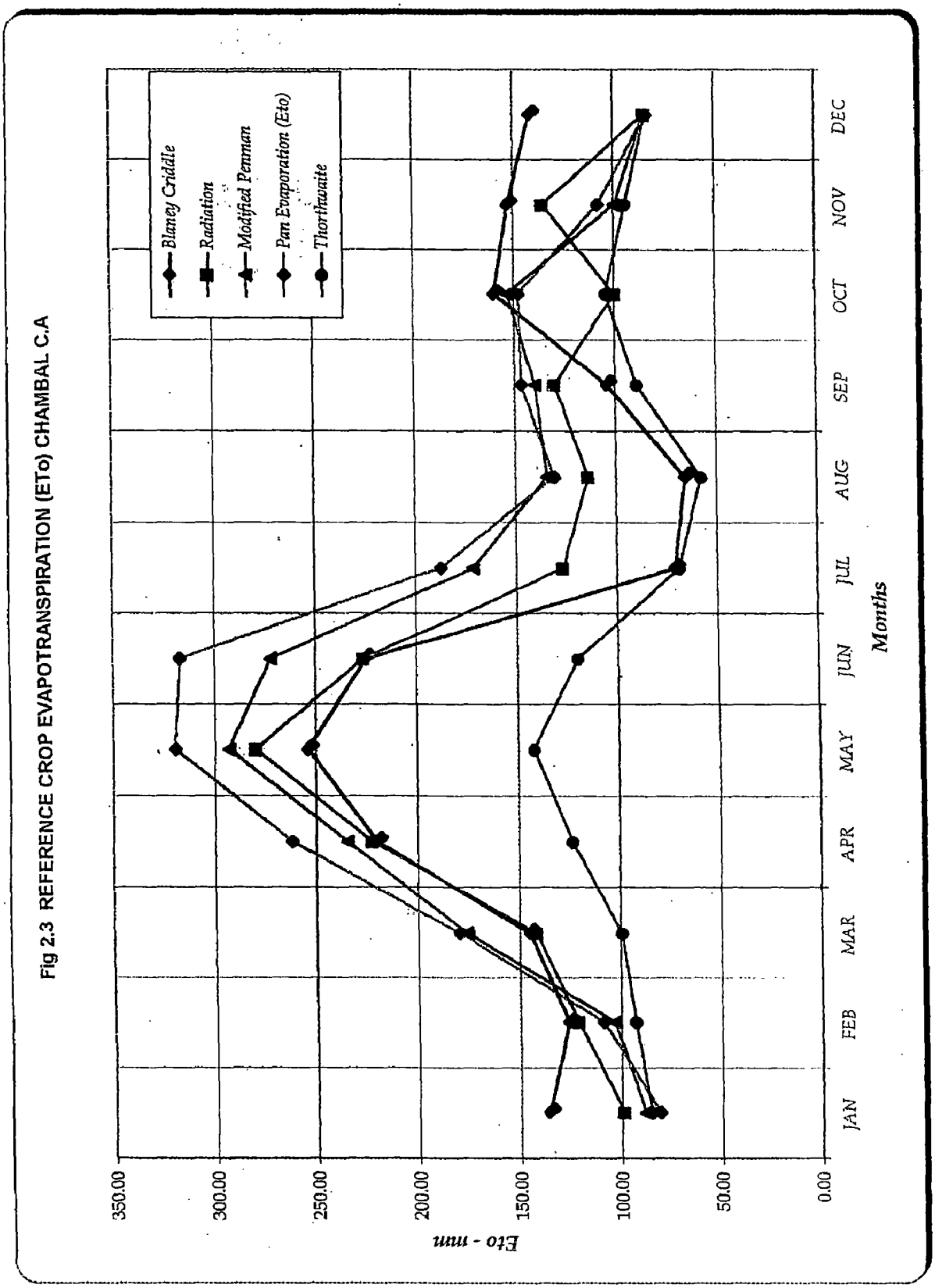


Fig 2.3 REFERENCE CROP EVAPOTRANSPIRATION (ETo) CHAMBAL C.A

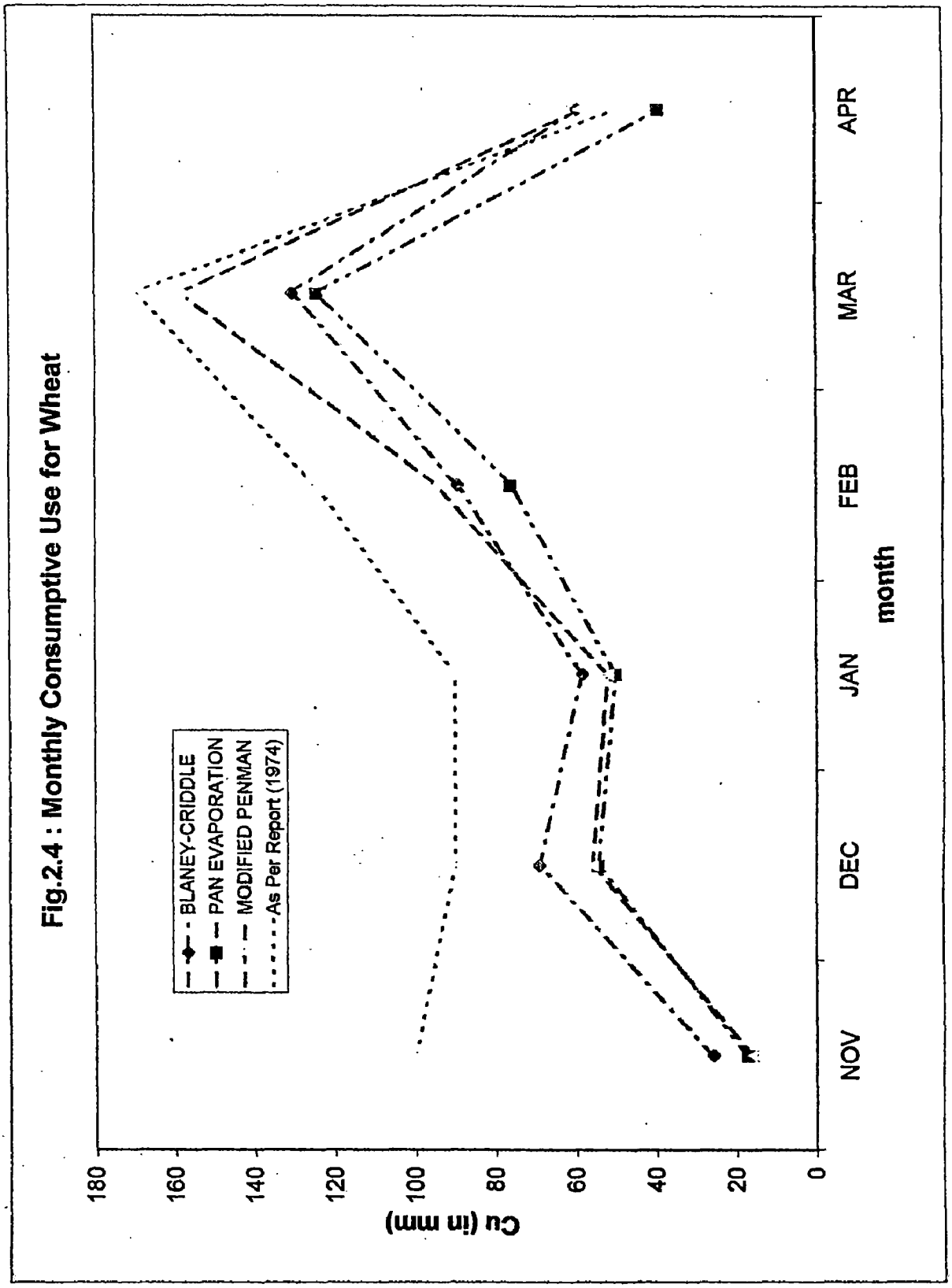


Fig.2.4 : Monthly Consumptive Use for Wheat
BLANEY-CRIDDLE
PAN EVAPORATION
MODIFIED PENMAN
As Per Report (1974)
Cu (in mm)
0
20
40
60
80
100
120
140
160
180
NOV
DEC
JAN
FEB
MAR
APR
month

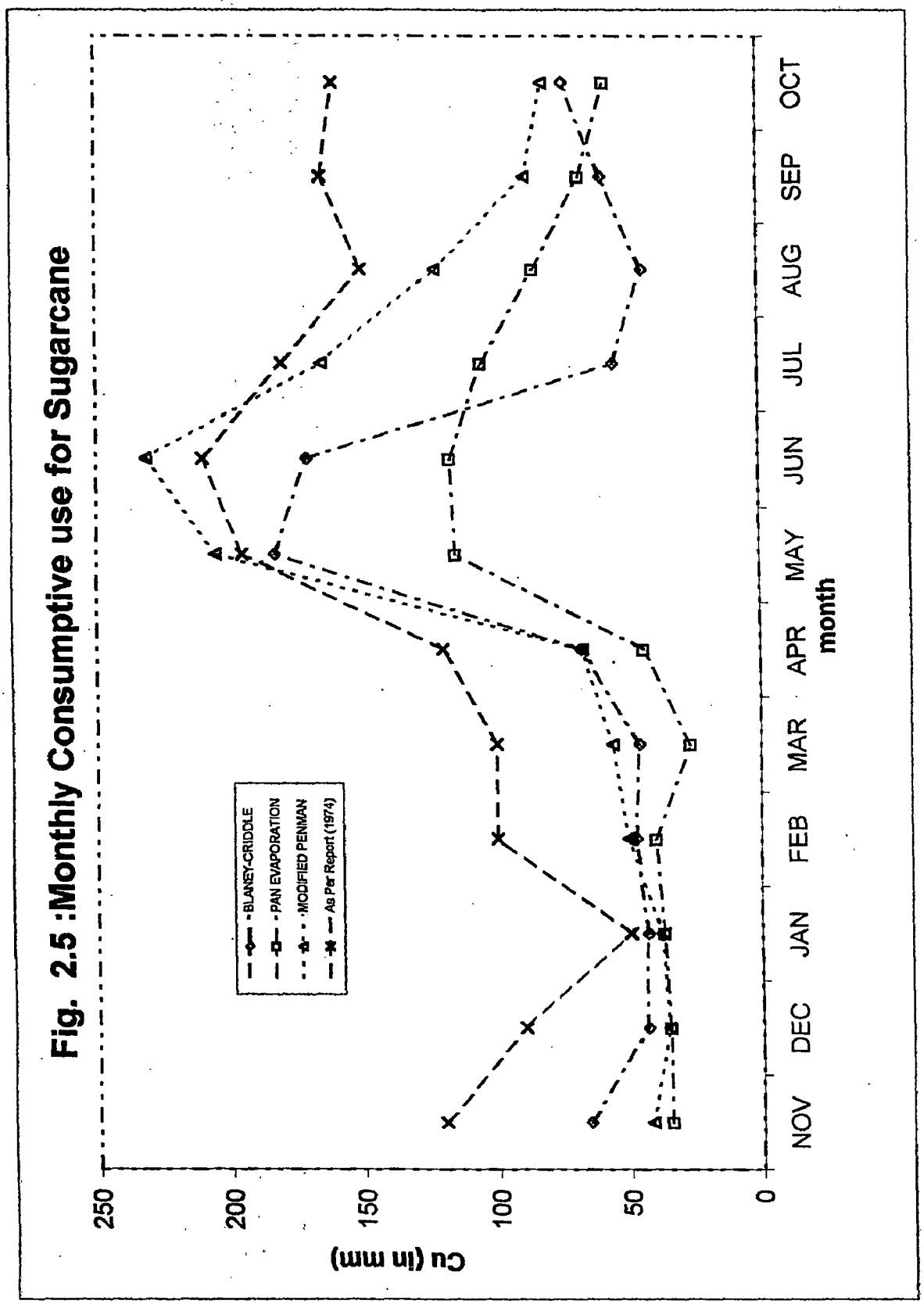


Fig. 2.5 :Monthly Consumptive use for Sugarcane
Cu (in mm)
250
200
150
100
50
0
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
month
BLANEY-CRIDDLE
PAN EVAPORATION
MODIFIED PENMAN
Ag Per Report (1974)

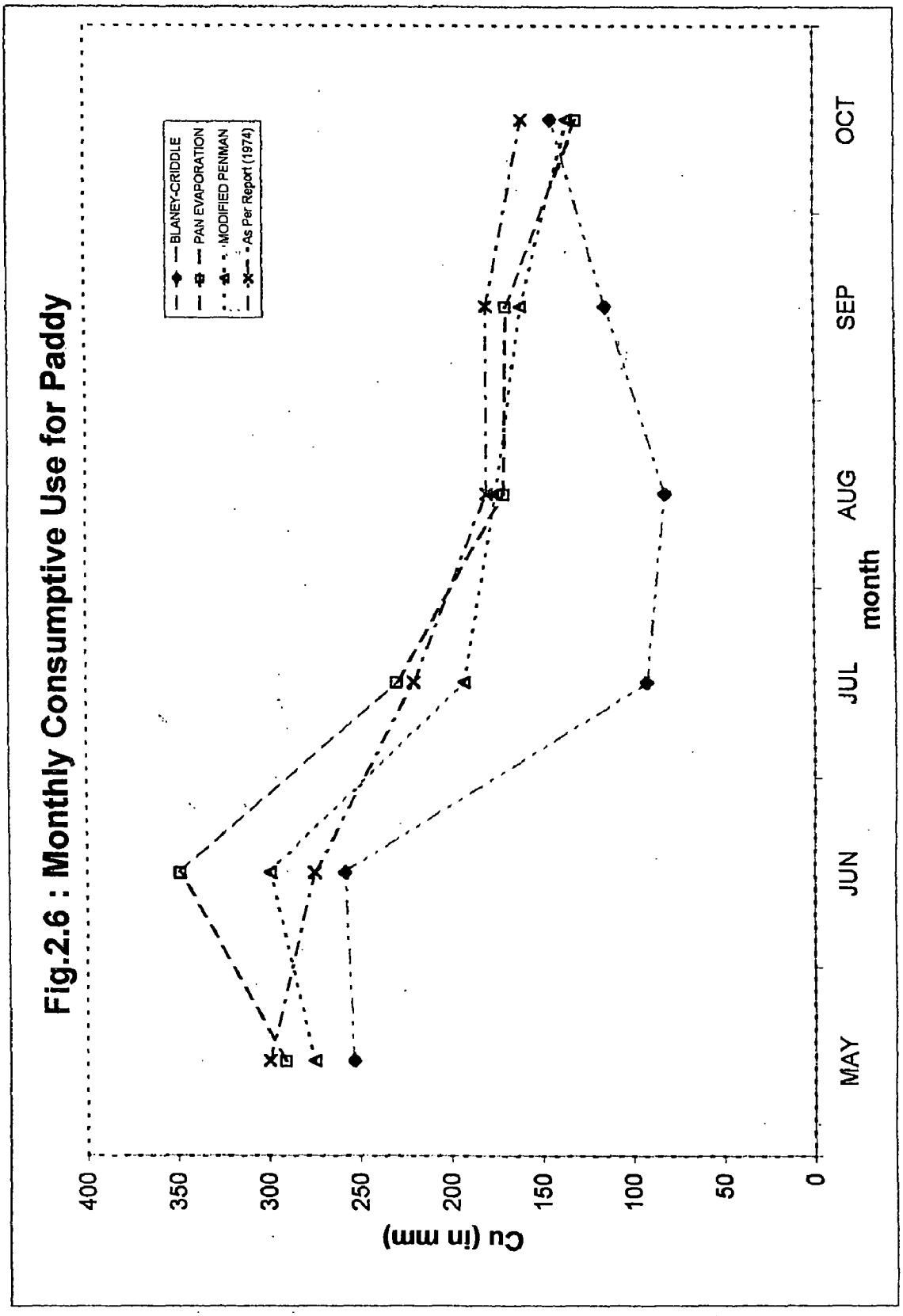


Fig.2.6 : Monthly Consumptive Use for Paddy
BLANEY-CRIDDLE
PAN EVAPORATION
MODIFIED PENMAN
As Per Report (1974)
Cu (in mm)
400
350
300
250
200
150
100
50
0
MAY
JUN
JUL
AUG
SEP
OCT
month

CHAPTER 3

ANALYSIS OF CROPPING PATTERN

3.1 GENERAL

With the development of irrigation, cropping pattern also develops as per the suitability of land and availability of water and other inputs. The transformation from rainfed to irrigated agriculture occurs gradually. Adequacy, reliability and timely availability of water resources plays great role in implementation of design cropping pattern. The cropping pattern throughout the project area may not remain uniform because of several technical and economic reasons. Generally, farmers tend to adopt cash crops with increased reliability of water supply and availability of fertilizer , seeds, transportation and storage facility. Market prices also influence choice of crops

3.2 CROPPING PATTERN BEFORE PROJECT

Prior to the introduction of irrigation in the area, the crops were grown generally as rainfed (kharif) on the residual soil moisture of rainfall (rabi crop). The yields were generally very low. In the initial stage of irrigation, the transformation from rainfed farming to irrigated farming had been very slow. The agriculture technology level at that time was far from satisfactory

Crops grown during rainy season (kharif) under rainfed condition in the project area were mainly sorghum (Sorghum vulgare) and pulses. The main pulses grown were red gram usually mixed planted with sorghum and black and green gram. Gram was grown mostly on residual soil moisture and irrigated in a very small area of the project. A perusal of original cropping pattern given in 1954 Project Report (1954) shows :

Table 3.1 : Pre Project Cropping Pattern

CROPS	% OF SEASONAL CROPPING		DELTA mm	
	IRRIGATED	RAINFED	IRRIGATED	RAINFED
Kharif				
1. Sorghum	-	60.00	-	313
2. Til	-	8.00	-	188
3. Maize	0.33	3.00	753	500
4. Pulses	-	3.00	188	-
5. Cotton	-	1.00	-	125
6. Sun (hemp)	-	0.50	-	250
7. Groundnut	-	0.33	-	750
Rabi				
9. Wheat	1.00	29.00	750	188
10. Linseed	-	22.00	-	188
11. Barley	1.00	1.00	750	375
12. Gram	-	11.25	-	188
13. Corriander	2.25	0.50	750	190
TOTAL	4.58	139.58		

It is evident from the above cropping pattern that before project, most of the crops were rainfed and irrigated crops were almost negligible. The irrigated crops were dependent upon local sources such as small ponds and wells. Sorghum was the main kharif rainfed crop with 60 % area of CCA and Wheat (29 %), Linseed (22 %) and Gram (11.25 %) were the main rabi crops which utilized soil moisture at end of kharif season for growth.

3.3 ORIGINAL DESIGN CROPPING PATTERN

Based on existing practices, the project was designed for 76 % irrigation intensity and kharif, rabi cropping pattern was proposed as shown in table 3.2 . 21 % irrigation

intensity in kharif and 55 % in rabi was proposed. Main kharif crop was paddy (15 %) and main rabi crop was wheat (53 %).

The Chambal Project was implemented with this designed cropping pattern on CCA 229,000 ha and all water requirement and availability studies were based on this cropping pattern. This can be termed as base cropping pattern. The cropping pattern designed in original project report has undergone changes several times as discussed in following section.

3.4 DEVELOPMENT OF CROPPING PATTERN AFTER PROJECT

Table 3.2 shows cropping pattern in selected periods (actual and revised targets) cropping pattern for irrigated and unirrigated lands as well as seasonal and annual intensities are as shown in table 3.2. Crops grown during rainy season (kharif) under rainfed condition in the project area were mainly sorghum and pulses. The main pulses grown were red gram usually mixed planted with sorghum and green gram. Gram was grown mostly on residual soil moisture and as irrigated in a very small area of project. It is interesting to note that the total area under paddy was very small when irrigation was started in 1960. Wheat area during 1960 – 1961 was 15,289 ha in irrigated and 92,620 ha in unirrigated area respectively (table 3.2). Besides these corriander, linseed crops were also grown mostly on preserved soil moisture.. The area under sugarcane was 992 ha during the year 1960-1961. The intensity of irrigated crops in the initial year was about 14 % and the average yield were also far from satisfactory. After start of irrigation in 1960, more and more area were brought into cultivation and farmers switched over from rainfed to irrigated farming. Cropping pattern has undergone several times changes from 1960 onward. Unfortunately with start of irrigation, initially farmers were forced to take irrigation with only part of command area having conveyance network and this resulted in over irrigation and irregular distribution of irrigation water.. This resulted in development of high water requiring crops in head portion of system and low water requiring crops in tail of system.

The transformation from rainfed to irrigated agriculture had been slow in the areas which were far away from the main canals resulting in imbalances in cropping pattern from head to tail (CBIP1987).

3.5 ANALYSIS OF CHANGES IN CROPPING PATTERN

For proper appreciation of change of cropping pattern it would be worth while to divide the period of development :

1. Cropping pattern in the initial year of irrigation 1960-1961
2. Cropping pattern after completion of network i.e. after a decade 1970-1971.
3. Cropping pattern in the base year of CAD phase I i.e. 1973-1974 designed
4. Cropping pattern after completion of project ie. 1983-1984
5. Cropping pattern as in the year 1988-1989
6. Cropping pattern in recent years 1995-1996 to 1998-1999

Table 3.2 shows the crop area as percent with respect to CCA for irrigated and unirrigated crops. Figure 3.1 showns pie diagram of important cropping pattern in different periods.

3.5.1 Change in Transition and Adaptation Period (upto 1970)

Design cropping pattern could not be developed fully at the end of transition period. Paddy area could be developed to 4.64 percent as against 15 % in design, showing the major shortfall whereas kharif pulses, or kharif oilseeds started increasing. These were not anticipated in the original design. Similarly irrigated gram and pulses increased to 16.38 percent as against 2 percent in rabi season. Corriander and rabi oilseeds also developed during this period. There was a transformation from wheat unirrigated to wheat irrigated. Unirrigated wheat reduced from 40.45 percent to 17.94 percent (Fig. 3.1). Cotton crop did not be develop as designed in original cropping pattern.

The transition period witnessed major dependence on unirrigated crops in spite of development of infrastructure and irrigation facility. Kharif

unirrigated area was 58.17 percent and rabi unirrigated area was 44.50 percent of CCA (Table 3.2).Paddy, wheat and gram occupied the major percentage of cropped area during this period.

3.5.2. Changes in CAD Phase I Period (1974-1984)

Targets for CAD phase I project are shown in table 3.2 .The changes of cropping pattern from base year and appraisal design estimate (phase I target) show reduction shortfall in paddy. The area could not be developed as envisaged but paddy area has certainly increased from 2.66 % in 1973-1974. Similarly in rabi season wheat, gram and pulses showed the achievement. During this period also rabi oilseed area had crossed the design area (Table 3.2.) As compared to original designed cropping pattern (1954) paddy and wheat area could not achieve the 15 percent and 53 percent target respectively but increase was noticed in oilseeds, corriander. The dominance of kharif oilseed, rabi oilseed, corriander as percent of cropped area had increased Dependence on rainfed cultivation had decreased on account of increased reliability of supply. The farmers have adopted cash crops in place of wheat and gram.

The percent deviation from design phase I at the end of 1983-1984 indicates shortfall in paddy (from 8.78 to 6.451), sorghum, maize(from 5.11 to 0.55 %), whereas rabi crop achieved its design target

3.5.3 Changes in CAD Phase II Period.

CAD phase II target are shown in table 3.2. The change in post CAD phase area is similar to changes in CAD phase I. In kharif cropping pattern did not show encouraging trend. In rabi, gram and pulses area has decreased. Oilseed and other cash crops continued to rise. Rabi oilseed occupied 22.94 % percent of cropped area in the year 1988-1989 as compared to phase II target of 3.25 % and phase I target of 3.32 % where as in original design in 1954 oilseed was not proposed at all.

3.5.4 Change Over Entire Period.

Table 3.3 showns irrigated cropping intensity for 13 crops from 1974-1975 to 2000-2001 Figure 3.2 shows variation from year to year for paddy,

sorghum maize, oilseeda, sugarcane, vegetable, other. Figure 3.3 shows variation in intensity of major rabi crops (wheat, gram and pulses, barley, coriander, oilseeds and other) .The following major deviations took place during the entire period of analysis (upto 2001) for which data were obtained from Rajasthan Irrigation Department :

1. The design cropping pattern had been revised three times from the original design cropping pattern of (1954). The revision took place in 1973(phase I of CAD), 1983 phase II of CAD, 1989 (Drainage Project) , cropping pattern revision having been influenced by actual development which took place. However, no effort was made to critically examine reasons for wide variation in cropping pattern
2. The area under paddy has never achieved the original design target of 15 % except in 1974-1980 . Therefore this has in turn reduced the net irrigation requirement but at the same time system efficiency has also gone down . Sugarcane crop also could not achieve substantial growth. Sorghum and maize have almost disappeared in recent years.
3. Kharif cropping pattern has shown major short fall in the entire span of 40 years.
4. The area under wheat has remained below original design in design target of 53 %. however in recent years it has shown increasing trend from 1993-1994 onward and exceeding the target from 1998-1999 onward.
5. Increase in rabi oilseed, was seen from 1982-1983 to 1993-1994 but afterward it has been declining. Oilseeds are low water requiring crops and farmers are getting higher net return. Soyabean in kharif and mustard in rabi are the major oilseed crops of the area now. These crops were not proposed in original cropping pattern. Gram and pulses have shown declining trend throughout.

3.5.5 *Comparative changes in Left Bank & Right Bank Canal.*

The 10 years (1980-1989) average cropping pattern in LBC and RBC indicate a major deviation in paddy and rabi oilseed. The LBC has witnessed rise in paddy cultivation whereas RBC has not shown the remarkable improvement in paddy cultivation. The RBC has witnessed increase in rabi oilseed as compared to LBC. The reason for this may be attributed to exercising regulatory control of LBC

Total CCA is 229 thousand ha, out of which LBC command area is 102 thousand ha and RBC command area is 127 thousand ha . Table 3.4 shows average cropping pattern over a 10 year period from 1980 to 1989 in the LBC and RBC command areas. Table 3.5 shows design cropping pattern in these two command area in the phase I of command area development programme.

3.5.6. *Impact of Irrigation on Cropping Intensity*

The impact of irrigation on cropping intensity is shown in table 3.3. Rabi intensity has shown rising trend from 60 % in 1974-1975 to nearly 90 % in recent years. Year 1979-1980 and 1980-1981 witnessed highest kharif intensity of 21 %. The rise and full of cropping intensity is influenced by changes in irrigated area. Dependence on rainfed cultivation in rabi has been decreasing. There has been failure in achieving kharif targets which have been revised from 21 % in 1954 to 23.68 % in CAD phase I, 59.5% in phase II and 39.2 % in drainage project. Target have been kept high while achievement in irrigated cropping intensities have continued to be low. Possible reasons for failure in achieving kharif irrigation target could be :

- ✓ Releases from upstream reservoirs are based on power generation requirement which may be in conflict with irrigation requirement particularly in May and June, July when kharif crops are sown and land has to be prepared.
- ✓ Unreliable releases in canals in May, June, July might be discouraging the farmers to take up proposed kharif crops

Table 3.2 : Comparative Index Of Cropping Pattern (in percent)

CROP	PRE PROJECT 1954	AS PER DESIGN 1964	BEGINNING YEAR 1960	BEGINNING YEAR 1970	1973-1974	FUTURE WITH PROJECT CAD (PHASE I)	ACHIEVEMENT 1983-1984	PHASE II TARGET CAD	ACHIEVEMENT 1988-1989	ACHIEVEMENT 10 YEAR (1989-1999)	FUTURE WITH DRAINAGE PROJECT (1990-1995)
Kharif - Irrigated											
Paddy	0	15	0.36	4.64	2.66	8.78	6.95	9	9.89	8.82	10.5
Sorghum & Maize	3.33	0	0.47	0.24	0.52	5.11	0.55	7.5	0.85	2.9	10
Pulses	0	0	0	0.17	2.97	4.98	0	13	N.A	0.07	10
Oilseeds	1	0	0	1.01	1.31	3.19	1.92	16.5	6.85	4.44	4.5
Sugarcane	0	2	0.43	0.81	0.7	1.62	0.96	6	1.11	1.03	1.7
Vegatable	0	0.5	0.48	0.68	0	0	0.14	0.5	0.11	0.55	0.5
Other	0	3.5	1.67	2.49	0	0	0	7	0.21	N.A	N.A
Intensity	4.33	21	3.41	10.04	8.16	23.68	10.52	59.5	19.02	17.81	37.2
Unirrigated											
Sorghum & Maize	60	0	48	45.39	12.66	11.88	22.2	7	22.22	N.A.	11.3
Pulses	3	0	3	3.47	0.79	1.22	2.18	0	2.86	N.A.	3
Oilseeds	8.33	0	1.21	0.4	0.31	1.88	1.93	1.5	1.97	N.A.	3.1
Spices	0	0	9.44	5.78	0	0	0	0	N.A.	N.A.	N.A.
Other	0	0	0	0	0	0	3.06	0	N.A.	N.A.	N.A.
fooder	0.5	0	0	3.13	0	0.61	0	0	3.06	N.A.	2.9
Intensity	71.83		61.65	58.17	13.76	15.59	29.37	8.5	30.11	0	20.3
Rab'i - Irrigated											
Wheat	1	53	6.68	37.23	39.3	43.5	44.8	54.9	45.07	42.19	50.2
Gram & Pulses	1	2	0.12	16.38	14.14	12.14	15.5	12.75	5.54	13.03	16.7
Barley	2.25	0	1.8	1.28	1.22	2.16	2.23	1.3	1.86	2.17	0
Corriander	0	0	0.18	1.09	1.7	1.83	4.76	2.3	3.39	5.81	6.8
Oilseeds	0	0	0	0.33	0.49	3.32	7.22	3.25	22.94	9.24	4.4
Other	0	0	0	0	0.52	1.7	2.66	1	2.39	2.85	2.2
Intensity	4.25	55	8.78	56.31	57.37	64.65	77.17	75.5	81.19	75.29	80.3
Unirrigated											
Wheat	29	0	40.45	17.94	4.63	3.67	4.02	1.1	4.46	0	1.5
Gram & Pulses	11.25	0	21.03	12.53	3.32	3.54	6.23	3.75	6.64	0	5.7
Barley	1	0	1.63	0.9	0	0	0	0.2	5.2	0	0
Corriander	0.5	0	0	0	1.48	1.4	1.34	1.2	1.35	0	0.7
Oilseeds	22	0	14.64	13.13	0	0	4.9	2.25	4.49	0	5
Other	0	0	0	0	0	0.74	0	0	0	0	0
Sub Total	63.75	0	77.75	44.5	9.43	9.35	16.49	8.5	22.14	0	12.9
Intensity	144.16	76	151.59	169.02	88.72	113.27	133.55	152	152.46	93.1	150.7

Source : Vinod Shah (1990)

Table 3.3. : Irrigated cropping Intensity in Chambal Command (Rajasthan) in % of CCA

CCA : 229000 ha

YEAR	KHARIF								RAB'I							Annual
	Paddy	Sorghum & Maize	Pulses	Oilseeds	Sugarca	Vegetabl	Other	Total Kharif	Wheat	Gram & Pulses	Barley	Corriande	Oilseed	Other	Total Rab'I	
1974-1975	8.2	0.7	0.1	0.0	1.4	0.2	0.3	11.0	39.6	13.0	4.0	1.3	0.6	1.5	60.0	71.0
1975-1976	10.6	0.0	0.0	0.0	1.0	0.1	0.2	11.9	38.1	16.6	3.1	1.1	0.4	1.6	61.0	72.8
1976-1977	9.3	0.0	0.0	0.0	1.1	0.2	0.3	11.0	39.7	13.2	2.1	1.7	0.7	1.9	59.3	70.3
1977-1978	9.6	0.1	0.0	0.0	2.7	0.1	0.3	12.7	38.1	11.2	2.1	8.7	0.8	1.6	62.4	75.1
1978-1979	14.0	0.2	0.1	0.0	2.0	0.2	0.3	16.8	48.1	12.0	2.5	3.1	0.8	2.0	68.6	85.4
1979-1980	15.8	3.6	0.2	0.0	0.8	0.2	0.2	20.8	45.2	16.1	2.5	1.7	0.8	2.3	68.5	89.3
1980-1981	17.2	2.0	0.2	0.0	1.0	0.3	0.2	21.0	38.2	19.4	3.1	5.2	2.2	2.3	70.4	91.4
1981-1982	6.1	4.8	0.1	0.0	1.5	0.2	0.2	12.9	38.7	17.2	2.2	0.5	2.7	3.6	64.9	77.8
1982-1983	2.6	2.9	0.1	0.0	1.5	0.2	0.2	7.4	44.9	10.2	2.2	4.9	2.8	2.7	67.7	75.1
1983-1984	7.0	0.4	0.0	0.0	1.0	0.1	0.2	8.7	44.8	15.5	2.2	4.8	7.2	2.7	77.2	85.9
1985-1986	5.9	0.9	0.0	0.0	0.7	0.1	0.2	7.8	37.1	10.7	2.3	4.0	22.9	3.0	80.0	87.8
1986-1987	6.5	2.0	0.0	0.0	0.9	0.2	0.2	9.8	42.1	14.0	2.5	6.4	7.6	3.2	75.8	85.5
1987-1988	8.8	2.6	0.0	0.0	1.7	0.1	0.2	13.5	45.0	11.9	2.5	10.5	10.2	3.6	83.7	97.2
1988-1989	8.6	2.2	0.0	0.1	1.5	0.1	0.2	12.7	40.9	6.2	2.0	12.7	13.0	2.2	76.9	89.6
1989-1990	9.9	0.7	0.0	0.0	1.1	0.1	0.2	12.0	45.1	5.5	1.8	3.4	22.9	2.4	81.2	93.2
1991-1992	6.5	1.3	0.0	0.1	1.1	0.2	0.2	9.3	40.8	10.4	1.8	7.9	18.3	3.1	82.4	91.6
1992-1993	0.2	0.0	0.0	0.0	1.0	0.0	0.2	1.4	32.8	6.1	1.4	5.0	37.4	2.8	85.5	86.9
1993-1994	3.8	1.2	0.0	0.0	1.4	0.1	0.2	6.7	30.4	2.8	1.3	3.5	49.0	2.2	89.2	95.9
1994-1995	9.0	0.5	0.0	0.1	0.9	0.1	0.2	10.8	43.3	3.0	1.2	5.1	34.8	2.3	89.6	100.4
1995-1996	4.4	0.1	0.0	0.0	0.8	0.1	0.2	5.6	44.7	3.3	1.1	4.6	33.2	2.4	89.4	95.0
1996-1997	5.1	0.0	0.0	0.1	0.9	0.1	0.2	6.3	45.6	7.5	1.4	4.5	28.5	3.3	90.7	97.0
1997-1998	6.8	0.1	0.0	0.1	1.1	0.1	0.2	8.3	44.7	3.8	1.2	6.8	31.9	4.3	92.7	101.0
1998-1999	7.3	0.2	0.0	0.2	1.2	0.0	0.2	9.1	54.1	2.1	0.9	5.0	25.7	7.6	95.4	104.5
1999-2000	10.9	0.0	0.0	0.1	0.8	0.0	0.2	12.0	56.2	1.9	0.9	3.8	15.5	10.8	89.0	100.9
2000-2001	13.1	0.0	0.0	0.1	0.5	0.0	0.2	13.8	64.2	2.6	0.8	1.8	10.6	9.2	89.1	102.9
2001-2002																

Source : Data from Irrigation Circle CAD, Kota

Table 3.4 : ACTUAL AVERAGE IRRIGATED CROP AREA YEAR 1980-1989

CCA RBC - 127,000 ha
LBC - 102,000 ha

CROP	LBC (1,000 ha)	% of CCA	RBC (1,000 ha)	% of CCA	PROJECT (1,000 ha)	% of CCA
Kharif - Irrigated						
Paddy	16.7150	16.3900	3.4830	2.7400	20.2000	8.8200
Sorghum & Maize	1.5270	1.5000	5.1130	4.0300	6.6400	2.9000
Kharif Pulses	0.0430	0.0100	0.1160	0.0900	0.1600	0.0700
Kharif Oilseeds	2.0850	2.0400	8.0790	6.3600	10.1600	4.4400
Vegatable & Other	0.8740	0.8600	0.3970	0.3100	1.2700	0.5500
Sugarcane	2.3300	2.2800	0.0290	0.0200	2.3600	1.0300
TOTAL	23.574	23.08	17.217	13.55	40.79	17.81
Rabi - Irrigated						
Wheat	45.740	44.840	50.880	40.060	96.620	42.190
Gram & Pulses	11.659	11.430	18.190	14.320	29.850	13.030
Barley	2.820	2.760	2.150	0.169	4.970	2.170
Rabi Oilseeds	3.598	3.430	17.650	13.190	21.150	9.240
Corriander	2.585	2.530	10.712	8.430	3.300	5.810
Other (Vegetable)	3.000	2.940	1.300	0.100	4.300	1.880
Fodder	1.020	1.000	1.200	0.940	2.220	0.970
TOTAL	70.422	68.93	102.082	77.209	162.41	75.29

notes :Cropping Pattern is 10 years average from 1980-1989 after CAD Phase I

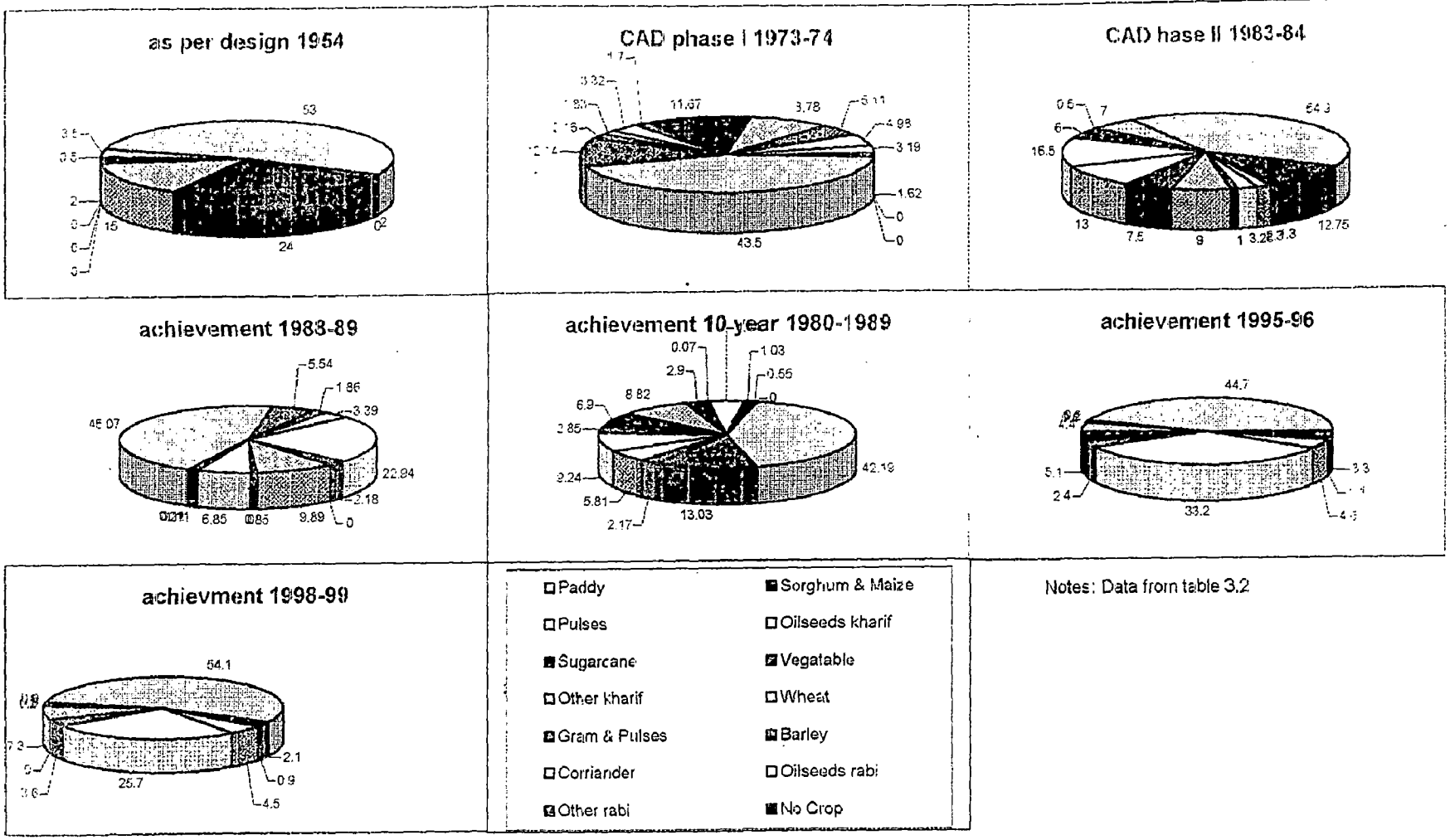
Table 3.5 : DESIGN IRRIGATED CROP AREA (PHASE I)

CCA RBC - 127,000 ha
LBC - 102,000 ha
Unit - 1'000 ha

CROP	LBC	% of CCA	RBC	% of CCA
Kharif - Irrigated				
Paddy	9.18	9.00	11.43	9.00
Sorghum & Maize	5.10	5.00	6.35	5.00
Kharif Pulses	5.10	5.00	6.35	5.00
Kharif Oilseeds	3.06	3.00	3.81	3.00
Sugarcane	2.04	2.00	2.54	2.00
TOTAL	24.48	24	30.48	24
Rabi - Irrigated				
Wheat	44.37	43.50	55.25	43.50
Gram & Pulses	13.26	13.00	16.51	13.00
Barley	2.04	2.00	2.54	2.00
Rabi Oilseeds	4.08	4.00	5.08	4.00
Corriander	2.04	2.00	2.54	2.00
Other (Vegetable)	1.02	1.00	1.27	1.00
Fodder	1.02	1.00	1.27	1.00
TOTAL	67.83	66.5	84.46	66.5

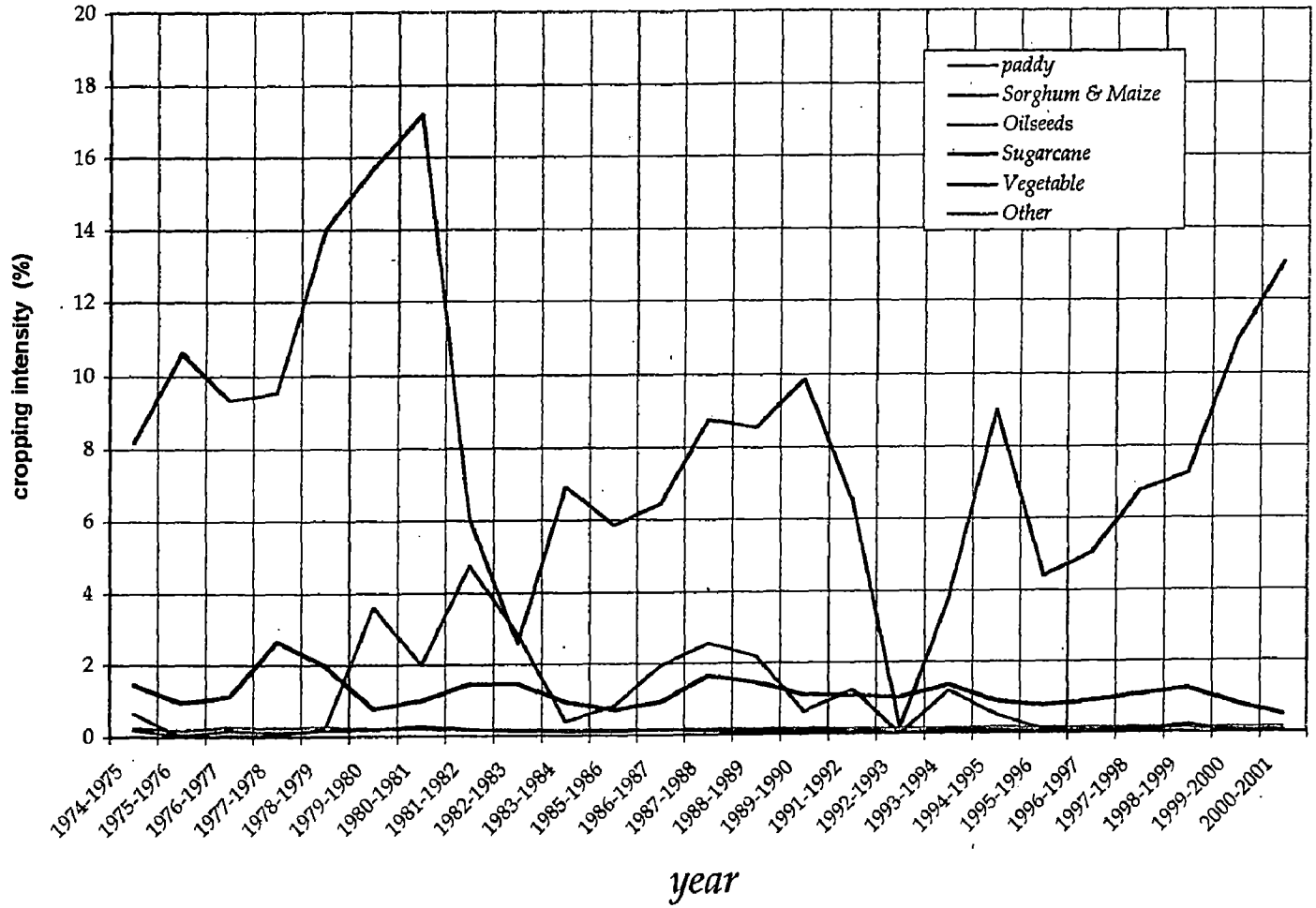
Proposed area (World Bank Appriasal estimate) Report No.430-IH with project
The ultimate area after improvement was envisaged at 57% kharif and 80 %rabi in post CAD Phase

Fig. 3.1 : PIE Diagram Depiction of Cropping Pattern in Different Period



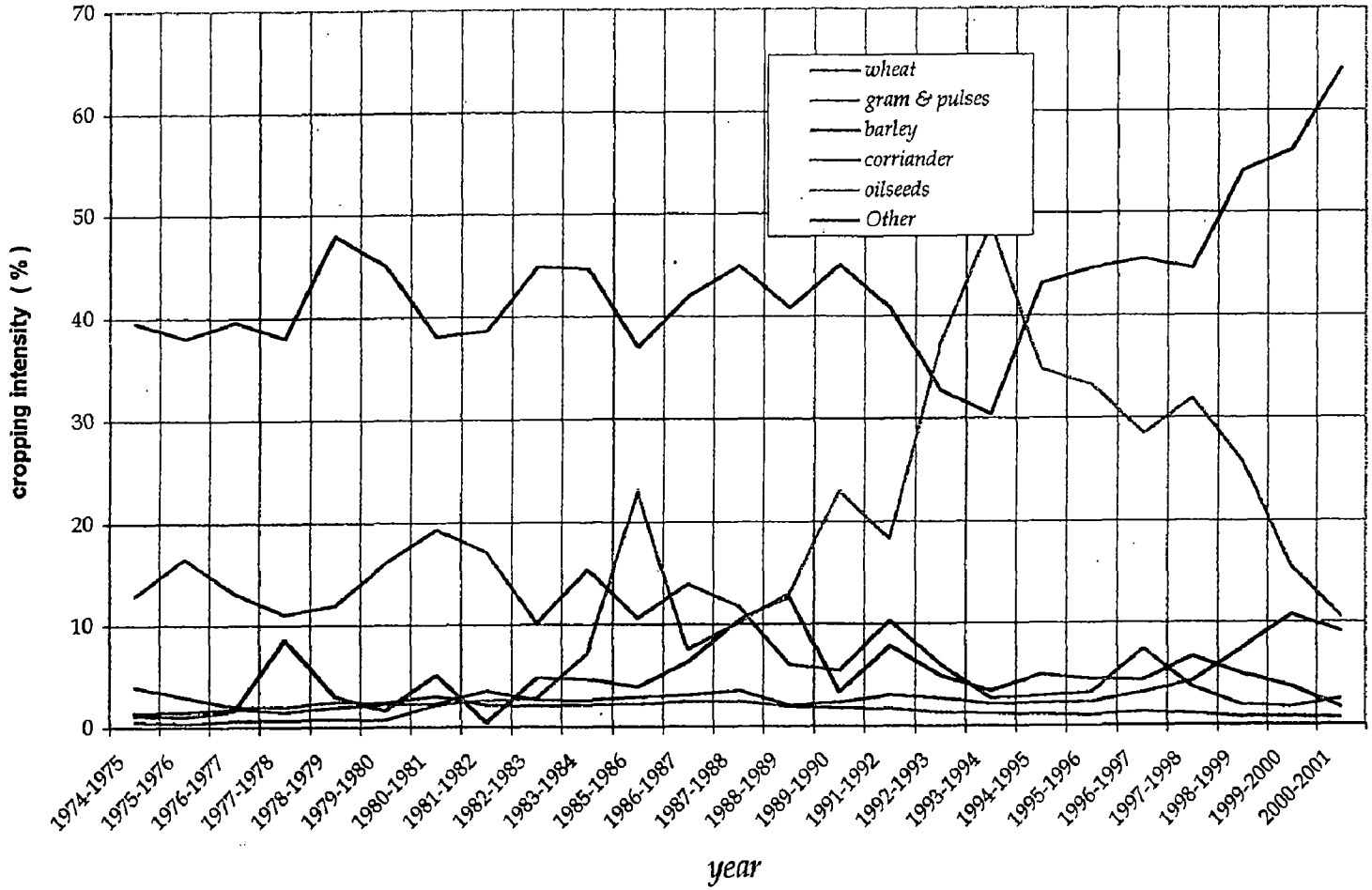
Notes: Data from table 3.2

Fig.3.2: Yearly Variation in Intensity of Major Kharif Crops



Data from table 3.3

Fig. 3.3: Yearly Variation in Intensity of Major Rabi Crops



Data from table 3.3

CHAPTER 4

CROP WATER REQUIREMENT AND IRRIGATION DEMAND FOR CHANGING CROPPING PATTERN

4.1 GENERAL

Analysis of changing cropping pattern has been presented in Chapter 3. With change in cropping pattern irrigation water demand has also changed. A large number of crops are grown in the command area. Also several changes have occurred in cropping pattern both in design as well as actual as shown in chapter 3. In order to analyse the impact of changing cropping pattern on irrigation demand, some significant periods of historical development and the present 4 years period as shown below have been considered in this chapter. Table 4.1 and Table 4.2 show the 13 crops, their crop area and crop percentages for the following conditions.

- As per design in 1954
- Phase I target for LBC and RBC
- Phase II target
- Achievement in 1988 - 1989
- Average achievement (1980-1989) for LBC and RBC
- Achievement in 1995 – 1996
- Achievement in 1996 – 1997
- Achievement in 1997 – 1998
- Achievement in 1998 - 1999

4.2 CROP WATER AND FIELD IRRIGATION REQUIREMENT

Reference crop evapotranspiration has been computed by various methods as explained in Chapter 2. For computation of irrigation water demand in this chapter, Pan evaporation data and Hargreave's method has been adopted to find crop water requirement of the 13 crops. Computations are shown in Table 4.3 to Table 4.15.

While computing crop water requirement and field irrigation requirement in different months for kharif and rabi crops, following aspects have been kept in view:

4.2.1. Nursery Requirement and Percolation Loss

For Paddy percolation loss has been considered where as for other crops, percolation loss has been assumed to be zero. Similarly nursery requirement has been considered only for paddy

4.2.2. Efficiency

Under condition prevailing in 1960 to 1974 system efficiency was very low at 30 % due to leakage and seepage from canal system, inadequate maintenance of water courses and absence of on farm development and of rotational irrigation . these losses contributed to waterlogging in some parts of command area. With proposed command area development phase I, it was expected that efficiencies would improve significantly as indicated below (IBRD Report 1974)

Item	Pre CAD Phase I	Proposed in CAD Phase I	
		Condition 1	Condition 2
Field efficiency (%)	60	80	65
Conveyance effeciency :			
Water course (%)	70	80	73
Canal system (%)	75	80	77
System efficiency (%) rounded	30	50	35

Source : Report World Bank 1974

Condition 1 : full control over water application, full development of on farm works and enforcement of warabandi, lining, weed control etc.
Condition2 : weed control, lining of some critical reaches and enforcement of warabandi

For the purpose of present study, field application efficiency of 80% and conveyance efficiency of 75% have been assumed reflecting average improvement situation.

4.2.3. Kharif Season has been assumed to extend from May to October keeping in view different sowing periods for same crop in the season. Similarly Rabi season has been assumed to extend from October to March.

4.2.4. Literature study (Shah 1990,IBRD 1974) shows that areas under a particular crop are different in different months as sowing/planting periods depend on

farmers choice, reliability of water, availability of ground water as alternative source and several other factors. Therefore instead of assuming area of a particular crop to be same in different months from sowing to harvesting crop area coverage have been used. Crop area coefficient have been worked out for thirteen selected crops based on past trends and are shown in Table 4.16.

4.3. GROSS IRRIGATION REQUIREMENT

Monthly gross irrigation requirement in volume unit have been computed for various cropping pattern in different years .

- Cropping Pattern as per design I 1954 — Table 4.17
- Cropping Pattern in phase I RBC — Table 4.18
- Cropping Pattern in phase I LBC — Table 4.19
- Cropping Pattern in phase II — Table 4.20
- Ten Year average Crop Pattern — Table 4.21
- Cropping Pattern in 1988 - 1989 — Table 4.22
- Cropping Pattern in 1945 - 1996 — Table 4.23
- Cropping Pattern in 1996 - 1997 — Table 4.24
- Cropping Pattern in 1997 - 1998 — Table 4.25
- Cropping Pattern in 1998 - 1999 — Table 4.26

Table 4.17 to table 4.26 show computation of following monthly gross irrigation requirements in different years

- ✓ Monthly volume of water required at field level for entire command area
- ✓ Monthly volume of water required at canal head for entire
- ✓ Monthly volume of water required at head for RBC command
- ✓ Monthly volume of water required at head for LBC command

Monthly water demand have also been worked out as per water allowance given IBRD Report (1974). (Table 4.27) These water allowances were based on following considerations:

- Field efficiencies is 80 %, water course and canal system conveyance efficiencies are 80 % each.
- A year of average rainfall is considered.
- Blaney Criddle and Penman equation together with appropriate crop coefficients are used to estimate consumptive use
- A presowing irrigation of 100 mm for all crops except for paddy for which a consumptive use of 300 mm has been assumed in the first month for land preparation and nursery.
- Crop area coefficients are same as shown in Table 4.16.
- An area of 50,000 ha was considered for estimating monthly water demands and water allowance. On proportional basis demend for project command of 229,000 ha was worked out and it is shown in table 4.27

4.4. MONTHLY OF WATER DEMAND IN RBC AND LBC

Water demand at head of RBC and LBC have been worked out on proportionate command area basis for design crop pattern, phase II actual in 1988 – 1989, 1995-1996, 1996-1997, 1997-1998, 1998-1999 as separate cropping pattern for these commands were not available. For phase I and 10 year average condition, cropping patterns were available for LBC and RBC separately.

Table 4.28 shows comparison of monthly water demand at head of LBC (Rajasthan) for various cropping pattern in different years.

Table 4.29 shows comparison of water demand at head of RBC (for Rajasthan area only) for various cropping pattern in different years.

4.5. DISCUSSION OF RESULTS

For designing capacities of right bank canal and left bank canal, cropping pattern was assumed to be uniform over the entire project area and it was assumed to be constant with time for entire life of the project.

Historical development of cropping pattern analysed in Chapter 3 has shown that cropping pattern is not constant with time. Detailed information on geographic variation of cropping pattern in the command area was not available. However data for phase I and 10 year average condition cropping pattern, in LBC command and RBC command show that area variation in cropping pattern has also taken place.

The comparison of water demend at head of LBC and RBC in different years is shown in table 4.28 and table 4.29.

4.5.1. Water demand at head of LBC

Design discharge capacity of LBC is 42.5 m^3/sec. Which is equivalent to monthly volumetric supply capacity of 110.16 MCM (for 30 day month) and 113.83 MCM (for 31 day month) and 102.82 MCM (for 28 day month) table 4.28 shows that, canal capacity was in adequate mainly in October.

Comparison of demand in recent year (1995 to 1999) with demand in previous years shows that water demand has increased in September, October, November months.

Compared with original design (1954) demand in recent year have significantly increased in all months.

4.5.2. *Water Demand at Head of RBC*

Reserved design discharge capacity of RBC for Rajasthan command is 78.1 m^3/sec out of actual capacity in any of the month which is equivalent to 202.43 MCM, 209.18 MCM in 30 day month, 31 day month and 28 day month respectively.

Demand corresponding to phase II target are higher than for other targets. Compared with original design (1954) demand in recent years have significantly increased in all months.

In contrast to capacity of LBC, the capacity of RBC is found to be significantly larger than the demand.

Table 4.1 : CHAMBAL COMMAND AREA - COMPARATIVE INDEX OF CROPPING PATTERN

Total CCA = 229,000 ha

CROP	AS PER DESIGN 1954	PHASE I TARGET 1973	PHASE II TARGET 1983	ACHIEVEMENT 1980 - 1989	AV.ACHIEVEMENT 1980 -1989	ACHIEVEMENT 1995 - 1996	ACHIEVEMENT 1996 - 1997	ACHIEVEMENT 1997 - 1998	ACHIEVEMENT 1998 - 1999
	%	%	%	%	%	%	%	%	%
KHARIF (Irrigated)									
Paddy	15.00	8.78	9.00	9.89	8.82	4.4	5.1	6.8	7.3
Sorghum (Maize)	N.A	5.11	7.50	0.85	2.90	0.1	N.A	0.1	0.2
Oilseeds	N.A	3.19	16.50	6.85	4.44	0	0.1	0.1	0.2
Vegetables	0.50	N.A	0.30	0.11	0.55	0.1	0.1	0.1	N.A
Pulses	N.A	4.98	13.00	N.A	0.07	N.A	N.A	N.A	N.A
Sugarcane	2.00	1.62	6.00	1.11	1.03	0.8	0.9	1.1	1.2
Other	3.50	N.A	7.00	0.21	N.A	0.2	0.2	0.2	0.2
TOTAL	21.00	23.68	59.30	19.02	17.81	5.60	6.40	8.40	9.10
RAB'I (Irrigated)									
Wheat	53.00	43.50	54.90	45.07	42.19	44.7	45.6	44.7	54.1
Gram & Pulses	2.00	12.14	12.75	5.54	13.03	3.3	7.5	3.8	2.1
Oilseeds	N.A	3.32	3.25	22.94	9.24	33.2	28.5	31.9	25.7
Coriander	N.A	1.83	2.30	1.39	5.81	4.6	4.5	6.8	5
Other (Vegetables)	N.A	1.09	1.00	2.39	1.88	2.4	3.3	4.3	7.6
Barley	N.A	2.16	1.20	1.85	2.17	1.1	1.4	1.2	0.9
TOTAL	55.00	64.04	75.40	79.18	74.32	89.30	90.80	92.70	95.40

Table 4.2 : CROP PATTERN IN LEFT AND RIGHT BANK CANAL COMMAND

RBC = 127,000 ha
LBC = 102,000 ha

CROP	CAD PHASE I 1973			AV.ACHIEVEMENT 10 YEAR (1980-89)		
	LBC	RBC	TOTAL	LBC	RBC	TOTAL
	%	%	%	%	%	%
Paddy	9.00	9.00	8.78	16.39	2.74	8.82
Sorghum (Maize)	5.00	5.00	5.11	1.50	4.03	2.90
K.Oilseeds	3.00	3.00	3.19	2.04	6.36	4.44
Vegetables	N.A	N.A	N.A	0.86	0.31	0.55
Pulses	5.00	5.00	4.98	0.04	0.09	0.07
Sugarcane	2.00	2.00	1.62	2.28	0.02	1.03
Other	N.A	N.A	N.A	N.A	N.A	N.A
TOTAL	24.00	24.00	23.68	23.11	13.55	17.81
Wheat	43.50	43.50	43.50	44.84	40.06	42.19
Gram & Pulses	13.00	13.00	12.14	11.43	14.32	13.03
R.Oilseeds	4.00	4.00	3.32	3.43	13.19	9.24
Coriander	2.00	2.00	1.83	2.53	8.43	5.81
Other (Vegetables)	1.00	1.00	1.09	2.94	0.10	1.88
Barley	2.00	2.00	2.16	2.76	0.17	2.17
TOTAL	65.50	65.50	64.04	67.93	76.27	74.32

Table 4.3 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR PADDY CROP

No.	ITEM	KHARIF							RAB'I					
		MAY		JUN	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR
		1	2											
a.	Number of days	15	16	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	5.50	5.50	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	PADDY PERIOD : 01/05 - 31/10 = 184 Days													
	Group Rice													
1	No of Days	15	16	30	31	31	30	31						
2	Mid Point	15	26	46	77	108	138	169						
3	% Of Growing Season	8.15	14.13	25.00	41.85	58.70	75.00	91.85						
4	Crop Coefficient (Kc)	0.93	0.99	1.10	1.22	1.30	1.15	0.88						
5	Pan Evap. Loss (Ep) (mm)	154.80	165.12	317.10	187.86	131.13	147.00	147.87						
6	Consumptive Use (Kcx Ep) (mm)	143.96	163.47	348.81	229.19	170.47	169.05	130.13						
7	Nursery = 5% x (6) (mm)	7.20	8.17	0.00	0.00	0.00	0.00	0.00						
8	Total CU = (6+7) (mm)	151.16	171.64	348.81	229.19	170.47	169.05	130.13						
9	Eff. Rain Fall (Pe) (mm)	0.00	0.00	30.20	182.20	174.20	66.20	0.00						
10	Pre-Irrigation Water Req(5%)	1.21	1.21	0.00	0.00	0.00	0.00	0.00						
11	For Transplantation (mm)	50	50	0	0	0	0	0						
12	Percolation Loss (mm)	22.50	24.00	45.00	46.50	46.50	45.00	46.50						
13	NIR=(8+10+11+12-9) (mm)	224.87	246.85	363.61	93.49	42.77	147.85	176.63						
14	FIR=NIR/Eff. 0.8 (mm)	281.09	308.57	454.51	116.86	53.46	184.81	220.78						

Table 4.4 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR SORGHUM & MAIZE

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	SORGHUM & MAIZE	**PERIOD : 01/05 - 31/10 = 184 Days**											
	Group A												
1	No of Days	31	30	31	31	30	31						
2	Mid Point	16	46	77	108	138	169						
3	% Of Growing Season	8.70	25.00	41.85	58.70	75.00	91.85						
4	Crop Coefficient (Kc)	0.29	0.75	0.97	0.99	0.85	0.42						
5	Pan Evap. Loss (Ep) (mm)	319.92	317.10	187.86	131.13	147.00	147.87						
6	Consumptive Use (Kcx Ep) (mm)	92.78	237.83	182.22	129.82	124.95	62.11						
7	Nursery = 5% x (6) (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
8	Total CU = (6+7) (mm)	92.78	237.83	182.22	129.82	124.95	62.11						
9	Eff. Rain Fall (Pe) (mm)	0.00	30.20	182.20	174.20	66.20	5.60						
10	Pre-Irrigation Water Req(5%)	3.75	0.00	0.00	0.00	0.00	0.00						
11	For Transplantation (mm)	75	0.00	0.00	0.00	0.00	0.00						
12	Percolation Loss (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
13	NIR=(8+10+11+12-9) (mm)	171.53	207.63	0.02	0.00	58.75	56.51						
14	FIR=NIR/Eff. 0.8 (mm)	214.41	259.53	0.03	0.00	73.44	70.63						

Table 4.5 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR KHARIF OILSEEDS

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	OILSEEDS **PERIOD : 01/05- 31/10 = 184 Days**												
	Group A												
1	No of Days	31	30	31	31	30	31						
2	Mid Point	16	46	77	108	138	169						
3	% Of Growing Season	8.70	25.00	41.85	58.70	75.00	91.85						
4	Crop Coefficient (Kc)	0.32	0.75	0.97	0.99	0.85	0.42						
5	Pan Evap. Loss (Ep) (mm)	319.92	317.10	187.86	131.13	147.00	147.87						
6	Consumptive Use (Kcx Ep) (mm)	102.37	237.83	182.22	129.82	124.95	62.11						
7	Nursery = 5% x (6) (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
8	Total CU = (6+7) (mm)	102.37	237.83	182.22	129.82	124.95	62.11						
9	Eff. Rain Fall (Pe) (mm)	0.00	30.20	182.20	174.20	66.20	5.60						
10	Pre-Irrigation Water Req(5%)	3.75	0.00	0.00	0.00	0.00	0.00						
11	For Transplantation (mm)	75	0.00	0.00	0.00	0.00	0.00						
12	Percolation Loss (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
13	NIR=(8+10+11+12-9) (mm)	181.12	207.63	0.02	0.00	58.75	56.51						
14	FIR=NIR/Eff. 0.8 (mm)	226.41	259.53	0.03	0.00	73.44	70.63						

Table 4.6 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR KHARIF VEGETABLES

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	VEGETABLES PERIOD : 01/05 - 31/10 = 184 Days												
	Group C												
1	No of Days	31	30	31	31	30	31						
2	Mid Point	16	46	77	108	138	169						
3	% Of Growing Season	8.70	25.00	41.85	58.70	75.00	91.85						
4	Crop Coefficient (Kc)	0.18	0.45	0.58	0.60	0.51	0.26						
5	Pan Evap. Loss (Ep) (mm)	319.92	317.10	187.86	131.13	147.00	147.87						
6	Consumptive Use (Kcx Ep) (mm)	57.59	142.70	108.96	78.7	74.97	38.45						
7	Nursery = 5% x (6) (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
8	Total CU = (6+7) (mm)	57.59	142.70	108.96	78.7	74.97	38.45						
9	Eff. Rain Fall (Pe) (mm)	0.00	30.20	182.20	174.20	66.20	5.60						
10	Pre-Irrigation Water Req(5%)	3.75	0.00	0.00	0.00	0.00	0.00						
11	For Transplantation (mm)	75	0.00	0.00	0.00	0.00	0.00						
12	Percolation Loss (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
13	NIR=(8+10+11+12-9) (mm)	136.34	112.50	0.00	0.0	0.00	32.85						
14	FIR=NIR/Eff. 0.8 (mm)	170.42	140.62	0.00	0.00	0.00	41.06						

Table 4.7 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR KHARIF PULSES

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	PULSES **PERIOD : 01/05 - 31/10 = 184 Days**												
	Group D												
1	No of Days	31	30	31	31	30	31						
2	Mid Point	16	46	77	108	138	169						
3	% Of Growing Season	8.70	25.00	41.85	58.70	75.00	91.85						
4	Crop Coefficient (Kc)	0.13	0.27	0.47	0.69	0.86	0.70						
5	Pan Evap. Loss (Ep) (mm)	319.92	317.10	187.86	131.13	147.00	147.87						
6	Consumptive Use (Kcx Ep) (mm)	41.59	85.62	88.29	90.48	126.42	103.51						
7	Nursery = 5% x (6) (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
8	Total CU = (6+7) (mm)	41.59	85.62	88.29	90.48	126.42	103.51						
9	Eff. Rain Fall (Pe) (mm)	0.00	30.20	182.20	174.20	66.20	5.60						
10	Pre-Irrigation Water Req(5%)	3.75	0.00	0.00	0.00	0.00	0.00						
11	For Transplantation (mm)	75	0.00	0.00	0.00	0.00	0.00						
12	Percolation Loss (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
13	NIR=(8+10+11+12-9) (mm)	120.34	55.42	0.00	0.00	60.22	97.91						
14	FIR=NIR/Eff . 0.8 (mm)	150.42	69.27	0.00	0.00	75.28	122.39						

Table 4.8 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR SUGARCANE (Perennial Crop)

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	SUGARCANE **PERIOD : 01/31 - 31/12 = 365 Days**												
	Group G												
1	No of Days	31	30	31	31	30	31	30	31	31	28	31	30
2	Mid Point	16	46	77	108	138	169	199	230	261	290	319	350
3	% Of Growing Season	8.70	25.00	41.85	58.70	75.00	91.85	108.15	125.00	141.85	157.61	173.37	190.22
4	Crop Coefficient (Kc)	0.58	0.75	0.91	1.00	0.85	0.70	0.90	0.90	0.90	0.90	0.90	0.90
5	Pan Evap. Loss (Ep) (mm)	319.92	317.10	187.86	131.13	147.00	147.87	108.00	84.01	80.91	108.92	180.11	261.90
6	Consumptive Use (Kcx Ep) (mm)	185.55	237.83	170.95	131.13	124.95	103.51	97.20	75.61	72.82	98.03	162.10	235.71
7	Nursery = 5% x (6) (mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Total CU = (6+7) (mm)	185.55	237.83	170.95	131.13	124.95	103.51	97.20	75.61	72.82	98.03	162.10	235.71
9	Eff. Rain Fall (Pe) (mm)	0.00	30.20	182.20	174.20	66.20	5.60	0.00	0.00	0.00	0.00	0.00	0.00
10	Pre-Irrigation Water Req(5%)	3.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	For Transplantation (mm)	75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	Percolation Loss (mm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	NIR=(8+10+11+12-9) (mm)	264.30	207.63	0.00	0.00	58.75	97.91	97.20	75.61	72.82	98.03	162.10	235.71
14	FIR=NIR/Eff. 0.8 (mm)	330.38	259.53	0.00	0.00	73.44	122.39	121.50	94.51	91.02	122.54	202.62	294.64

Table 4.9 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR OTHER CROPS IN KHARIF (SPICES,COTTON)

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	OTHER PERIOD : 01/05 - 31/10 = 184 Days												
	Group C												
1	No of Days	31	30	31	31	30	31						
2	Mid Point	16	46	77	108	138	169						
3	% Of Growing Season	8.70	25.00	41.85	58.70	75.00	91.85						
4	Crop Coefficient (Kc)	0.18	0.45	0.58	0.60	0.51	0.26						
5	Pan Evap. Loss (Ep) (mm)	319.92	317.10	187.86	131.13	147.00	147.87						
6	Consumptive Use (Kcx Ep) (mm)	57.59	142.70	108.96	78.7	74.97	38.45						
7	Nursery = 5% x (6) (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
8	Total CU = (6+7) (mm)	57.59	142.70	108.96	78.7	74.97	38.45						
9	Eff. Rain Fall (Pe) (mm)	0.00	30.20	182.20	174.20	66.20	5.60						
10	Pre-Irrigation Water Req(5%)	3.75	0.00	0.00	0.00	0.00	0.00						
11	For Transplantation (mm)	75	0.00	0.00	0.00	0.00	0.00						
12	Percolation Loss (mm)	0.00	0.00	0.00	0.00	0.00	0.00						
13	NIR=(8+10+11+12-9) (mm)	136.34	112.50	0.00	0.0	8.77	32.85						
14	FIR=NIR/Eff. 0.8 (mm)	170.42	140.62	0.00	0.00	10.96	41.06						

Table 4.10 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR WHEAT

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	WHEAT **PERIOD : 01/10 - 30/03 = 212 Days**												
	Group D												
1	No of Days						31	30	31	31	28	31	30
2	Mid Point						16	46	77	107	137	166	197
3	% Of Growing Season						8.70	25.00	41.85	58.15	74.46	90.22	107.07
4	Crop Coefficient (Kc)						0.13	0.27	0.47	0.69	0.86	0.70	0.85
5	Pan Evap. Loss (Ep) (mm)						147.87	108.00	84.01	80.91	108.92	180.11	261.90
6	Consumptive Use (Kcx Ep) (mm)						19.22	29.16	39.48	55.83	93.67	126.08	222.62
7	Nursery = 5% x (6) (mm)						0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Total CU = (6+7) (mm)						19.22	29.16	39.48	55.83	93.67	126.08	222.62
9	Eff. Rain Fall (Pe) (mm)						5.60	0.00	0.00	0.00	0.00	0.00	0.00
10	Pre-Irrigation Water Req(5%)						3.75	0.00	0.00	0.00	0.00	0.00	0.00
11	For Transplantation (mm)						75.00	0.00	0.00	0.00	0.00	0.00	0.00
12	Percolation Loss (mm)						0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	NIR=(8+10+11+12-9) (mm)						92.37	29.16	39.48	55.83	93.67	126.08	222.62
14	FIR=NIR/Eff. 0.8 (mm)						115.47	36.45	49.36	69.78	117.09	157.60	278.27

Table 4.11 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR GRAM & PULSES IN RAB'I

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	GRAM &PULSES	**PERIOD : 01/10 - 31/03 = 182 Days**											
	Group D												
1	No of Days						31	30	31	31	28	31	
2	Mid Point						16	46	77	107	137	166	
3	% Of Growing Season						8.70	25.00	41.85	58.15	74.46	90.22	
4	Crop Coefficient (Kc)						0.13	0.27	0.47	0.69	0.86	0.70	
5	Pan Evap. Loss (Ep) (mm)						147.87	108.00	84.01	80.91	108.92	180.11	
6	Consumptive Use (Kcx Ep) (mm)						19.22	29.16	39.48	55.83	93.67	126.08	
7	Nursery = 5% x (6) (mm)						0.00	0.00	0.00	0.00	0.00	0.00	
8	Total CU = (6+7) (mm)						19.22	29.16	39.48	55.83	93.67	126.08	
9	Eff. Rain Fall (Pe) (mm)						5.60	0.00	0.00	0.00	0.00	0.00	
10	Pre-Irrigation Water Req(5%)						3.75	0.00	0.00	0.00	0.00	0.00	
11	For Transplantation (mm)						75.00	0.00	0.00	0.00	0.00	0.00	
12	Percolation Loss (mm)						0.00	0.00	0.00	0.00	0.00	0.00	
13	NIR=(8+10+11+12-9) (mm)						92.37	29.16	39.48	55.83	93.67	126.08	
14	FIR=NIR/Eff. 0.8 (mm)						115.47	36.45	49.36	69.78	117.09	157.60	

Table 4.12 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR RAB'I OILSEEDS

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	OILSEEDS **PERIOD : 01/10 - 28/02 = 151 Days**												
	Group A												
1	No of Days						31	30	31	31	28		
2	Mid Point						16	46	77	107	137		
3	% Of Growing Season						8.70	25.00	41.85	58.15	74.46		
4	Crop Coefficient (Kc)						0.29	0.75	0.97	0.99	0.85		
5	Pan Evap. Loss (Ep) (mm)						147.87	108.00	84.01	80.91	108.92		
6	Consumptive Use (Kcx Ep) (mm)						42.88	81.00	81.49	80.10	92.58		
7	Nursery = 5% x (6) (mm)						0.00	0.00	0.00	0.00	0.00		
8	Total CU = (6+7) (mm)						42.88	81.00	81.49	80.10	92.58		
9	Eff. Rain Fall (Pe) (mm)						5.60	0.00	0.00	0.00	0.00		
10	Pre-Irrigation Water Req(5%)						3.75	0.00	0.00	0.00	0.00		
11	For Transplantation (mm)						75.00	0.00	0.00	0.00	0.00		
12	Percolation Loss (mm)						0.00	0.00	0.00	0.00	0.00		
13	NIR=(8+10+11+12-9) (mm)						116.03	81.00	81.49	80.10	92.58		
14	FIR=NIR/Eff . 0.8 (mm)						145.04	101.25	101.86	100.13	115.73		

Table 4.13 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR CORIANDER

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	CORIANDER **PERIOD : 01/10 - 31/03 = 182 Days**												
	Group A												
1	No of Days						31	30	31	31	28	31	
2	Mid Point						16	46	77	107	137	166	
3	% Of Growing Season						8.70	25.00	41.85	58.15	74.46	90.22	
4	Crop Coefficient (Kc)						0.32	0.75	0.97	0.99	0.85	0.42	
5	Pan Evap. Loss (Ep) (mm)						147.87	108.00	84.01	80.91	108.92	180.11	
6	Consumptive Use (Kcx Ep) (mm)						47.32	81.00	81.49	80.10	92.58	75.65	
7	Nursery = 5% x (6) (mm)						0.00	0.00	0.00	0.00	0.00	0.00	
8	Total CU = (6+7) (mm)						47.32	81.00	81.49	80.10	92.58	75.65	
9	Eff. Rain Fall (Pe) (mm)						5.60	0.00	0.00	0.00	0.00	0.00	
10	Pre-Irrigation Water Req(5%)						3.75	0.00	0.00	0.00	0.00	0.00	
11	For Transplantation (mm)						75.00	0.00	0.00	0.00	0.00	0.00	
12	Percolation Loss (mm)						0.00	0.00	0.00	0.00	0.00	0.00	
13	NIR=(8+10+11+12-9) (mm)						120.47	81.00	81.49	80.10	92.58	75.65	
14	FIR=NIR/Eff. 0.8 (mm)						150.59	101.25	101.86	100.13	115.73	94.56	

Table 4.14 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR BARLEY

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	BARLEY **PERIOD : 01/10 - 30/03 = 212 Days**												
	Group D												
1	No of Days						31	30	31	31	28	31	30
2	Mid Point						16	46	77	107	137	166	197
3	% Of Growing Season						8.70	25.00	41.85	58.15	74.46	90.22	107.07
4	Crop Coefficient (Kc)						0.13	0.27	0.47	0.69	0.86	0.70	0.85
5	Pan Evap. Loss (Ep) (mm)						147.87	108.00	84.01	80.91	108.92	180.11	261.90
6	Consumptive Use (Kcx Ep) (mm)						19.22	29.16	39.48	55.83	93.67	126.08	222.62
7	Nursery = 5% x (6) (mm)						0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Total CU = (6+7) (mm)						19.22	29.16	39.48	55.83	93.67	126.08	222.62
9	Eff. Rain Fall (Pe) (mm)						5.60	0.00	0.00	0.00	0.00	0.00	0.00
10	Pre-Irrigation Water Req(5%)						3.75	0.00	0.00	0.00	0.00	0.00	0.00
11	For Transplantation (mm)						75.00	0.00	0.00	0.00	0.00	0.00	0.00
12	Percolation Loss (mm)						0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	NIR=(8+10+11+12-9) (mm)						92.37	29.16	39.48	55.83	93.67	126.08	222.62
14	FIR=NIR/Eff. 0.8 (mm)						115.47	36.45	49.36	69.78	117.09	157.60	278.27

Table 4.15 : MONTHLY CROP WATER AND FIELD IRRIGATION REQUIREMENT FOR OTHER CROPS (VEGETABLE etc)

No.	ITEM	KHARIF						RAB'I					
		MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL
a.	Number of days	31	30	31	31	30	31	30	31	31	28	31	30
b.	Pan Evaporation / day	10.32	10.57	6.06	4.23	4.90	4.77	3.60	2.71	2.61	3.89	5.81	8.73
c.	Percolation(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
d.	Field Applied Eff.	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
e.	Normal Rainfall	11.00	67.00	259.00	249.00	114.00	26.00	8.00	8.00	13.00	8.00	7.00	10.00
	OTHER (VEGETABLES) etc Group C	**PERIOD : 01/10 - 31/03 = 182 Days**											
1	No of Days						31	30	31	31	28	31	
2	Mid Point						16	46	77	107	137	166	
3	% Of Growing Season						8.70	25.00	41.85	58.15	74.46	90.22	
4	Crop Coefficient (Kc)						0.18	0.45	0.58	0.60	0.51	0.26	
5	Pan Evap. Loss (Ep) (mm)						147.87	108.00	84.01	80.91	108.92	180.11	
6	Consumptive Use (Kcx Ep) (mm)						26.62	48.60	48.73	48.55	55.55	46.83	
7	Nursery = 5% x (6) (mm)						0.00	0.00	0.00	0.00	0.00	0.00	
8	Total CU = (6+7) (mm)						26.62	48.60	48.73	48.55	55.55	46.83	
9	Eff. Rain Fall (Pe) (mm)						5.60	0.00	0.00	0.00	0.00	0.00	
10	Pre-Irrigation Water Req(5%)						3.75	0.00	0.00	0.00	0.00	0.00	
11	For Transplantation (mm)						75.00	0.00	0.00	0.00	0.00	0.00	
12	Percolation Loss (mm)						0.00	0.00	0.00	0.00	0.00	0.00	
13	NIR=(8+10+11+12-9) (mm)						99.77	48.60	48.73	48.55	55.55	46.83	
14	FIR=NIR/Eff. 0.8 (mm)						124.71	60.75	60.91	60.68	69.44	58.54	

Computational explanatory notes on Table 4.4

FIELD IRRIGATION REQUIREMENT for Sorghum & Maize for month of May

No. row

No. a = Number of day, 31 day

No. b = Corresponding in table 2.6, we get 10.32 mm/day

No. c = Assume, we taken 0 mm/day

No. d = Corresponding page IV-2, we get 80 %

No. e = Corresponding in table 2.5, we get 11 mm

No. 1 = Number of day, 31 day

No. 2 = Row No.1/2
= 31/2
= 16 day

No.3 = (No.2/growth period)*100
= (16/184)*100
= 8.7 %

No.4 = Corresponding in table varsney, we get 0.29

No. 5 = No.1*No. b
= 31*10.32
= 319.92 mm

No. 6 = No.4*No.5
= 0.29*319.92
= 92.78 mm

No. 7 = 5 %*No.6
= 5 %*0
= 0 mm

No. 8 = No.6+No.7
= 92.78+0
= 92.78 mm

No. 9 = Corresponding in formula if P> 75 mm/month we taken (0.8*P)-25, if P<75 mm/month we taken (0.6*P)-10

Corresponding in No. e, 11 mm

= (0.6*11)-10

= -3.4 ~ 0

No. 10 = assume, 150 mm for paddy, 75 mm non paddy

No. 11 = assume, 100 mm for paddy, 75 mm non paddy

No. 12 = No. c, 0

No. 13 = No.8+No.10+No.11+No.12-No.9

= 92.78+3.75+75+0+0

= 171.53 mm

No. 14 = No.13/No.d

= 171.53/0.8

= 214.41 mm

Table 4.16 : CROP AREA COEFFICIENT IN DIFFERENT MONTHS

	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DES	JAN	FEB	MAR	APR
Paddy	0.50	0.80	1.00	1.00	0.80	0.30	-	-	-	-	-	-
Sorghum (Maize)	0.46	0.77	1.00	1.00	1.00	0.67	-	-	-	-	-	-
Oilseed	0.50	1.00	1.00	1.00	1.00	0.50	-	-	-	-	-	-
Vegetable	0.80	1.00	1.00	1.00	1.00	0.30	-	-	-	-	-	-
Pulses	0.17	1.00	1.00	1.00	1.00	0.17	-	-	-	-	-	-
Sugarcane	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50	0.50
Other	0.20	0.50	1.00	1.00	1.00	0.30	-	-	-	-	-	-
Wheat	-	-	-	-	-	0.32	0.67	1.00	1.00	1.00	0.80	0.33
Gram & Pulses	-	-	-	-	-	0.12	0.70	1.00	1.00	1.00	0.47	-
Oilseed	-	-	-	-	-	0.20	0.80	1.00	1.00	0.40	-	-
Coriander	-	-	-	-	-	0.50	0.40	1.00	1.00	1.00	0.25	-
Other (Vegetable)	-	-	-	-	-	1.00	1.00	1.00	1.00	1.00	1.00	-
Barley	-	-	-	-	-	0.33	0.67	1.00	1.00	1.00	0.60	-

Table 4.17 : MONTHLY GROSS IRRIGATION REQUIREMENT for ORIGINAL DESIGN CROPPING PATTERN (1954)

No.	ITEM	KHARIF							RABI							Annual
		MAY	JUNE	JULY	AUG	SEPT	OCT	Total kharif	NOV	DEC	JAN	FEB	MAR	APR	Total rabi	Rabi+Kharif
1	**Paddy**															
	- Area (ha)	17,175	27,480	34,350	34,350	27,480	10,305									
	- F I R (mm)	589.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	101.27	124.90	40.14	18.36	50.79	22.75									
2	**Sorghum (Maize)**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	214.41	259.53	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	-	-	-	-	-	-									
3	**Oilseed**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	226.41	259.53	0.03	-	73.44	70.63	630.04							-	630.04
	- Q (10^3/m^3/Monthly)	-	-	-	-	-	-									
4	**Vegetable**															
	- Area (ha)	88.00	110.00	110.00	110.00	110.00	33.00									
	- F I R (mm)	170.42	140.62	0.00	0.00	0.00	41.06	352.10							-	352.10
	- Q (MCM)	0.15	0.15	-	-	-	0.01									
5	**Pulses**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	150.42	69.27	-	-	75.28	122.39	417.36							-	417.36
	- Q (MCM)	-	-	-	-	-	-									
6	**Sugarcane**															
	- Area (ha)	460	460	460	460	460	460		460	460	460	230	230	230		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	1.52	1.19	-	-	0.34	0.56		0.56	0.43	0.42	0.28	0.47	0.68		
7	**Other**															
	- Area (ha)	3.21	8.02	16.03	16.03	16.03	4.81									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	0.01	0.01	-	-	0.00	0.00									
8	**Wheat**															
	- Area (ha)						38838		81318	121370	121370	121370	97096	40052		
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- Q (MCM)						44.85		29.64	59.90	84.70	142.11	153.02	111.45		
9	**Gram & Pulses**															
	- Area (ha)						550		3206	4580	4580	4580	2153			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						0.63		1.17	2.26	3.20	5.36	3.39			
10	**Oilseed**															
	- Area (ha)						0		0	0	0	0	0			
	- F I R (mm)						145.04	145.04	101.25	101.86	100.13	115.73			418.97	564.01
	- Q (MCM)						-		-	-	-	-				
11	**Coriander**															
	- Area (ha)						0		0	0	0	0	0			
	- F I R (mm)						150.59	150.59	101.25	101.86	100.13	115.73	94.56		513.52	664.11
	- Q (MCM)						-		-	-	-	-	-			
12	**Other (Vegetable)**															
	- Area (ha)						0		0	0	0	0	0			
	- F I R (mm)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- Q (MCM)						-		-	-	-	-	-			
13	**Barley**															
	- Area (ha)						0		0	0	0	0	0			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						-		-	-	-	-	-			
Volume at Field (MCM)		102.95	126.26	40.14	18.36	51.13	68.81		31.37	62.60	88.31	147.76	156.88	112.13		
Volume at Head (MCM)		137.26	168.35	53.52	24.49	68.17	91.75		41.82	83.46	117.75	197.01	209.17	149.51		
Volume at Head of LBC (MCM)		61.14	74.98	23.84	10.91	30.36	40.87		18.63	37.18	52.45	87.75	93.17	66.59		
Volume at Head of RBC (MCM)		76.12	93.36	29.68	13.58	37.80	50.88		23.19	46.29	65.30	109.26	116.00	82.91		

Table 4.18 : MONTHLY GROSS IRRIGATION REQUIREMENT for PHASE I - RBC

No.	ITEM	KHARIF							RABI							Annual
		MAY	JUNE	JULY	AUG	SEPT	OCT	Total kharif	NOV	DEC	JAN	FEB	MAR	APR	Total rabi	Rabi+Kharif
1	**Paddy**															
	- Area (ha)	5,715	9,144	11,430	11,430	9,144	3,429									
	- F I R (mm)	589.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	33.70	41.56	13.36	6.11	16.90	7.57									
2	**Sorghum (Maize)**															
	- Area (ha)	2,921	4,890	6,350	6,350	6,350	4,255									
	- F I R (mm)	214.41	259.53	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	6.26	12.69	0.00	-	4.66	3.01									
3	**Oilseed**															
	- Area (ha)	1,905	3,810	3,810	3,810	3,810	1,905									
	- F I R (mm)	226.41	259.53	0.03	-	73.44	70.63	630.04							-	630.04
	- Q ($10^3/m^3$/Monthly)	4.31	9.89	0.00	-	2.80	1.35									
4	**Vegetable**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	170.42	140.62	-	-	-	41.06	352.10							-	352.10
	- Q (MCM)	-	-	-	-	-	-									
5	**Pulses**															
	- Area (ha)	1079.6	6350	6350	6350	6350	1079.6									
	- F I R (mm)	150.42	89.27	0.00	0.00	75.28	\ 122.39	417.36							-	417.36
	- Q (MCM)	1.62	4.40	-	-	4.78	1.32									
6	**Sugarcane**															
	- Area (ha)	2,540	2,540	2,540	2,540	2,540	2,540		2,540	2,540	2,540	1,270	1,270	1,270		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	8.39	6.59	-	-	1.87	3.11		3.09	2.40	2.31	1.56	2.57	3.74		
7	**Other**															
	- Area (ha)	0.00	0.00	0.00	0.00	0.00	0.00									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	-	-	-	-	-	-									
8	**Wheat**															
	- Area (ha)						17680		37018	55250	55250	55250	44200	18233		
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- Q (MCM)						20.41		13.49	27.27	38.56	64.69	69.66	50.74		
9	**Gram & Pulses**															
	- Area (ha)						1981		11557	16510	16510	16510	7760			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						2.29		4.21	8.15	11.52	19.33	12.23			
10	**Oilseed**															
	- Area (ha)						1016		4064	5080	5080	2032				
	- F I R (mm)						145.04	145.04	101.25	101.86	100.13	115.73			418.97	564.01
	- Q (MCM)						1.47		4.11	5.17	5.09	2.35				
11	**Coriander**															
	- Area (ha)						1270		1016	2540	2540	2540	635			
	- F I R (mm)						150.59	150.59	101.25	101.86	100.13	115.73	94.56		513.52	664.11
	- Q (MCM)						1.91		1.03	2.59	2.54	2.94	0.60			
12	**Other (Vegetable)**															
	- Area (ha)						1270		1270	1270	1270	1270	1270			
	- F I R (mm)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- Q (MCM)						1.58		0.77	0.77	0.77	0.88	0.74			
13	**Barley**															
	- Area (ha)						838.20		1701.80	2540.00	2540.00	2540.00	1524.00			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						0.97		0.62	1.25	1.77	2.97	2.40			
Volume at Field (MCM)		52.67	70.73	13.36	6.11	26.23	43.67		27.33	47.61	62.56	94.73	88.21	54.48		
Volume at Head (MCM)		70.22	94.31	17.81	8.15	34.97	58.23		38.44	83.48	83.42	126.30	117.61	72.64		
Volume at Head of RBC (MCM)		38.94	52.30	9.88	4.52	19.39	32.29		20.21	35.20	46.26	70.05	65.22	40.28		

Table 4.19 : MONTHLY GROSS IRRIGATION REQUIREMENT for PHASE I - LBC

No.	ITEM	KHARIF							RABI							Annual
		MAY	JUNE	JULY	AUG	SEPT	OCT	Total kharif	NOV	DEC	JAN	FEB	MAR	APR	Total rabi	Rabi+Kharif
1	**Paddy**															
	- Area (ha)	4,590	7,344	9,180	9,180	7,344	7,344									
	- F I R (mm)	589.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	27.07	33.38	10.73	4.91	13.57	16.21									
2	**Sorghum (Maize)**															
	- Area (ha)	5,372	8,993	11,679	11,679	11,679	7,825									
	- F I R (mm)	214.41	259.53	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	11.52	23.34	0.00	-	8.58	5.53									
3	**Oilseed**															
	- Area (ha)	3,504	7,007	7,007	7,007	7,007	3,504									
	- F I R (mm)	226.41	259.53	0.03	-	73.44	70.63	630.04							-	630.04
	- Q (10^3/m^3/Monthly)	7.93	18.19	0.00	-	5.15	2.47									
4	**Vegetable**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	170.42	140.62	-	-	-	41.06	352.10							-	352.10
	- Q (MCM)	-	-	-	-	-	-									
5	**Pulses**															
	- Area (ha)	1,985	11,679	11,679	11,679	11,679	1,985									
	- F I R (mm)	150.42	89.27	0.00	0.00	75.28	122.39	417.36							-	417.36
	- Q (MCM)	2.99	8.09	-	-	8.79	2.43									
6	**Sugercane**															
	- Area (ha)	4,672	4,672	4,672	4,672	4,672	4,672		4,672	4,672	4,672	2,336	2,336	2,336		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	15.43	12.12	-	-	3.43	5.72		5.68	4.42	4.25	2.86	4.73	6.88		
7	**Other**															
	- Area (ha)	0.00	0.00	0.00	0.00	0.00	0.00									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	-	-	-	-	-	-									
8	**Wheat**															
	- Area (ha)						32,514		68,077	101,607	101,607	101,607	81,286	33,530		
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- Q (MCM)						37.54		24.81	50.15	70.91	118.97	128.10	93.30		
9	**Gram & Pulses**															
	- Area (ha)						3,644		21,256	30,365	30,365	30,365	14,272			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						4.21		7.75	14.99	21.19	35.55	22.49			
10	**Oilseed**															
	- Area (ha)						1,869		7,475	9,343	9,343	3,737				
	- F I R (mm)						145.04	145.04	101.25	101.86	100.13	115.73			418.97	564.01
	- Q (MCM)						2.71		7.57	9.52	9.35	4.33				
11	**Coriander**															
	- Area (ha)						2,336		1,869	4,672	4,672	4,672	1,168			
	- F I R (mm)						150.59	150.59	101.25	101.86	100.13	115.73	126.08		545.05	695.63
	- Q (MCM)						3.52		1.89	4.76	4.68	5.41	1.47			
12	**Other (Vegetable)**															
	- Area (ha)						2,336		2,336	2,336	2,336	2,336	2,336			
	- F I R (mm)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- Q (MCM)						2.91		1.42	1.42	1.42	1.62	1.37			
13	**Barley**															
	- Area (ha)						1,542		3,130	4,672	4,672	4,672	2,803			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	0.00		272.68	388.15
	- Q (MCM)						1.78		1.14	2.31	3.26	5.47	-			
Volume at Field (MCM)		61.95	87.03	10.73	4.91	30.73	82.60		50.26	87.56	115.06	174.21	158.17	100.19		
Volume at Head (MCM)		82.60	116.04	14.31	6.54	40.97	110.14		67.01	116.74	153.41	232.28	210.89	133.58		
Volume at Head of LBC (MCM)		36.79	51.69	6.37	2.91	18.25	49.06		29.85	52.00	68.33	103.46	93.93	59.50		

Table 4.20 : MONTHLY GROSS IRRIGATION REQUIREMENT for PHASE II

No.	ITEM	KHARIF						Total kharif	RABI						Total rabi	Annual Rabi+Kharif
		MAY	JUNE	JULY	AUG	SEPT	OCT		NOV	DEC	JAN	FEB	MAR	APR		
1	Paddy															
	- Area (ha)	10,305	16,488	20,610	20,610	16,488	6,183									
	- F I R (mm)	599.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	60.76	74.94	24.09	11.02	30.47	13.65									
2	Sorghum (Maize)															
	- Area (ha)	7,898	13,221	17,170	17,170	17,170	11,504									
	- F I R (mm)	214.41	259.53	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	16.93	34.31	0.01	-	12.61	8.13									
3	Oilseed															
	- Area (ha)	18,890	37,780	37,780	37,780	37,780	18,890									
	- F I R (mm)	226.41	259.53	0.03	-	73.44	70.63	630.04							-	630.04
	- Q (10^3/m^3/Monthly)	42.77	98.05	0.01	-	27.74	13.34									
4	Vegetable															
	- Area (ha)	920	1,150	1,150	1,150	1,150	345									
	- F I R (mm)	170.42	140.62	-	-	-	41.06	352.10							-	352.10
	- Q (MCM)	1.57	1.62	-	-	-	0.14									
5	Pulses															
	- Area (ha)	5060.9	29770	29770	29770	29770	5060.9									
	- F I R (mm)	150.42	69.27	0.00	0.00	75.28	122.39	417.36							-	417.36
	- Q (MCM)	7.61	20.62	-	-	22.41	6.19									
6	Sugarcane															
	- Area (ha)	13,740	13,740	13,740	13,740	13,740	13,740		13,740	13,740	13,740	6,870	6,870	6,870		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	45.39	35.66	-	-	10.09	16.82		16.69	12.99	12.51	8.42	13.92	20.24		
7	Other															
	- Area (ha)	3.21	8.02	16.03	16.03	16.03	4.81									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	0.01	0.01	-	-	0.00	0.00									
8	Wheat															
	- Area (ha)						40230		84232	125720	125720	125720	100576	41488		
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- Q (MCM)						46.45		30.70	62.05	87.73	147.20	158.50	115.45		
9	Gram & Pulses															
	- Area (ha)						3504		20440	29200	29200	29200	13724			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						4.05		7.45	14.41	20.38	34.19	21.63			
10	Oilseed															
	- Area (ha)						1488		5952	7440	7440	2976				
	- F I R (mm)						145.04	145.04	101.25	101.86	100.13	115.73			418.97	564.01
	- Q (MCM)						2.16		6.03	7.58	7.45	3.44				
11	Coriander															
	- Area (ha)						2635		2108	5270	5270	5270	1318			
	- F I R (mm)						150.59	150.59	101.25	101.86	100.13	115.73	94.56		513.52	664.11
	- Q (MCM)						3.97		2.13	5.37	5.28	6.10	1.25			
12	Other (Vegetable)															
	- Area (ha)						2290		2290	2290	2290	2290	2290			
	- F I R (mm)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- Q (MCM)						2.86		1.39	1.39	1.39	1.59	1.34			
13	Barley															
	- Area (ha)						983		1997	2980	2980	2980	1788			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						1.14		0.73	1.47	2.08	3.49	2.82			
Volume at Field (MCM)		167.43	244.59	24.10	11.02	80.92	112.69		48.43	92.27	124.31	196.02	185.54	115.45		
Volume at Head (MCM)		223.25	326.12	32.14	14.69	107.89	150.26		64.58	123.03	165.74	261.36	247.38	153.93		
Volume at Head of LBC (MCM)		99.44	145.26	14.31	6.54	48.06	66.93		28.76	54.80	73.82	116.41	110.19	68.56		
Volume at Head of RBC (MCM)		123.81	180.86	17.82	8.15	59.83	83.33		35.81	68.23	91.92	144.94	137.19	85.37		

Table 4.21 : MONTHLY GROSS IRRIGATION REQUIREMENT for ACHIEVEMENT AV. 10 YEAR

No.	ITEM	KHARIF							RAB'I							Annual
		MAY	JUNE	JULY	AUG	SEPT	OCT	Total kharif	NOV	DEC	JAN	FEB	MAR	APR	Total rabi	Rabi+Kharif
1	**Paddy**															
	- Area (ha)	10,100	16,160	20,200	20,200	16,160	6,060									
	- F I R (mm)	589.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	59.56	73.45	23.61	10.80	29.87	13.38									
2	**Sorghum (Maize)**															
	- Area (ha)	3,054	5,113	6,640	6,640	6,640	4,449									
	- F I R (mm)	214.41	259.53	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	6.55	13.27	0.00	-	4.88	3.14									
3	**Oilseed**															
	- Area (ha)	5,080	10,160	10,160	10,160	10,160	5,080									
	- F I R (mm)	226.41	259.53	0.03	-	73.44	70.63	630.04							-	630.04
	- Q ($10^3/m^3$/Monthly)	11.50	26.37	0.00	-	7.46	3.59									
4	**Vegetable**															
	- Area (ha)	1,016	1,270	1,270	1,270	1,270	381									
	- F I R (mm)	170.42	140.62	-	-	-	41.06	352.10							-	352.10
	- Q (MCM)	1.73	1.79	-	-	-	0.16									
5	**Pulses**															
	- Area (ha)	27.2	160	160	160	160	27.2									
	- F I R (mm)	150.42	89.27	0.00	0.00	75.28	122.39	417.36							-	417.36
	- Q (MCM)	0.04	0.11	-	-	0.12	0.03									
6	**Sugarcane**															
	- Area (ha)	2,350	2,350	2,350	2,350	2,350	2,350		2,350	2,350	2,350	1,175	1,175	1,175		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	7.76	6.10	-	-	1.73	2.88		2.86	2.22	2.14	1.44	2.38	3.46		
7	**Other**															
	- Area (ha)	0.00	0.00	0.00	0.00	0.00	0.00									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	-	-	-	-	-	-									
8	**Wheat**															
	- Area (ha)						30886.40		64668.40	96520.00	96520.00	96520.00	77216.00	31851.60		
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- Q (MCM)						35.66		23.57	47.64	67.36	113.01	121.69	88.63		
9	**Gram & Pulses**															
	- Area (ha)						3582		20895	29850	29850	29850	14030			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						4.14		7.62	14.73	20.83	34.95	22.11			
10	**Oilseed**															
	- Area (ha)						4230		16920	21150	21150	8460				
	- F I R (mm)						145.04	145.04	101.25	101.86	100.13	115.73			418.97	564.01
	- Q (MCM)						6.14		17.13	21.54	21.18	9.79				
11	**Coriander**															
	- Area (ha)						6650		5320	13300	13300	13300	3325			
	- F I R (mm)						150.59	150.59	101.25	101.86	100.13	115.73	126.08		545.05	695.63
	- Q (MCM)						10.01		5.39	13.55	13.32	15.39	4.19			
12	**Other (Vegetable)**															
	- Area (ha)						4300		4300	4300	4300	4300	4300			
	- F I R (mm)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- Q (MCM)						5.36		2.61	2.62	2.61	2.99	2.52			
13	**Barley**															
	- Area (ha)						1640		3330	4970	4970	4970	2982			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	0.00		272.68	388.15
	- Q (MCM)						1.89		1.21	2.45	3.47	5.82	-			
Volume at Field (MCM)		87.10	120.97	23.61	10.80	43.93	86.35		60.39	104.76	130.90	183.39	152.89	92.10		
Volume at Head (MCM)		116.13	161.30	31.48	14.40	58.57	115.13		80.52	139.67	174.53	244.52	203.85	122.78		
Volume at Head of LBC (MCM)		51.73	71.84	14.02	6.41	26.09	51.28		35.86	62.21	77.74	108.91	90.80	54.69		
Volume at Head of RBC (MCM)		64.41	89.45	17.46	7.99	32.48	63.85		44.65	77.46	96.79	135.61	113.05	68.10		

Table 4.22 : MONTHLY GROSS IRRIGATION REQUIREMENT for ACHIEVEMENT 1988-1989

No.	ITEM	KHARIF							RABI							Annual Rabi+Kharif
		MAY	JUNE	JULY	AUG	SEPT	OCT	Total kharif	NOV	DEC	JAN	FEB	MAR	APR	Total rabi	
1	**Paddy**															
	- Area (ha)	11,330	18,128	22,660	22,660	18,128	6,798									
	- F I R (mm)	589.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	66.81	82.39	26.48	12.11	33.50	15.01									
2	**Sorghum (Maize)**															
	- Area (ha)	902	1,509	1,960	1,960	1,960	1,313									
	- F I R (mm)	214.41	259.53	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	1.93	3.92	0.00	-	1.44	0.93									
3	**Oilseed**															
	- Area (ha)	7,840	15,680	15,680	15,680	15,680	7,840									
	- F I R (mm)	226.41	259.53	0.03	-	73.44	70.63	630.04							-	630.04
	- Q (10^3/m^3/Monthly)	17.75	40.69	0.00	-	11.52	5.54									
4	**Vegetable**															
	- Area (ha)	192.00	240.00	240.00	240.00	240.00	72.00									
	- F I R (mm)	170.42	140.62	-	-	-	41.06	352.10							-	352.10
	- Q (MCM)	0.33	0.34	-	-	-	0.03									
5	**Pulses**															
	- Area (ha)	0	0	0	0	0	0									
	- F I R (mm)	150.42	69.27	0.00	0.00	75.28	122.39	417.36							-	417.36
	- Q (MCM)	-	-	-	-	-	-									
6	**Sugarcane**															
	- Area (ha)	2,550	2,550	2,550	2,550	2,550	2,550		2,550	2,550	2,550	1,275	1,275	1,275		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	8.42	6.62	-	-	1.87	3.12		3.10	2.41	2.32	1.56	2.58	3.76		
7	**Other**															
	- Area (ha)	94.00	235.00	470.00	470.00	470.00	141.00									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	0.16	0.33	-	-	0.05	0.06									
8	**Wheat**															
	- Area (ha)						33030		69157	103220	103220	103220	82576	34063		
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- Q (MCM)						38.14		25.21	50.95	72.03	120.86	130.14	94.79		
9	**Gram & Pulses**															
	- Area (ha)						1521.60		8876.00	12680.00	12680.00	12680.00	5959.60			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						1.76		3.24	6.26	8.85	14.85	9.39			
10	**Oilseed**															
	- Area (ha)						10506.00		42024.00	52530.00	52530.00	21012.00				
	- F I R (mm)						145.04	145.04	101.25	101.86	100.13	115.73			418.97	564.01
	- Q (MCM)						15.24		42.55	53.51	52.60	24.32				
11	**Coriander**															
	- Area (ha)						3885.00		3108.00	7770.00	7770.00	7770.00	1942.50			
	- F I R (mm)						150.59	150.59	101.25	101.86	100.13	115.73	94.56		513.52	664.11
	- Q (MCM)						5.85		3.15	7.91	7.78	8.99	1.84			
12	**Other (Vegetable)**															
	- Area (ha)						5470.00		5470.00	5470.00	5470.00	5470.00	5470.00			
	- F I R (mm)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- Q (MCM)						6.82		3.32	3.33	3.32	3.80	3.20			
13	**Barley**															
	- Area (ha)						141.24		286.76	428.00	428.00	428.00	256.80			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						0.16		0.10	0.21	0.30	0.50	0.40			
Volume at Field (MCM)		95.40	134.29	26.49	12.11	48.38	92.65		80.67	124.58	147.20	174.88	147.56	98.54		
Volume at Head (MCM)		127.20	179.06	35.31	16.15	64.51	123.53		107.55	166.11	196.26	233.17	196.74	131.39		
Volume at Head of LBC (MCM)		56.66	79.75	15.73	7.19	28.73	55.02		47.91	73.99	87.42	103.86	87.63	58.52		
Volume at Head of RBC (MCM)		70.55	99.30	19.59	8.96	35.78	68.51		59.65	92.12	108.84	129.31	109.11	72.87		

Table 4.23 : MONTHLY GROSS IRRIGATION REQUIREMENT for year 1995-1996

No.	ITEM	KHARIF							RABI							Annual
		MAY	JUNE	JULY	AUG	SEPT	OCT	Total kharif	NOV	DEC	JAN	FEB	MAR	APR	Total rabi	Rabi+Kharif
1	**Paddy**															
	- Area (ha)	5,038	8,061	10,076	10,076	8,061	3,023									
	- F I R (mm)	589.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	29.71	36.64	11.77	5.39	14.90	6.67									
2	**Sorghum (Maize)**															
	- Area (ha)	105.34	176.33	229.00	229.00	229.00	153.43									
	- F I R (mm)	214.41	259.53	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	0.23	0.46	0.00	-	0.17	0.11									
3	**Oilseed**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	226.41	259.53	0.03	-	73.44	70.63	630.04							-	630.04
	- Q (10^3/m^3/Monthly)	-	-	-	-	-	-									
4	**Vegetable**															
	- Area (ha)	183.20	229.00	229.00	229.00	229.00	68.70									
	- F I R (mm)	170.42	140.62	0.00	0.00	0.00	41.06	352.10							-	352.10
	- Q (MCM)	0.31	0.32	-	-	-	0.03									
5	**Pulses**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	150.42	69.27	-	-	75.28	122.39	417.36							-	417.36
	- Q (MCM)	-	-	-	-	-	-									
6	**Sugarcane**															
	- Area (ha)	1,832	1,832	1,832	1,832	1,832	1,832		1,832	1,832	1,832	916	916	916		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	6.05	4.75	-	-	1.35	2.24		2.23	1.73	1.67	1.12	1.86	2.70		
7	**Other**															
	- Area (ha)	91.60	229.00	458.00	458.00	458.00	137.40									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	0.16	0.32	-	-	0.05	0.06									
8	**Wheat**															
	- Area (ha)						32756		68583	102363	102363	102363	81890	33780		
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- Q (MCM)						37.82		25.00	50.52	71.43	119.86	129.06	94.00		
9	**Gram & Pulses**															
	- Area (ha)						907		5290	7557	7557	7557	3552			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						1.05		1.93	3.73	5.27	8.85	5.60			
10	**Oilseed**															
	- Area (ha)						15206		60822	76028	76028	30411				
	- F I R (mm)						145.04	145.04	101.25	101.86	100.13	115.73			418.97	564.01
	- Q (MCM)						22.05		61.58	77.44	76.12	35.19				
11	**Coriander**															
	- Area (ha)						5267		4214	10534	10534	10534	2634			
	- F I R (mm)						150.59	150.59	101.25	101.86	100.13	115.73	94.56		513.52	664.11
	- Q (MCM)						7.93		4.27	10.73	10.55	12.19	2.49			
12	**Other (Vegetable)**															
	- Area (ha)						5496		5496	5496	5496	5496	5496			
	- F I R (mm)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- Q (MCM)						6.85		3.34	3.35	3.34	3.82	3.22			
13	**Barley**															
	- Area (ha)						831.27		1687.73	2519.00	2519.00	2519.00	1511.40			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						0.96		0.62	1.24	1.76	2.95	2.38			
Volume at Field (MCM)		36.45	42.49	11.78	5.39	16.46	85.78		98.96	148.75	170.14	183.98	144.60	96.70		
Volume at Head (MCM)		48.60	56.66	15.70	7.18	21.95	114.37		131.94	198.33	226.85	245.30	192.80	128.93		
Volume at Head of LBC (MCM)		21.65	25.24	6.99	3.20	9.78	50.94		58.77	88.34	101.04	109.26	85.89	57.43		
Volume at Head of RBC (MCM)		26.96	31.42	8.71	3.98	12.17	63.43		73.17	109.99	125.81	136.04	106.92	71.50		

Table 4.24 : MONTHLY GROSS IRRIGATION REQUIREMENT for year 1996-1997

No.	ITEM	KHARIF						Total kharif	RABI						Total rabi	Annual Rabi+Kharif
		MAY	JUNE	JULY	AUG	SEPT	OCT		NOV	DEC	JAN	FEB	MAR	APR		
1	Paddy															
	- Area (ha)	5,840	9,343	11,679	11,679	9,343	3,504									
	- F I R (mm)	589.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	34.43	42.47	13.65	6.24	17.27	7.74									
2	Sorghum (Maize)															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	214.41	259.63	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	-	-	-	-	-	-									
3	Oilseed															
	- Area (ha)	115	229	229	229	229	115									
	- F I R (mm)	226.41	259.33	0.03	-	73.44	70.63	630.04							-	630.04
	- Q (10^3/m^3/Monthly)	0.26	0.59	0.00	-	0.17	0.08									
4	Vegetable															
	- Area (ha)	183.20	229.00	229.00	229.00	229.00	68.70									
	- F I R (mm)	170.42	140.62	0.00	0.00	0.00	41.06	352.10							-	352.10
	- Q (MCM)	3.12	3.22	-	-	-	0.28									
5	Pulses															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	150.42	69.27	-	-	75.28	122.39	417.36							-	417.36
	- Q (MCM)	-	-	-	-	-	-									
6	Sugarcane															
	- Area (ha)	2,061	2,061	2,061	2,061	2,061	2,061		2,061	2,061	2,061	1,031	1,031	1,031		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	6.81	5.35	-	-	1.51	2.52		2.50	1.95	1.88	1.26	2.09	3.04		
7	Other															
	- Area (ha)	91.60	229.00	458.00	458.00	458.00	137.40									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	0.16	0.32	-	-	0.05	0.06									
8	Wheat						33415.7		69964.1	104424.0	104424.0	104424.0	83539.2	34459.9		
	- Area (ha)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- F I R (mm)						38.58		25.50	51.54	72.87	122.27	131.65	95.89		
	- Q (MCM)															
9	Gram & Pulses						2061.00		12022.50	17175.00	17175.00	17175.00	8072.25			
	- Area (ha)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- F I R (mm)						2.38		4.38	8.48	11.99	20.11	12.72			
	- Q (MCM)															
10	Oilseed						13053.00		52212.00	65265.00	65265.00	26106.00				
	- Area (ha)						145.04	145.04	101.25	101.86	100.13	115.73			418.97	564.01
	- F I R (mm)						18.93		52.86	66.48	65.35	30.21				
	- Q (MCM)															
11	Coriander						5152.50		4122.00	10305.00	10305.00	10305.00	2576.25			
	- Area (ha)						150.59	150.59	101.25	101.86	100.13	115.73	94.56		513.52	664.11
	- F I R (mm)						7.76		4.17	10.50	10.32	11.93	2.44			
	- Q (MCM)															
12	Other (Vegetable)						7557.00		7557.00	7557.00	7557.00	7557.00	7557.00			
	- Area (ha)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- F I R (mm)						9.42		4.59	4.60	4.59	5.25	4.42			
	- Q (MCM)															
13	Barley						1057.98		2148.02	3206.00	3206.00	3206.00	1923.60			
	- Area (ha)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- F I R (mm)						1.22		0.78	1.58	2.24	3.75	3.03			
	- Q (MCM)															
Volume at Field (MCM)		44.78	51.95	13.65	6.24	19.00	88.98		94.80	145.13	169.22	194.78	156.36	98.93		
Volume at Head (MCM)		59.71	69.27	18.20	8.32	25.33	118.64		128.40	193.50	225.83	259.71	208.47	131.90		
Volume at Head of LBC (MCM)		26.59	30.85	8.11	3.71	11.28	52.84		56.30	86.19	100.50	115.68	92.86	58.75		
Volume at Head of RBC (MCM)		33.11	38.42	10.09	4.62	14.05	65.79		70.10	107.31	125.13	144.03	115.62	73.15		

Table 4.25 : MONTHLY GROSS IRRIGATION REQUIREMENT for year 1997-1998

No.	ITEM	KHARIF							RABI							Annual
		MAY	JUNE	JULY	AUG	SEPT	OCT	Total kharif	NOV	DEC	JAN	FEB	MAR	APR	Total rabi	Rabi+Kharif
1	**Paddy**															
	- Area (ha)	7,786	12,458	15,572	15,572	12,458	4,672									
	- F I R (mm)	589.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	45.91	56.62	18.20	8.32	23.02	103.14									
2	**Sorghum (Maize)**															
	- Area (ha)	105	176	229	229	229	153									
	- F I R (mm)	214.41	259.53	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	0.23	0.46	0.00	-	0.17	0.11									
3	**Oilseed**															
	- Area (ha)	115	229	229	229	229	115									
	- F I R (mm)	226.41	259.53	0.03	-	73.44	70.63	630.04							-	630.04
	- Q (10^3/m^3/Monthly)	0.26	0.59	0.00	-	0.17	0.08									
4	**Vegetable**															
	- Area (ha)	183	229	229	229	229	69									
	- F I R (mm)	170.42	140.62	0.00	0.00	0.00	41.06	352.10							-	352.10
	- Q (MCM)	3.12	3.22	-	-	-	0.28									
5	**Pulses**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	150.42	69.27	-	-	75.28	122.39	417.36							-	417.36
	- Q (MCM)	-	-	-	-	-	-									
6	**Sugarcane**															
	- Area (ha)	2,519	2,519	2,519	2,519	2,519	2,519		2,519	2,519	2,519	1,260	1,260	1,260		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	8.32	6.54	-	-	1.85	3.08		3.06	2.38	2.29	1.54	2.55	3.71		
7	**Other**															
	- Area (ha)	92	229	458	458	458	137									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	0.16	0.32	-	-	0.05	0.06									
8	**Wheat**						32,756		68,583	102,363	102,363	102,363	81,890	33,780		
	- Area (ha)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- F I R (mm)						37.82		25.00	50.52	71.43	119.86	129.06	94.00		
	- Q (MCM)															
9	**Gram & Pulses**						1,044		6,091	8,702	8,702	8,702	4,090			
	- Area (ha)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- F I R (mm)						1.21		2.22	4.29	6.07	10.19	6.45			
	- Q (MCM)															
10	**Oilseed**						14,610		58,441	73,051	73,051	29,220				
	- Area (ha)						145.04	145.04	101.25	101.86	100.13	0.00			303.24	448.28
	- F I R (mm)						21.19		59.17	74.41	73.14	-				
	- Q (MCM)															
11	**Coriander**						7,786		6,229	15,572	15,572	15,572	3,893			
	- Area (ha)						150.59	150.59	101.25	101.86	100.13	115.73	94.56		513.52	664.11
	- F I R (mm)						11.72		6.31	15.86	15.59	18.02	3.68			
	- Q (MCM)															
12	**Other (Vegetable)**						9,847		9,847	9,847	9,847	9,847	9,847			
	- Area (ha)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- F I R (mm)						12.28		5.98	6.00	5.98	6.84	5.76			
	- Q (MCM)															
13	**Barley**						907		1,841	2,748	2,748	2,748	1,649			
	- Area (ha)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- F I R (mm)						1.05		0.67	1.36	1.92	3.22	2.60			
	- Q (MCM)															
Volume at Field (MCM)		58.00	67.75	18.20	8.32	25.26	192.02		102.41	154.82	176.49	159.66	150.10	97.71		
Volume at Head (MCM)		77.33	80.34	24.26	11.10	33.68	256.03		136.55	206.43	235.24	212.89	200.13	130.28		
Volume at Head of LBC (MCM)		34.44	40.24	10.81	4.94	15.00	114.04		60.82	91.95	104.78	94.82	89.14	58.03		
Volume at Head of RBC (MCM)		42.89	50.10	13.46	6.16	18.68	141.99		75.73	114.48	130.46	118.06	110.99	72.25		

Table 4.26 : MONTHLY GROSS IRRIGATION REQUIREMENT for year 1998-1999

No.	ITEM	KHARIF							RABI							Annual
		MAY	JUNE	JULY	AUG	SEPT	OCT	Total kharif	NOV	DEC	JAN	FEB	MAR	APR	Total rabi	Rabi+Kharif
1	**Paddy**															
	- Area (ha)	8,359	13,374	16,717	16,717	13,374	5,015									
	- F I R (mm)	589.66	454.51	116.86	53.46	184.81	220.78	1,620.09							-	1,620.09
	- Q (MCM)	49.29	60.78	19.54	8.94	24.72	11.07									
2	**Sorghum (Maize)**															
	- Area (ha)	211	353	458	458	458	307									
	- F I R (mm)	214.41	259.53	0.03	-	73.44	70.63	618.04							-	618.04
	- Q (MCM)	0.45	0.92	0.00	-	0.34	0.22									
3	**Oilseed**															
	- Area (ha)	229	458	458	458	458	229									
	- F I R (mm)	226.41	259.53	0.03	-	73.44	70.63	630.04							-	630.04
	- Q (10^3/m^3/Monthly)	0.52	1.19	0.00	-	0.34	0.16									
4	**Vegetable**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	170.42	140.62	0.00	0.00	0.00	41.06	352.10							-	352.10
	- Q (MCM)	-	-	-	-	-	-									
5	**Pulses**															
	- Area (ha)	-	-	-	-	-	-									
	- F I R (mm)	150.42	69.27	-	-	75.28	122.39	417.36							-	417.36
	- Q (MCM)	-	-	-	-	-	-									
6	**Sugarcane**															
	- Area (ha)	2,748	2,748	2,748	2,748	2,748	2,748		2,748	2,748	2,748	1,374	1,374	1,374		
	- F I R (mm)	330.38	259.53	-	-	73.44	122.39	785.73	121.50	94.51	91.02	122.54	202.62	294.64	926.83	1,712.57
	- Q (MCM)	9.08	7.13	-	-	2.02	3.36		3.34	2.60	2.50	1.68	2.78	4.05		
7	**Other**															
	- Area (ha)	92	229	458	458	458	137									
	- F I R (mm)	170.42	140.62	0.00	0.00	10.96	41.06	363.06							-	363.06
	- Q (MCM)	0.16	0.32	-	-	0.05	0.06									
8	**Wheat**															
	- Area (ha)						39,644		83,006	123,889	123,889	123,889	99,111	40,883		
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60	278.27	708.54	824.01
	- Q (MCM)						45.78		30.26	61.15	86.46	145.06	156.20	113.77		
9	**Gram & Pulses**															
	- Area (ha)						577		3,366	4,809	4,809	4,809	2,260			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						0.67		1.23	2.37	3.36	5.63	3.56			
10	**Oilseed**															
	- Area (ha)						11,771		47,082	58,853	58,853	23,541				
	- F I R (mm)						145.04	145.04	101.25	101.86	100.13	0.00			303.24	448.28
	- Q (MCM)						17.07		47.67	59.95	58.93	-				
11	**Coriander**															
	- Area (ha)						5,725		4,580	11,450	11,450	11,450	2,863			
	- F I R (mm)						150.59	150.59	101.25	101.86	100.13	115.73	94.56		513.52	664.11
	- Q (MCM)						8.62		4.64	11.66	11.46	13.25	2.71			
12	**Other (Vegetable)**															
	- Area (ha)						17,404		17,404	17,404	17,404	17,404	17,404			
	- F I R (mm)						124.71	124.71	60.75	60.91	60.68	69.44	58.54		310.31	435.02
	- Q (MCM)						21.70		10.57	10.60	10.56	12.08	10.19			
13	**Barley**															
	- Area (ha)						680		1,391	2,061	2,061	2,061	1,237			
	- F I R (mm)						115.47	115.47	36.45	49.36	69.78	117.09	157.60		430.28	545.74
	- Q (MCM)						0.79		0.50	1.02	1.44	2.41	1.95			
Volume at Field (MCM)		59.49	70.34	19.54	8.94	27.46	109.50		98.21	149.35	174.70	180.12	177.38	117.81		
Volume at Head (MCM)		79.32	93.79	26.05	11.92	36.61	145.99		130.94	199.13	232.94	240.16	236.51	157.09		
Volume at Head of LBC (MCM)		35.33	41.78	11.60	5.31	16.31	65.03		58.32	88.70	103.75	106.97	105.35	69.97		
Volume at Head of RBC (MCM)		43.99	52.01	14.45	6.61	20.30	80.97		72.62	110.43	129.18	133.19	131.17	87.12		

Computational explanatory notes on Table 4.17

GROSS IRRIGATION REQUIREMENT, for Paddy for month of May

Area(ha) = Corresponding in table 3.2, we get 15%

= Corresponding Cropping Area Coefficient in table 4.16, we get 0.5

= (15%*229,000)*0.5

= 17,175 ha

FIR(mm) = Corresponding in table 4.3, we get 186.61 + 201.29 = 387.90 mm

Q (MCM) = Area*FIR

= $(17,175*10^4)*(387.90/10^3)/10^6$

= 66.62 MCM

Volume at Field = a sum Q in may, 68.30 MCM

Volume at Head = Volume at Field/Conveyance Efficiency

= 60.30 MCM/0.75

= 9.06 MCM

Volume at LBC = Volume at Head*(Area LBC/CCA)

= 9.06 MCM*(102,000 ha/229,000 ha)

= 40.56 MCM

Volume at RBC = Volume at Head*(Area RBC/CCA)

= 9.06 MCM*(127,000 ha/229,000 ha)

= 50.50 MCM

Table 4.27 : MONTHLY WATER DEMAND AS PER REPORT (IBRD 1974)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Water Allawance (l/sec/ha)	0.27	0.39	0.47	0.20	0.53	0.47	0.08	0.03	0.22	0.35	0.35	0.32
Water Demand m3/sec in RBC command (127,000 ha)	34.29	49.53	59.69	25.4	67.31	59.69	10.2	3.81	27.9	44.45	44.45	40.64
Water Demand m3/sec in LBC command (102,000 ha)	27.54	39.78	47.94	20.4	54.06	47.94	8.16	3.06	22.4	35.7	35.7	32.64
Water Demand m3/sec in Project command (229,000 ha)	61.83	89.31	107.6	45.8	121.4	107.6	18.3	6.87	50.4	80.15	80.15	73.28

Table 4.28 : WATER DEMAND AT HEAD OF LEFT BANK CANAL

Canal Capacity : 42.5 M^3/Sec (110.16 MCM in 30 day month and 113.83 MCM in 31 day month)

CONDITION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
As Per Design 1954 (MCM)	40.56	74.98	23.84	10.91	30.36	40.87	18.63	37.18	52.45	87.75	93.17	66.59
Phase I Target 1973 (MCM)	31.29	51.69	6.37	2.91	18.25	49.06	29.85	52.00	68.33	103.46	93.93	59.50
Phase II Target 1984 (MCM)	87.09	145.3	14.31	6.54	48.06	66.93	28.76	54.80	73.82	116.4	110.2	68.56
Achievement 1988-1989 (MCM)	43.08	79.75	15.73	7.19	28.73	55.02	47.91	73.99	87.4	103.9	87.63	58.52
Av.Achievement 10 year (MCM)	39.63	71.84	14.02	6.41	26.09	51.28	35.86	62.21	77.7	108.9	90.80	54.69
Achievement 1995-1996 (MCM)	15.61	25.24	6.99	3.20	9.78	50.94	58.77	88.34	101.0	109.3	85.88	57.43
Achievement 1996-1997 (MCM)	19.60	30.85	8.11	3.71	11.28	52.84	56.30	86.19	100.5	115.7	92.86	58.75
Achievement 1997-1998 (MCM)	31.27	50.10	13.46	6.16	18.68	141.99	75.73	114.5	130.5	118.1	111.0	72.25
Achievement 1998-1999 (MCM)	25.32	41.78	11.60	5.31	16.31	65.03	58.32	88.7	103.8	107.0	105.3	69.97
As per IBRD 1974 (MCM)	27.5	39.80	47.9	20.4	54.06	47.90	8.16	3.06	22.40	35.70	35.70	32.60

Table 4.29 : WATER DEMAND AT HEAD OF RIGHT BANK CANAL FOR RAJASTHAN

Canal Capacity : 78.1 m3/sec (202.43 MCM in 30 day month and 209.18 MCM in 31 day month)

CONDITION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
As Per Design 1954 (MCM)	50.50	93.36	29.68	13.6	37.80	50.88	23.2	46.3	65.3	109.3	116.0	82.91
Phase I Target 1973 (MCM)	30.42	52.30	9.88	4.52	19.39	32.29	20.2	35.2	46.3	70.05	65.2	40.28
Phase II Target 1984 (MCM)	108.4	180.9	17.82	8.15	59.83	83.33	35.8	68.2	91.9	144.9	137.2	85.37
Achievement 1988-1989 (MCM)	53.64	99.30	19.59	8.96	35.78	68.51	59.6	92.1	109	129.3	109.1	72.87
Av.Achievement 10 year (MCM)	49.34	89.45	17.46	7.99	32.48	63.85	44.7	77.5	96.8	135.6	113.1	68.10
Achievement 1995-1996 (MCM)	19.44	31.42	8.71	3.98	12.17	63.43	73.2	110.0	125.8	136.0	106.9	71.50
Achievement 1996-1997 (MCM)	24.40	38.42	10.09	4.62	14.05	65.79	70.1	107.3	125.1	144.0	115.6	73.15
Achievement 1997-1998 (MCM)	25.11	40.24	10.81	4.94	15.00	114.04	60.82	91.95	104.8	94.82	89.14	58.03
Achievement 1998-1999 (MCM)	31.52	52.01	14.45	6.61	20.30	80.97	72.6	110.4	129	133.2	131.2	87.12
As per IBRD 1974 (MCM)	34.30	49.50	59.70	25.40	67.31	59.7	10.2	3.81	27.90	44.50	44.50	40.60

Note : Capacity of RBC at head is 188.62 m^3/s and of which capacity at boarder with M.P. for irrigation in M.P is 110.52 m^3/s

Table 4.30 : COMPARATIVE FIELD IRRIGATION REQUIREMENT FOR PADDY CROPS (in mm)

CONDITION	May	Jun	Jul	Aug	Sep	Oct
As per report World Bank (1974)	300.00	210.00	50.00	20.00	90.00	150.00
As Per Design 1954	387.9	454.51	116.86	53.46	184.81	220.78
Phase I Target 1973	387.9	454.51	116.86	53.46	184.81	220.78
Phase II Target 1984	387.9	454.51	116.86	53.46	184.81	220.78
Achievement 1988-1989	387.9	454.51	116.86	53.46	184.81	220.78
Av.Achievement 10 year	387.9	454.51	116.86	53.46	184.81	220.78
Achievement 1995-1996	387.9	454.51	116.86	53.46	184.81	220.78
Achievement 1996-1997	387.9	454.51	116.86	53.46	184.81	220.78
Achievement 1997-1998	387.9	454.51	116.86	53.46	184.81	220.78
Achievement 1998-1999	387.9	454.51	116.86	53.46	184.81	220.78

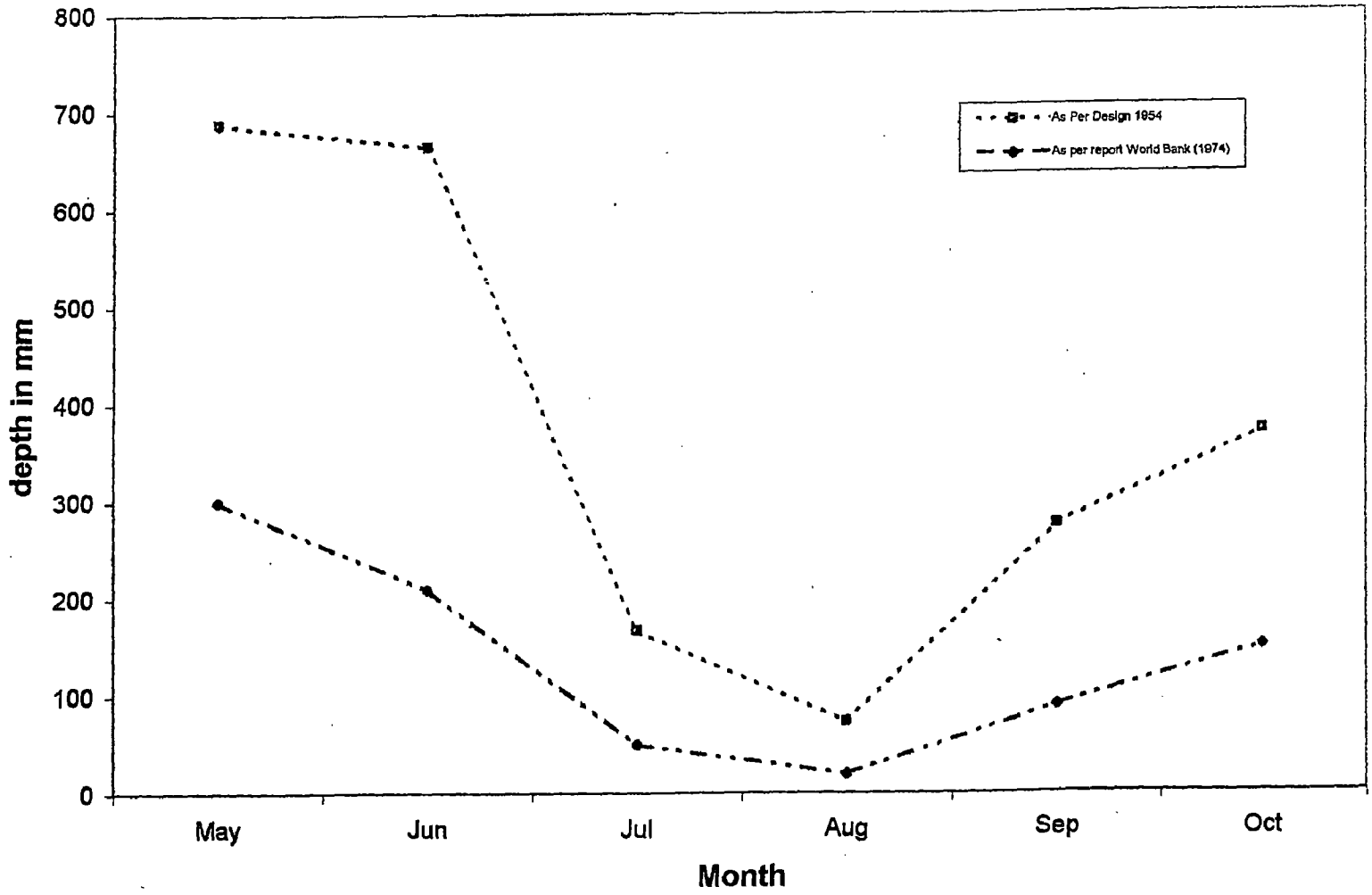
Note : Data from table.IV-8 to IV-20

Table 4.31 : COMPARATIVE AREA FOR PADDY CROPS (in ha)

CONDITION	May	Jun	Jul	Aug	Sep	Oct
As per report World Bank (1974)	5,000	8,000	10,000	10,000	8,000	3,000
As Per Design 1954	17,175	27,480	34,350	34,350	27,480	10,305
Phase I Target 1973 RBC	5,715	9,144	11,430	11,430	9,144	3,429
Phase I Target 1973 LBC	4,590	7,344	9,180	9,180	7,344	2,754
Phase II Target 1984	10,305	16,488	20,610	20,610	16,488	6,183
Achievement 1988-1989	11,330	18,128	22,660	22,660	18,182	6,798
Av.Achievement 10 year	10,100	16,160	20,200	20,200	16,160	6,060
Achievement 1995-1996	5,038	8,061	10,076	10,076	8,061	3,023
Achievement 1996-1997	5,840	9,343	11,679	11,679	9,343	3,504
Achievement 1997-1998	7,786	12,458	15,572	15,572	12,458	4,672
Achievement 1998-1999	6,359	13,374	16,717	16,717	13,374	5,015

Note : Data from table.IV-24 to IV-33

Fig. 4.1 :Comparative Irrigation Requirement for paddy



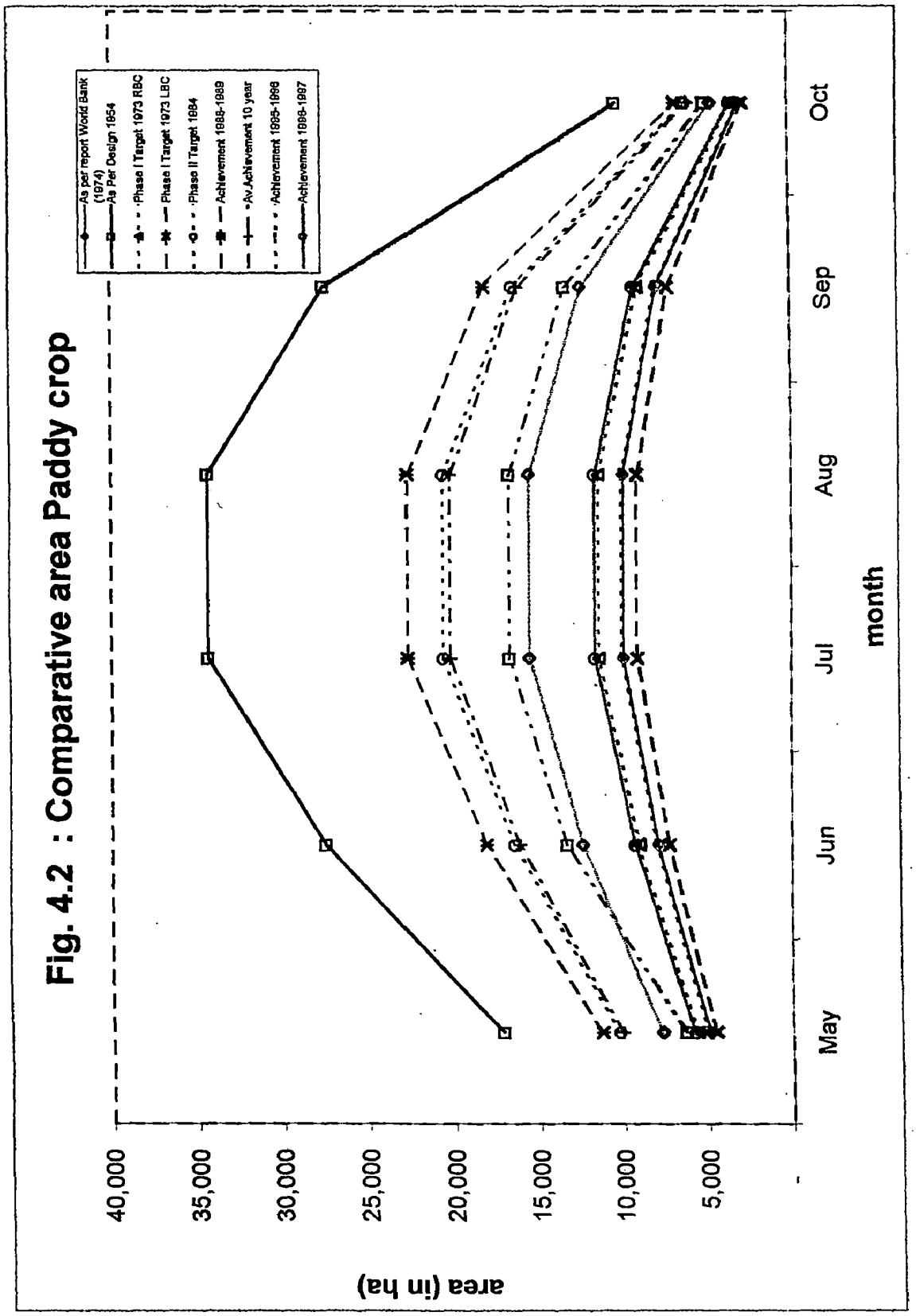


Fig. 4.2 : Comparative area Paddy crop
As per report World Bank (1974)
As Per Design 1954
Phase I Target 1973 RBC
Phase I Target 1973 LBC
Phase II Target 1984
Achievement 1988-1989
Av.Achievement 10 year
Achievement 1995-1996
Achievement 1996-1997
area (in ha)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
May
Jun
Jul
Aug
Sep
Oct
month

CHAPTER 5

WATER SUPPLY AND UTILISATION

5.1. WATER SUPPLY

The water supply for Chambal command is derived from its three storage reservoirs. Ground water developed by shallow dug wells is used throughout the project area but mainly for domestic purposes. Little attention has been paid for conjunctive use of surface and groundwater in the command area. The reservoirs as originally envisaged were constructed with the assumption of carryover affect of storage.

Since the Jawahar Sagar has no storage, canal water at barrage is drawn from discharges after power generation from Gandhi Sagar & Ranapratap Sagar (figure – 1.1. chapter 1).

Table 5.1. shows annual inflows at Kota barrage and canal diversion from 1979 – 1980 to 1988 – 1989 for which data were available on annual basis. Water availability is much more than annual releases or allocation. Figure 5.1. is graphical depiction of data in table 5.1. Actual canal diversion as percentage of inflow at Kota barrage in different years are also shown in table 5.1. It was lowest in the year 1984 – 1985 (69 %) and highest in 1980-1981 (94 %).

Annual diversion capacities of canal are :

- Left Bank Canal (Rajasthan) 42.5 cumecs = 1340.28 MCM/year
- Right Bank Canal (Rajasthan) 78.1 cumecs = 2462.96 MCM/year
- Right Bank Canal (M.P) 110.52 cumecs = 3485.36 MCM/year

Capacity utilization on annual basis for each of these canals are also shown in table 5.1.

Capacity utilization in LBC :

It ranges from 44.36 % in 1982 – 1983 to 72.21 % in 1987 – 1988.

Capacity utilization in RBC (Rajasthan) :

It ranges from 28.08 % in 1981 – 1982 to 48.77 % in 1986 – 1987. In general the capacity utilization shows increasing trend but compared to LBC the capacity utilization in RBC has been significantly lower.

Capacity Utilization in RBC (M.P):

It ranges from 31.85 % in 1982 – 1983 to 67.43 % in 1986 – 1987. In general the capacity utilization shows increasing trend. Capacity utilization in (M.P) is higher than in Rajasthan for the Left Bank Canal.

Water Availability at Kota Barrage :

Data on storage in upstream reservoir show that Gandhi Sager has never filled to its live storage capacity during 1971 to 1989 and Ranapratap Sagar could fill upto live storage capacity only in 4 years at the end of monsoon season each year. And yet as seen from table 5.1, there has been spillage from Kota barrage which could be power release only.

The average diversion into canals in the nine years of study period is 3520.63 MCM. The main reasons for lower supply of water for irrigation could be.

- Conflict in operational requirements for power generation and irrigation.
- Reservoirs planned as carryover storage scheme mainly for power generation.

Pond level of Kota barrage was raised by 0.6 m in 1986-1987 to increase the supply in canals, mainly to RBC which was not able to take its full share of carrying capacity. As seen in figure 5.1 diversion increased compared to previous years after raising of pond level. Data for water availability at Kota barrage and actual releases into canals after 1988 – 1989 are not available to analyse the water release pattern.

As seen figure 5.1 and table 5.1 there has been considerable spillage downstream of Kota barrage. Average annual spillage was 887.52 MCM of which 500 MCM occurred in kharif season mainly on account of power releases not being fully utilized for diversion into canal.

5.2. UTILISATION OF WATER

Table 3.3 in chapter 3 depicts historical development of irrigation in terms of percent area (of CCA) of different crops placed under irrigation from 1974 – 1975 to 2000 – 2001. The results are not encouraging, seldom exceeding planned target as compared to ultimate irrigation intensity planned (Govt. of Rajasthan 1981). Extremely low utilization during kharif throughout the period has been seen while utilization during rabi is generally satisfactory.

Table 5.2 shows design water allocation in rabi and kharif seasons in original design (1954) phase I (1973) and phase II (1984). Average water supply during 1980-1989 shows that phase II target have been met in terms of supply. Seasonal water allocation have been revised in 1973, and 1984 in consideration of revision in cropping pattern. Compared to original design, allocation in phase I were significantly increased for rabi season both in RBC and LBC. However these were reduced in phase II target. There might have been further revisions particularly in Chambal command drainage project component. Allocation in 1995 and 1999 are based on estimated data (Shah 1990). Kharif targets in RBC and LBC have been enhanced. Average performance in terms of seasonal water supply during 1980-1989 suggests that kharif targets can be met only through proper regulation of power releases.

5.3. COMPARISON OF WATER DEMAND AND CANAL CAPACITY

Monthly water demand at head of LBC and RBC have been worked out in chapter 4 for different cropping pattern. These demands were compared with carrying capacity of the canals in monthly volume units (Table 4.28 and Table 4.29 in chapter 4).

Capacity of RBC (Rajasthan)is found to be significantly larger than the demand in all months and in all the years. On the other hand capacity of LBC is found to be inadequate to meet increased demand in recent years during rabi season.

Inadequacy of capacity with respect to demand based in results on table 4.28 and table 4.29 of chapter 4 are given below for the LBC.

Table 5.3 : INADEQUANCY OF CANAL CAPACITY IN LBC

		Feb	Jun	Aug	Oct
1984	Demand (MCM)	145.3	-	-	116.4
	Capacity (MCM)	102.8	-	-	113.8
1996-1997	Demand (MCM)	-	-	-	115.7
	Capacity (MCM)	-	-	-	113.8
1997-1998	Demand (MCM)	-	141.9	114.5	118.1
	Capacity (MCM)	-	110.2	113.8	113.8

Rabi demand in recent years has increased

Conjunctive use of groundwater or irrigation priority releases from upstream reservoirs in deficit months is necessary so as to increase irrigated crop area.

5.4. COMPARISON OF WATER DEMAND AND WATER SUPPLY

Seasonal water supply/allocation to RBC and LBC in different years are shown in table 5.2. These have been compared with demand in table 5.4.

5.4.1. Comparison for LBC

Kharif supply/allocation is more than demand. Rabi supply/allocation is significantly higher than demand. Demand has increased in recent years and so is the allocation.

5.4.2. Comparison for RBC

Kharif supply/allocation is more than demand except in phase II and average 1980-1984 target. Rabi supply is more than demand.

Water utilization is better in rabi season compared to kharif season. Reduction in paddy area in RBC as compared to LBC is a clear evidence of water supply shortage in RBC.

The reason of failure to utilize irrigation during kharif are

- Releases in the month of May, June insufficient to meet demand.
- Inability of system to respond effectively to kharif needs at the time of peak demands.

- Lack of economic incentives from the farmer's point of view.
- Farm management difficulties such as non availability of labour, difficulty of communication and transport during monsoon season.

Kharif irrigation demand is expected to increase in the future as new technologies become available and the farmers have more suitable crops. The need of the area is to grow lesser water requiring crop in kharif. Paddy and sugarcane needs to be restricted to certain limits so as to prevent land from waterlogging.

The apparent discrepancies between water supply and demand emphasize the need to refine estimates of losses and base crop water requirements on modified PENMAN equation and realistic estimate of effective rainfall. Operational efficiency (canal release as percentage of river inflow) also plays an important roll in managing irrigation system,(table 5.1).

The following conclusions can be draw from the analysis .

- Actual water deliveries at allocations have not met design target in rabi season in RBC and LBC
- Precise demand estimation for future is unpredictable due to variation in cropping pattern.
- Crop development is not as planned. This has affected water utilization and systematic growth.
- Capacity utilization in RBC (Rajasthan) is significantly low.
- There appears to be incompatibility in operational requirements for power generation and irrigation.
- Capacity of LBC is found to be inadequate to meet, increased demand in recent years during rabi season.
- Conjumtive use of ground water in October, November and February are necessary.

Table 5.1 : INFLOW AT BARRAGE AND RELEASES (unit - Mm^3)

Sl. No.	YEAR	TOTAL INFLOW	SPILLAGE	LBC (Raj) DIVERTION	RBC (Raj) DIVERTION	RBC (M.P.) DIVERTION	TOTAL RELEASES	CANAL REL-EASEAS % OF INFLOW	CAPACITY UTILISATION		
									LBC (Rajasthan)	RBC (Rajasthan)	RBC (M.P.)
	Design estimate	4587.25									
1	1980-1981	3572.09	53.04	887.24	945.57	1686.24	3519.05	94	66.19	38.39	48.38
2	1981-1982	3452.68	575.03	717.83	690.66	1469.16	2877.65	79	53.56	28.04	42.15
3	1982-1983	3708.48	1237.00	594.54	766.97	1109.97	2471.48	72	44.36	31.14	31.85
4	1983-1984	3685.34	654.58	852.54	935.66	1242.56	3030.76	83	63.61	37.99	35.65
5	1984-1985	5241.24	1583.92	913.29	1002.24	1741.79	3657.32	69	68.14	40.69	49.97
6	1985-1986	4626.89	985.56	901.93	1146.51	1592.89	3641.33	78	67.29	46.55	45.70
7	1986-1987	6975.77	2470.92	953.66	1201.08	2350.11	4504.85	78	71.15	48.77	67.43
8	1987-1988	4373.18	269.95	967.75	1151.26	1984.22	4103.23	91	72.21	46.74	56.93
9	1988-1989	4043.13	152.71	843.54	997.31	2049.57	3890.42	91	62.94	40.49	58.80
10	1989-1990	-									
AVERAGE		4408.76	886.97	848.04	981.92	1691.83	3521.79				

Source : Report of Canal Circle, Command Area Development Authourity, Kota (Rajasthan)

Canal Capacities are 42.5 m^3/sec for LBC (Raj), 78.1 m^3/sec for RBC (Raj) and 110.52 m^3/sec for RBC (M.P)

Annual diversion capacities are 1340.28 MCM for LBC (Raj), 2462.96 MCM for RBC (Raj) and 3485.36 MCM for RBC (MP)

Table 5.2 : SEASONAL WATER SUPPLY TO LBC AND RBC (MCM)

		Original 1954	Phase I 1973	Phase II 1984	Average 1980-89	1995*	1999*
1	Inflow at Barrage	3947	4687	4687	4687	4687	4687
2	Available at Barrage	3947	4687	3643.4	3643.4	4342	4342
3	Alocation to Rajasthan	1973.5	2000	1821.7	1828.8	2171	2171
4	Seasonal Allocation/Diversion :						
a.	Right Bank Canal (RBC)						
	(i) kharif	318	263.5	226	236	242	401
	(ii) rabi	880	1074.5	710	746.51	854	768
b.	Left Bank Canal (LBC)						
	(i) kharif	221	218	320	326.4	363	465
	(ii) rabi	495	876.3	532	534.5	763	613

(*) Taken as estimated in shah 1990 as actual data not available

Table 5.4 : COMPARISON OF WATER SUPPLY AND DEMAND (MCM)

	Original 1954	Phase I 1973	Phase II 1984	Average 1980-89	1995*	1999*
LEFT BANK CANAL						
Kharif Supply	221	218	320	326.6	363	465
Kharif Demand	221.52	159.57	368.19	209.27	111.76	165.34
Rabi Supply	495	876.3	532	534.5	763	616
Rabi Demand	355.76	407.07	452.55	430.22	500.72	533.06
RIGHT BANK CANAL						
Kharif Supply	318	263.5	226	236	242	401
Kharif Demand	275.81	148.8	458.43	260.57	139.15	205.86
Rabi Supply	880	1079.5	710	746.5	854	768
Rabi Demand	442.96	277.22	563.47	535.67	623.44	663.71

Note : Demand for 1954, 1973, 1984 corespond to design water requirement as per design cropping pattern

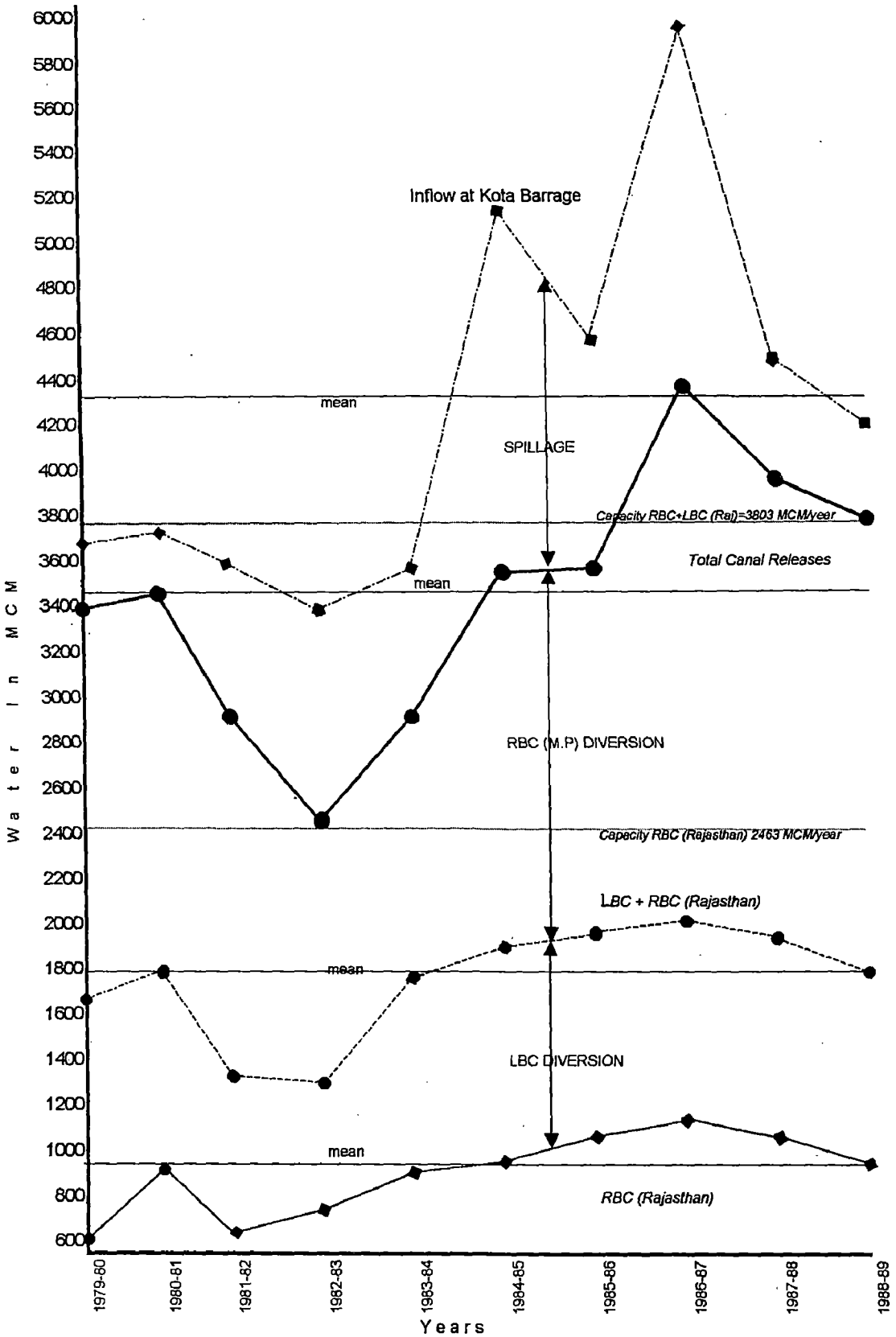


Fig. 5.1 : Inflow at Barrage and Releases in Canal

CHAPTER 6

SUMMARY AND CONCLUSIONS

The Chambal Project on river Chambal in India consists of Gandhi Sagar, Ranapratap Sagar and Jawahar Sagar dams for power generation and Kota barrage for irrigation in left bank and right bank command areas. The right bank canal supplies irrigation water to command area in Madhya Pradesh and Rajasthan whereas left bank canal serves command area in Rajasthan only.

The project construction began in 1953 and irrigation water was made available to farmers in 1960. In the present study only irrigation aspect of the project corresponding to command area in Rajasthan has been considered.

The project was scheduled to provide full benefits by 1968. However very shortly after commencement of irrigation in 1960, the Chambal command faced many problems and irrigation potential could not be utilized as planned.

This study was taken up with the following objectives.

- Analysis of agroclimatic characteristics of the command area as relevant to irrigated agriculture.
- Analysis of changes in cropping pattern and growth of irrigation water demand over different period.
- Analysis of irrigation supply and water utilization.

Agroclimatic Study :

Average monthly climatic parameters were compared for two periods 1931 to 1960 and 1960 to 1987. There has been increase in monthly evaporation particularly in the month of April, May and June. Average rainfall in monsoon months has decreased.

Reference crop evapotranspiration and for wheat, sugarcane, paddy crops have been computed by five different methods viz Blaney Criddle, Modified Penman, Radiation, Thornthwaite and Pan Evaporation. All these methods show peak values in May and October.

Rainfall pattern is erratic according to IMD Criteria. Coefficient of variability is 158 % in December (maximum) and 80 % in March (minimum).

Agroclimatic densification of the Chambal command according to different criteria is as shown below:

1. Thornthwaite's Classification	Semi arid
2. Krishnan and Singh's method	Semi dry
3. Hargreaves classification	Moderately deficient moisture
4. World Bank method	Semi arid

The area is agroclimatically suitable for crops such as sorghum, maize, oilseeds. Rice and sugarcane are not suitable in the area.

Analysis of Cropping Pattern :

Prior to introduction of irrigation in 1960, generally sorghum, maize, til (oilseed), groundnut etc. were grown in kharif and wheat, linseed, gram were grown in rabi season. Design cropping pattern in 1954 required paddy as main kharif crop (15 %) and wheat as main rabi crop (53 %) CCA of Chambal project is 229000 ha. The design cropping pattern has been revised three times since the original design cropping pattern in 1954. the revision look place in 1973 (phase I of CAD), 1983 (phase II of CAD) and 1989 (Drainage Project). Cropping patterns in different periods have been compared in table 3.2. The major deviation during entire period of analysis (upto 2001) are shown below:

1. The design cropping pattern had been revised three times from the original design cropping pattern of (1954). The revision took place in 1973(phase I of CAD), 1983 phase II of CAD, 1989 (Drainage Project) , cropping pattern revision having been influenced by actual development which took place. However, no effort appears to have been made to critically examine reasons for wide variation in cropping pattern
2. The area under paddy has never achieved the original design target of 15 % except in 1974-1980 . Therefore this has in turn reduced the net irrigation requirement but at the same time system efficiency has also gone down . Sugarcane crop also could not achieve substantial growth. Sorghum and maize have almost disappeared in recent years.

3. Kharif cropping pattern has shown major short fall in the entire span of 40 years.
4. The area under wheat has remained below original design target of 53 %. However in recent years it has shown increasing trend from 1993-1994 onward and exceeding the target from 1998-1999 onward.
5. Increase in rabi oilseed was seen from 1982-1983 to 1993-1994 but afterward it has been declining. Oilseeds are low water requiring crops and farmers are getting higher net return. Soyabean in kharif and mustard in rabi are the major oilseed crops of the area now. These crops were not proposed in original cropping pattern. Gram and pulses have shown declining trend throughout.

Comparative changes in Left Bank & Right Bank Canal :

The 10 years (1980-1989) average cropping pattern in LBC and RBC indicate a major deviation in paddy and rabi oilseed. The LBC has witnessed rise in paddy cultivation whereas RBC has not shown the remarkable improvement in paddy cultivation. The RBC has witnessed increase in rabi oilseed as compared to LBC. The reason for this may be attributed to exercising regulatory control of LBC

Total CCA is 229 thousand ha, out of which LBC command area is 102 thousand ha and RBC command area is 127 thousand ha . Table 3.4 shows average cropping pattern over a 10 year period from 1980 to 1989 in the LBC and RBC command areas. Table 3.5 shows design cropping pattern in these two command area in the phase I of command area development programme.

Crop water requirement and Irrigation Demand :

Reference crop evapotranspiration has been computed by various methods as explained in Chapter 2. For computation of irrigation water demand in this chapter, Pan evaporation data and Hargreave's method has been adopted to find crop water requirement of the 13 crops. Computations are shown in Table 4.3 to Table 4.15.

Literature study (Shah 1990,IBRD 1974) shows that areas under a particular crop are different in different months as sowing/planting periods depend on farmers choice, reliability of water, availability of ground water as alternative source and several other factors. Therefore, instead of assuming area of a particular crop to be same in different

months from sowing to harvesting, crop area coefficients have been used. Crop area coefficient have been worked out for thirteen selected crops based on past trends and are shown in Table 4.16.

Monthly gross irrigation requirement in volume unit have been computed for various cropping pattern in different years .

- Cropping Pattern as per design I 1954 — Table 4.17
- Cropping Pattern in phase I RBC — Table 4.18
- Cropping Pattern in phase I LBC — Table 4.19
- Cropping Pattern in phase II — Table 4.20
- Ten Year average Crop Pattern — Table 4.21
- Cropping Pattern in 1988 - 1989 — Table 4.22
- Cropping Pattern in 1945 - 1996 — Table 4.23
- Cropping Pattern in 1996 - 1997 — Table 4.24
- Cropping Pattern in 1997 - 1998 — Table 4.25
- Cropping Pattern in 1998 - 1999 — Table 4.26

Water demand at head of RBC and LBC have been worked out on proportionate command area basis for design crop pattern, phase II actual in 1988 – 1989, 1995-1996, 1996-1997, 1997-1998, 1998-1999 as separate cropping pattern for these commands were not available. For phase I and 10 year average condition, cropping patterns were available for LBC and RBC separately.

Comparison of demand in recent years (1995 to 1999) with demand in previous years shows that water demand has increased in September, October, November months.

Compared with original design (1954) demand in recent years have significantly increased in all months.

Demand corresponding to phase II target are higher than for other targets. Compared with original design (1954) demand in recent years have significantly increased in all months.

In contrast to capacity of LBC, the capacity of RBC is found to be significantly larger than the demand.

Water Supply and Utilization :

Annual water availability at Kota barrage and water supply / allocation to RBC and LBC have been analysed. Water demand as worked out in chapter 3 water compared with canal capacity and with water supply / allocation.

- Actual water deliveries and allocations have not met design target in rabi season in RBC and LBC
- Precise demand estimation for future is unpredictable due to variation in cropping pattern.
- Crop development is not as planned. This has affected water utilization and systematic growth.
- Capacity utilization in RBC (Rajasthan is significantly low.
- There appears to be incompatibility in operational requirements for power generation and irrigation.
- Capacity of LBC is found to be inadequate to meet increased demand in recent years during rabi season. Conjunctive use of ground water in October, November and February are necessary

CONCLUSIONS:

1. Monthly rainfall in the command area have high coefficient of variability in all months (more than 80 %).

2. The area is classified as semi arid with moderately deficit moisture availability. Rice and sugarcane crops are not suitable for the area. These high water consuming crops should not be grown in the command area.

3. Design cropping patterns have been revised several times having been influenced by actual development of cropping pattern. Actual cropping pattern as witnessed over the past 40 years also show wide variation. It is necessary to critically examine such wide variation. Target crop areas are high but actual achievement are low.

4. The area under paddy and sugarcane have not achieved design target. Sorghum and maize have disappeared in recent years. Kharif cropping pattern has shown major short fall in entire span of 40 years. Wheat area has shown rising trend from 1993-1994 onward, Soyabean in kharif and mustard in rabi are the major oilseed crops showing rising trend from 1982-1983 to 1993-1996 but declining afterward.

5. With change in cropping pattern, irrigation water demand has also been changing.

   - Water demand in recent years has significantly increased in all months particularly in rabi season.

   - Whereas RBC has adequate canal capacity, the capacity of LBC is found to be inadequate mainly in October.

   - Compared to available design capacity of RBC, the demand has been significantly low resulting in poor utilization of capacity.

6. Water availability at Kota barrage is governed by releases from upstream "carry over" reservoir. These releases are according to power generation schedule. Low water utilization in kharif and spillage occurring downstream of Kota barrage suggest that in certain critical months of kharif season (May,June) water available at Kota barrage is not as per irrigation requirement particularly in RBC resulting in decrease in paddy area.

7. Water utilization is better in rabi season compared to kharif season.

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Table 9 Saturation Vapour Pressure (ea) in mbar as Function of Mean Air Temperature (T) in °C ¥

Temperature °C	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
ea mbar	6.1	6.6	7.1	7.6	8.1	8.7	9.3	10.0	10.7	11.5	12.3	13.1	14.0	15.0	16.1	17.0	18.2	19.4	20.6	22.0

Temperature °C	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
ea mbar	23.4	24.9	26.4	28.1	29.8	31.7	33.6	35.7*	37.8*	40.1*	42.4	44.9	47.6	50.3	53.2	56.2	59.4	62.8	66.3	69.9

¥ Also actual vapour pressure (ed) can be obtained from this table using available Tdewpoint data.
(Example: Tdewpoint is 18°C; ed is 20.6 mbar)

Table 10 Extra-terrestrial Radiation (Ra) expressed in equivalent evaporation in mm/day

Northern Hemisphere												Lat	Southern Hemisphere											
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
6.4	8.6	11.4	14.3	16.4	17.3	16.7	15.2	12.5	9.6	7.0	5.7	40°	17.9	15.7	12.5	9.2	6.6	5.3	5.9	7.9	11.0	14.2	16.9	18.3
6.9	9.0	11.8	14.5	16.4	17.2	16.7	15.3	12.8	10.0	7.5	6.1	38	17.9	15.8	12.8	9.6	7.1	5.8	6.3	8.3	11.4	14.4	17.0	18.3
7.4	9.4	12.1	14.7	16.4	17.2	16.7	15.4	13.1	10.6	8.0	6.6	36	17.9	16.0	13.2	10.1	7.5	6.3	6.8	8.8	11.7	14.6	17.0	18.2
7.9	9.8	12.4	14.8	16.5	17.1	16.8	15.5	13.4	10.8	8.5	7.2	34	17.8	16.1	13.5	10.5	8.0	6.8	7.2	9.2	12.0	14.9	17.1	18.2
8.3	10.2	12.8	15.0	16.5	17.0	16.8	15.6	13.6	11.2	9.0	7.8	32	17.8	16.2	13.8	10,9	8.5	7.3	7.7	9.6	12.4	15.1	17.2	18.1
8.8	10.7	13.1	15.2	16.5	17.0	16.8*	15.7	13.9	11.6	9.5	8.3	30	17.8	16.4	14.0	11.3	8.9	7.8	8.1	10.1	12.7	15.3	17.3	18.1
9.3	11.1	13.4	15.3	16.5	16.8	16.7	15.7	14.1	12.0	9.9	8.8	28	17.7	16.4	14.3	11.6	9.3	8.2	8.6	10.4	13.0	15.4	17.2	17.9
9.8	11.5	13.7	15.3	16.4	16.7	16.6	15.7	14.3	12.3	10.3	9.3	26	17.6	16.4	14.4	12.0	9.7	8.7	9.1	10.9	13.2	15.5	17.2	17.8
10.2	11.9	13.9	15.4	16.4	16.6	16.5	15.8	14.5	12.6	10.7	9.7	24	17.5	16.5	14.6	12.3	10.2	9.1	9.5	11.2	13.4	15.6	17.1	17.7
10.7	12.3	14.2	15.5	16.3	16.4	16.4	15.8	14.6	13.0	11.1	10.2	22	17.4	16.5	14.8	12.6	10.6	9.6	10.0	11.6	13.7	15.7	17.0	17.5
11.2	12.7	14.4	15.6	16.3	16.4	16.3	15.9	14.8	13.3	11.6	10.7	20	17.3	16.5	15.0	13.0	11.0	10.0	10.4	12.0	13.9	15.8	17.0	17.4
11.6	13.0	14.6	15.6	16.1	16.1	16.1	15.8	14.9	13.6	12.0	11.1	18	17.1	16.5	15.1	13.2	11.4	10.4	10.8	12.3	14.1	15.8	16.8	17.1
12.0	13.3	14.7	15.6	16.0	15.9	15.9	15.7	15.0	13.9	12.4	11.6	16	16.9	16.4	15.2	13.5	11.7	10.8	11.2	12.6	14.3	15.8	16.7	16.8
12.4	13.6	14.9	15.7	15.8	15.7	15.7	15.7	15.1	14.1	12.8	12.0	14	16.7	16.4	15.3	13.7	12.1	11.2	11.6	12.9	14.5	15.8	16.5	16.6
12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5	12	16.6	16.3	15.4	14.0	12.5	11.6	12.0	13.2	14.7	15.8	16.4	16.5
13.2	14.2	15.3	15.7	15.5	15.3	15.3	15.5	15.3	14.7	13.6	12.9	10	16.4	16.3	15.5	14.2	12.8	12.0	12.4	13.5	14.8	15.9	16.2	16.2
13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	8	16.1	16.1	15.5	14.4	13.1	12.4	12.7	13.7	14.9	15.8	16.0	16.0
13.9	14.8	15.4	15.4	15.1	14.7	14.9	15.2	15.3	15.0	14.2	13.7	6	15.8	16.0	15.6	14.7	13.4	12.8	13.1	14.0	15.0	15.7	15.8	15.7
14.3	15.0	15.5	15.5	14.9	14.4	14.6	15.1	15.3	15.1	14.5	14.1	4	15.5	15.8	15.6	14.9	13.8	13.2	13.4	14.3	15.1	15.6	15.5	15.4
14.7	15.3	15.6	15.3	14.6	14.2	14.3	14.9	15.3	15.3	14.8	14.4	2	15.3	15.7	15.7	15.1	14.1	13.5	13.7	14.5	15.2	15.5	15.3	15.1
15.0	15.5	15.7	15.3	14.4	13.9	14.1	14.8	15.3	15.4	15.1	14.8	0	15.0	15.5	15.7	15.3	14.4	13.9	14.1	14.8	15.3	15.4	15.1	14.8

Table 11 Mean Daily Duration of Maximum Possible Sunshine Hours (N) for Different Months and Latitudes

Northern Latitudes / Southern Latitudes	Jan / July	Feb / Aug	Mar / Sept	Apr / Oct	May / Nov	June / Dec	July / Jan	Aug / Feb	Sept / Mar	Oct / Apr	Nov / May	Dec / June
40	9.6	10.7	11.9	13.3	14.4	15.0	14.7	13.7	12.5	11.2	10.0	9.3
35	10.1	11.0	11.9	13.1	14.0	14.5	14.3	13.5	12.4	11.3	10.3	9.8
30	10.4	11.1	12.0	12.9	13.6	14.0	13.9*	13.2	12.4	11.5	10.6	10.2
25	10.7	11.3	12.0	12.7	13.3	13.7	13.5	13.0	12.3	11.6	10.9	10.6
20	11.0	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
15	11.3	11.6	12.0	12.5	12.8	13.0	12.9	12.6	12.2	11.8	11.4	11.2
10	11.6	11.8	12.0	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5
5	11.8	11.9	12.0	12.2	12.3	12.4	12.3	12.3	12.1	12.0	11.9	11.8
0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0

Table 12 Effect of Temperature f(T) on Longwave Radiation (Rnl)

T°C	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36
$f(T) = \delta Tk^4$	11.0	11.4	11.7	12.0	12.4	12.7	13.1	13.5	13.8	14.2	14.6	15.0	15.4	15.9	16.3*	16.7	17.2	17.7	18.1

Table 13 Effect of Vapour Pressure f(ed) on Longwave Radiation (Rnl)

ed mbar	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
$f(ed) = 0.34 - 0.044\sqrt{ed}$	0.23	.22	.20	.19	.18	.16	.15	.14	.13*	.12	.12	.11	.10	.09	.08	.08	.07	.06

Table 14 Effect of the Ratio Actual and Maximum Bright Sunshine Hours f(n/N) on Longwave Radiation (Rnl)

n/N	0	.05	.1	.15	.2	.25	.3	.35	.4	.45	.5	.55	.6	.65	.7	.75	.8	.85	.9	.95	1.0
$f(n/N) = 0.1 + 0.9n/N$	0.10	.15	.19	.24	.28	.33	.37	.42	.46	.51	.55	.60	.64	.69	.73	.78	.82*	.87	.91	.96	1.0

Table 15 Values of Weighting Factor (W) for the Effect of Radiation on ETo at Different Temperatures and Altitudes

Temperature °C	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
W at altitude m																				
0	0.43	.46	.49	.52	.55	.58	.61	.64	.66	.69	.71	.73	.75	.77*	.78	.80	.82	.83	.84	.85
500	.45	.48	.51	.54	.57	.60	.62	.65	.67	.70	.72	.74	.76	.78	.79	.81	.82	.84	.85	.86
1000	.46	.49	.52	.55	.58	.61	.64	.66	.69	.71	.73	.75	.77	.79	.80	.82	.83	.85	.86	.87
2000	.49	.52	.55	.58	.61	.64	.66	.69	.71	.73	.75	.77	.79	.81	.82	.84	.85	.86	.87	.88
3000	.52	.55	.58	.61	.64	.66	.69	.71	.73	.75	.77	.79	.81	.82	.84	.85	.86	.88	.88	.89

Table 16 Adjustment Factor (c) in Presented Penman Equation

	RHmax = 30%				RHmax = 60%				RHmax = 90%			
Rs mm/day	3	6	9	12	3	6	9	12	3	6	9	12
Uday m/sec	Uday/Unight = 4.0											
0	.86	.90	1.00	1.00	.96	.98	1.05	1.05	1.02	1.06	1.10	1.10
3	.79	.84	.92	.97	.92	1.00	1.11	1.19	.99	1.10	1.27	1.32
6	.68	.77	.87	.93	.85	.96	1.11	1.19	.94	1.10	1.26	1.33
9	.55	.65	.78	.90	.76	.88	1.02	1.14	.88	1.01	1.16	1.27
	Uday/Unight = 3.0											
0	.86	.90	1.00	1.00	.96	.98	1.05	1.05	1.02	1.06	1.10	1.10
3	.76	.81	.88	.94	.87	.96	1.06	1.12	.94	1.04	1.18	1.28
6	.61	.68	.81	.88	.77	.88	1.02	1.10	.86	1.01	1.15	1.22
9	.46	.56	.72	.82	.67	.79	.88	1.05	.78	.92	1.06	1.18
	Uday/Unight = 2.0											
0	.86	.90	1.00	1.00	.96	.98	1.05	1.05	1.02	1.06	1.10	1.10
3	.69	.76	.85	.92	.83	.91	.99*	1.05*	.89	.98	1.10*	1.14*
6	.53	.61	.74	.84	.70	.80	.94	1.02	.79	.92	1.05	1.12
9	.37	.48	.65	.76	.59	.70	.84	.95	.71	.81	.96	1.06
	Uday/Unight = 1.0											
0	.86	.90	1.00	1.00	.96	.98	1.05	1.05	1.02	1.06	1.10	1.10
3	.64	.71	.82	.89	.78	.86	.94*	.99*	.85	.92	1.01*	1.05*
6	.43	.53	.68	.79	.62	.70	.84	.93	.72	.82	.95	1.00
9	.27	.41	.59	.70	.50	.60	.75	.87	.62	.72	.87	.96

Table 2: Monthly crop coefficient (K) to obtain consumptive use estimate from USWB class 'A' pan evaporation value (semi-arid region)

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Berseem	0.71	0.77	0.66	0.59	—	—	—	—	—	—	0.60	0.61
Cotton	—	—	—	0.09	0.13	—	—	—	—	—	—	—
Maize	—	—	—	—	—	—	—	—	—	—	—	—
Onion	0.42	0.45	0.72	0.51	0.18	0.33	—	—	—	—	—	—
Pea	0.50	—	—	—	—	—	—	—	—	—	—	—
Potato	1.21	0.37	—	—	—	—	—	—	—	0.14	0.29	1.42
Paddy (dry)	—	—	—	—	—	—	1.09	1.48	1.36	1.13	—	—
Paddy (wet)	—	—	—	—	—	—	0.95	0.79	0.11	0.00	—	—
Sugar cane	0.46	0.37	0.15	0.34	0.36	0.37	0.56	0.65	0.46	0.39	0.32	—
Tobacco	—	—	0.15	0.49	0.27	—	—	—	—	—	—	—
Tomato	—	—	—	0.31	0.31	0.26	0.31	—	—	—	—	—
Wheat (D)	0.62	0.70	0.69	0.30	—	—	—	—	—	—	—	0.65
Wheat (T)	0.83	0.75	0.85	—	—	—	—	—	—	—	0.16	0.54
Sunflower	0.75	0.70	0.49	0.18	—	—	—	—	—	—	0.36	0.38
Safflower	0.83	0.65	0.43	0.20	—	—	—	—	—	—	0.11	0.61
Linseed	1.33	1.00	0.49	—	—	—	—	—	—	—	0.16	0.58
Mustard	1.12	0.82	0.17	—	—	—	—	—	—	—	0.27	0.69
Lentil	0.54	0.52	0.55	—	—	—	—	—	—	—	0.20	0.38

Table 3: Monthly crop coefficient (K) to obtain consumptive use estimate by Blaney-Criddle equation (semi-arid region)

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Berseem	0.49	0.79	0.86	1.08	0.74	—	—	—	—	—	0.77	0.46
Cotton	—	—	—	0.16	0.26	0.67	—	—	—	—	—	—
Maize	—	—	—	—	—	—	0.68	0.89	0.67	—	—	—
Onion	0.29	0.46	0.95	0.93	0.37	—	—	—	—	—	—	—
Potato	0.83	0.38	—	—	—	—	—	—	—	0.17	0.31	1.06
Sugar cane	0.31	0.38	0.32	0.62	0.72	0.76	0.78	0.67	0.57	0.46	0.34	0.31
Tobacco	—	—	0.32	0.90	0.55	—	—	—	—	—	—	—
Tomato	—	—	—	0.57	0.62	0.54	0.29	—	—	—	—	—
Wheat (D)	0.43	0.71	0.90	0.54	—	—	—	—	—	—	—	0.49
Wheat (T)	0.57	0.76	1.11	—	—	—	—	—	—	—	0.17	0.40
Sunflower	0.51	0.71	0.64	0.33	—	—	—	—	—	—	0.39	0.46
Safflower	0.57	0.66	0.56	0.36	—	—	—	—	—	—	0.12	0.46
Linseed	0.91	1.02	0.64	—	—	—	—	—	—	—	0.17	0.43
Mustard	0.77	0.84	0.22	—	—	—	—	—	—	—	0.29	0.51
Lentil	0.37	0.53	0.72	—	—	—	—	—	—	—	0.22	0.29

Reference : Crop Water Management Research by Th.J. Bredero Oxford & IBH Publishing Co. New Delhi 1991