SR-8

HYDROLOGICAL ASPECTS OF DROUGHT IN 1985-86

(an interim report)

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SUMMARY

National Institute of Hydrology established a Drought Studies Division in February 1986 with the major objective to study the hydrological aspects of drought and develop both short and long term drought management strategies. In view of the gravity of the drought situation during 1985-86, the Institute sent-out scientific and technical teams to the States of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Rajasthan to acquaint with the drought situation and to collect necessary data and information for drought studies with emphasis on hydrological aspects. Due to limited time, only selected drought prone districts could be covered. Efforts were made to collect the required data for last 8 to 10 years including the latest ones for 1985-86. However, data in respect of the year 1985-86 could not become available for all the places. Therefore, the data of few selected sites have been used to demonstrate the hydrological aspects of drought and to emphasize their significance in analysing the drought situation of a particular area. On the basis of limited available data and preliminary analysis some interim conclusions have been made which perhaps may not be generalised for all the areas.

The rainfall patterns of 1984 and 1985 over drought affected meteorological sub-divisions indicate that Saurashtra region had maximum rainfall deficit during the monsoon of 1985 which was of the order of 55% as against 12% in 1984. Maharashtra had monsoon deficit of the order of 30% to 40%. In Karnataka both South-West and North-East monsoons failed during 1985 resulting in severe drought situ-

ation. Telangana and Rayalseema region of Andhra Pradesh continue to have rainfall deficits of about 30%. The categorisation of districts on the basis of this year's and last year's rainfall deficits indicates that in a number of districts there was persistent effect of deficit. Mahboobnagar in Andhra Pradesh appears to be having deficit for the last 3 years in succession, Prakasam and Cuddapah for the last 2 years in succession In Gujarat except the Kutch, most of the areas had a deficit of about 40% to 50% in 1985. Due to non-availability of rainfall data in Karnataka for the past few years, no comparative study could be made. In Madhya Pradesh Dhar, Jhabua, Betul & Shahdol recorded a rainfall deficit of about 30% to 40% in 1985 whereas Khargon is having rainfall deficit for the second year in succession. In Maharashtra 11 districts-Nasik, Ahmednagar, Solapur, Sangli, Aurangabad, Jalna, Parbhani, Beed, Nanded, Osmanabad and Latur are having persistent rainfall deficits for the last 2 years in succession. In Rajasthan, Tonk, Jodhpur and Barmer also recorded rainfall deficits for the second year in succession.

In Andhra Pradesh, data of two reservoirs, Pedderu and Bahuda in Chittoor district indicate relatively lower reservoir levels during end of 1985 and beginning of 1986 as compared to their corresponding levels of past few years. However, the rainfall deficit in Chittoor appears to be less than 20%. In Gujarat, the data of surface water storages for Saurashtra region indicate significant reductions during 1985 causing irrigation and drinking water problems. Surface water storages in Rajkot, Jamnagar and Amreli were so poor that no area was irrigated. Rainfall deficit during monsoon was of the order of 25-50% in these areas except Amreli where it was less than 20%.

In Karnataka, Malaprabha reservoir was affected in 1985 drought whereas Ghataprabha reservoir appears to have sufficient water. The flow data of Bhima and Sina (tributaries of Krishna) in Maharashtra indicate significantly low flows during 1985 as compared to previous years. The available water in the major and medium irrigation tanks in Maharashtra confirms the severe drought situation. The deficit in reservoir storage (available water as percentage of designed live storage capacity) of the order of 70% to 80% has been observed in some of the districts in Maharashtra which by and large had rainfall deficit also for the second year in succession. Similar trends were observed in Madhya Pradesh and Rajasthan. The tanks located at Dungarpur, Banswara and Jodhpur in Rajasthan had significantly more deficit during 1985. Based on various observations it can be deduced that the deficit in reservoir storages is caused not only due to failure of monsoon in current year but also due to lack of the carryover-storage from the previous years.

The groundwater levels in Prakasam district of Andhra Pradesh show decreasing trends in accordance with the decreasing rainfall trends. However, well-hydrographs in few blocks of Anantpur, Chittoor and Cuddapah districts do not show significant decreasing trends. It is inferred that this might be due to the increased abstraction of groundwater as a result of which the system is tending to adjust to a new equilibrium. Groundwater in western Madhya Pradesh is also observed to be affected. The premonsoon levels in the wells located in districts Dhar and Jhabua show drying of wells. The post-monsoon levels are observed to go down progressively with each year indicating insufficient recharge. In Maharashtra, the lowering of groundwater tables and the problem of wells going dry during 1985 is evident from

the data of Beed and Ahmednagar which are facing rainfall deficits for the second consecutive year. Data for other districts could not be obtained. No conclusion can be drawn about Gujarat and Rajasthan as data were not readily available. Soil moisture data of sufficient magnitude and duration were not available to draw pertinent conclusions. In general there was acute shortage of drinking water and fodder in drought prone areas. No definite conclusions can be made for want of data. Crop production in general was affected during the Kharif and Rabi 1985-86. This is observed from the crop yields estimates of different States.

The report also concludes that it is not sufficient to go by the variability in total amount of rainfall alone but also to analyse and understand the time and space variability in the surface runoff streamflow, soil moisture conditions and ground water levels as well as the demand patterns to appreciate the very nature of impact that a drought situation causes. It is also suggested to have proper data base, regular hydrological monitoring viz-a-viz drought monitoring and soil moisture monitoring on regular basis.

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1.0 INTRODUCTION

Drought is a dreadfully familiar word whose references can be easily found in our scriptures and other records of antiquity. Hardly do we appear to be overcoming the blows of a serious drought when another probably more vicious, strikes us tending to throw out of gear our careful economic planning and strategies. It is generally viewed as a sustained and regionally extensive occurrence of below precipitation, soil moisture, river runoff or groundwater. The variation of rainfall in India over space and time has created conditions that about one third of the geographical area and 29% of the population of the country are affected by drought.

The occurrence of drought leads to depletion of soil moisture, reduction in stream-flow and consequent reservoir and tank levels and depletion of ground water. This on a continued basis leads to reduced domestic and industrial water supply, reduced availability of fodder and decline in agricultural production.

The drought characteristics and problems posed by droughts vary from area to area, depending upon the amount of variability of available water supplies and the demand of water for specified users. The drought studies done so far have mainly concentrated on meteorological aspects and to some extent agricultural aspects. The hydrological aspects of drought are poorly understood and have not been scientifically studied. In order to understand the hydrological aspects of drought and its consequences on water supply, availability of fodder and agricultural production, the drought management strategies have to be developed both as short term and long term measures. There is a need to take up systematic drought studies in a coordinated and integrated manner following interdisciplinary approach.

In view of the recurrent drought in many States of the country and looking into the gravity of the problem, the National Institute of Hydrology established a Drought Studies Division in February 1986. The Division objectives are:

1. To coordinate the results of the on-going studies relating to various aspects of drought carried out in the country, to prepare a comprehensive information system.

2. Develop drought indices, establish norms for drought identification and quantification under different situations.

3. To carry out detailed studies in different regions of the country for assessment of drought impacts.

4. To carry out studies and research at national and regional levels on Hydrological Aspects of drought on long term and short term basis, and develop drought management strategies including preparedness in the case of impending drought.

The drought situation in India has been unprecendented as drought looms over many States and mainly in the States of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa and Rajasthan.

In view of the gravity of the drought situation, the Institute sent out scientific and technical teams to the States of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Rajasthan to acquaint with the drought situation and to collect necessary data and information for drought studies with emphasis on hydrological aspects. Due to limited time, only selected drought affected districts were visited by these teams. Efforts have been made to collect data for the last 8-10 years including data for 1985-86.

In order to exchange views and information and also measures adopted in different States, a National Seminar on Drought Management

Strategies was organised at Mysore on May 15-16, 1986 by Government of Karnataka and sponsored by the National Committee on Hydrology and the National Institute of Hydrology, in addition to the State of Karnataka. This Seminar was inaugurated by the Union Minister for Water Resources and presided over by the Minister-in-Charge of Irrigation, Government of Karnataka.

The scope of this Interim Report is limited to a preliminary study of the situation and analysis of hydrological aspects of drought for 1985-86. This report presents the data collected and analysed and demonstrates its application for studying hydrological aspects of drought in terms of deficit in rainfall, deficit in surface water supply, deficit in ground water storage and soil moisture. The report in a limited way also deals with effect of water deficit for water supply, fodder and crop production; and brings out interim conclusion and further studies are in progress.

2.0 CHARACTERISTICS OF HYDROLOGICAL DROUGHT

There are processes within the hydrological cycle which act over the time scale to cause water deficiency. Within the drought areas there are localities which are hard hit by drought and are affected persistently whereas others are relatively spared. There are examples where space and time hetrogenity of the climatic situation has affected the drought situation resulting in lesser water being available in rivers, ground water recharge and soil moisture for crop production.

Hydrological drought is an aspect of the total hydrological cycle and is affected by some degree of persistence because of the inertia of some processes within the cycle. Attempts to quantify and test the persistence can be considered in two ways. Using the annual rainfall or river flow data, the serial correlation can be tested to get the persistence. The other approach could be by studying the length of successive years of below average conditions. The release from the aquifer storages provides the dry weather flow to streams. Since the aquifer storages offers an inertia and is slow in the releases its hydrological response would be smoothened and may not be that clearly reflected in the persistence. Similarly Space and time variations effect the river discharge, soil moisoture and aquifer level deficiencies and would be different from point to point within the affected area. From the economical consideration this inhomogeneity in space and time is beneficial and allows the crop to survive as also makes available grass and fodder for cattle for some areas as also water supply, in ponds and wells. The recognition of the understanding of the extent of heterogenity is important in the management

of drought. The temporal variability causes not only the variation in the rainfall pattern but also results in runoff deficiency similar to the rainfall deficiency.

There is often the question asked as to whether the droughts are periodic. The study of the data has to be done on long term basis to get the reflection of this periodicity so as to be prepared for that situation. There is no well established link between droughts and sunspot cycle but there is reasonable evidence to indicate that from the droughts to occur at some particular phase of the sun spot cycle. It has been interpreted by some that a cycle of about 5-6 of 1/2 sun spot cycle may give rise to droughts.

The real indicators of the drought would be the deficit in rainfall resulting in deficit of surface water, deficit in ground water and deficit in soil moisture. These would eventually affect in a drought situation, the water supply, the availability of fodder and the crop production and can be said to be the characteristics of hydrological drought. One has to think of measures to avoid over exploitation of ground water, possibility of aquifer recharge augmentation, artificial enhancement of precipitation, reduction in evaporation and management of land, logistical and social measures for mitigating drought impacts.

3.0 DESCRIPTION OF STUDY AREA

Efforts have been made by the Institute to study the hydrological aspects of droughts in the selected drought prone areas of the various States. Scientific and technical teams of the Institute undertook visits to the State Headquarters and collected the data from various drought affected districts of the State. Discussions were held with the district level officers of various departments regarding their on going relief programmes and allied measures. The format used for data collection is given in Appendix I. The State Govt. Departments visited by the teams included Irrigation, Ground Water, Agriculture, Soil Conservation, Economics & Statistics, Revenue Board, Public Health Engineering, District Rural Development Authority etc. List of Departments contacted and the districts visited by the teams is given in Appendix II. Efforts were made to collect the required data for last 8 to 10 years including the latest ones for 1985-86. However, the data in respect of the year 1985 could not become available at all the places. Due to this reason the preliminary report on hydrological aspects of droughts has been mainly based on the hydrological variables for which data of 1985-86 is available. The data of few selected sites have been used to demonstrate the hydrological aspects of drought and to emphasise their significance in analysing the drought situation of a particular area.

In Andhra Pradesh the S.W.monsoon generally sets in from early June and lasts until about the end of September whereas the N.E.monsoon occurs from October to December. The annual average rainfall in coastal, Rayalaseema and Telangana regions is 700-1500 mm, 400-700mm, and 700-1200 mm respectively. About 60.74% area of the State is under agriculture. The total cropped area in 1983 was amounting to 46% of

and 41% of the total cropped area. Major crops of Andhra Pradesh are Jowar, Bajra, Rice, Pulses, Groundnut, Cotton, Tobacco etc.

In Gujarat the average annual precipitation over different parts of the State varies widely from 300 mm in the Western half of Kutch to 1500 mm in the Southern parts of the Valsad District and Dengs. The monsoon usually commences by the middle of June and withdraws by the end of September. Accoroding to the figures available for 1973-74 the irrigated area of Gujarat is about 15% of the total cultivated area. The soils of Gujarat can be broadly classified as : Residual loamy soils, Alluvial Deep clay soils, Alluvial clayey soils, Alluvial sandy soils, Alluvial sandy loam, Coastal littoral soils and Saline soils. Out of the total geographical area of 196 lakh ha, about 50% is under cultivation. Among the individual crops groundnut and cotton occupy the largest area which is about 20% each. Live-stock and poultry raising forms a very substantial part of the occupation of almost all the farms.

In Karnataka the Western Ghats and Mainad region receive an annual rainfall ranging from 4000 mm to 8000 mm over the Western Ghats and decreasing eastwards to about 2000 mm at the eastern edge of the region. The northern Maidan region is an extensive undulating plateau with an elevation ranging from 350 to 650 metres from the northern parts of the State and includes the districts of Bidar, Gulbarga, Bijapur, Dharwar, Bellary and Belgaum except the extreme south western parts. The annual rainfall received in this region varies from 1500 mm to 500 mm decreasing from west to east. The Southern Maidan region which includes the districts of Chitradurga, Tumkur, Kolar, Bangalore, Mandya and most of Mysore leaving the extreme south western parts and those parts of Hassan, Chikamagalur and Shimoga districts outside the

Malnad region receive an annual rainfall from 2000 mm in the western edge to about 460 mm in the eastern edge in the Chitradurga district. The State enjoys the benefits of two monsoon viz., the South West monsoon and the North East monsoon. The South-West monsoon which extends over four months from June to September contributing around 73 percent or about three fourth of the average rainfall received in the State.

In Madhya Pradesh monsoon generally breaks about in the middle of June and continues upto the end of September, with short dry spells in between. As a result, normally the norothern portion of Madhya Pradesh receives a rainfall of about 750 to 850 mm and the Malwa plateau receives 750 mm to 1250 mm annually. The hilly areas of Vindhyas and Satpuras receive rainfall of 1050 to 1750 mm whereas the Bastar plateau receives a maximum of 1600 to 1800 mm annually. The State of Madhya Pradesh has twelve agroclimatic zones. Broadly, it could be sub-divided into five major crop zones-rice zone, wheat zone, wheat-rice zone, wheat-jowar zone and cotton-jowar zone. The soil in the rice zone is mostly of red and yellow types whereas the wheat zone and the remaining crop zones have black soil of varying depths. The main crops produced in the State are wheat, Jowar, Rice, Grams, Maize, Groundnut, Sugarcane and Cotton. The major portion of State's economy is due to agriculture which involves nearly 80% of its population. Madhya Pradesh is however, much below the national average of 27.5%(as in 1983-84) in the field of irrigation. The irrigation potential in the State prior to 1950-51 was 4.6 lakh ha.whereas the target of irrigation potential at the end of the Sixth Plan is 25 lakh ha.

In Maharashtra, the coastal belt of Konkan and the windward side of the Western Ghats receive an annual rainfall of over 200 to 250 cm, rainfall decreases rapidly to less than 60 cm over the western

districts of Madhya Maharashtra. Parts of Dhule, Nasik, Pune, Satara and Solapur districts receive less than 50 cm. Marathwada receives 60-90 cm annually. The rainfall in 17 districts out of 27 in the State is 100 cm or less annually. Rainfall is more than 150 cm in many parts of Vidarbha. The soil over major part of the State to the east of the Western Ghats and to the west of eastern Vidarbha is of the medium black variety interspersed by long patches of deep black soil. East of the coastal alluvium the soil is lateritic and reddish brown lateritic and brown. While Bhandara district in the State is having shallow black soils. The land utilisation pattern reveals about 60% area is under cultivation including about 8% under irrigation, 18% under forest and remaining 22% under miscellaneous land use. The dry farming area in the State accounts for nearly 70% of the geographical area of the State. Jowar and Bajra are the principal crops followed by Wheat and Sugarcane in the interior districts. Rice is the principal crop in coastal districts.

Rajasthan receives rainfall from South-West monsoon. The duration of monsoon system in Rajasthan is hardly three months from 15th June to 15th September. There are 12 basic types of soils viz.,(i) Desert soils (ii) Desert riverive soils (iii) Alluvial serozems (iv) Gray Brown soils (v) Non-calcic brown soil(vi) Brown soils saline phase (vii) Alluvial soil recent origin (viii) Gray Brown alluvial soils (ix) Yellow brown soil (x) Red loamy (xi) Deep and medium black soils (xii) Hilly soils. Major crops of the State are Jowar, Bajara, Maize, Pulses, Wheat etc. Major source of irrigation in drought prone areas of State is through irriation tanks supplemented by groundwater.

Description of drought prone districts of various States is given in Table 3.1

TABLE 3.1 DROUGHT PRONE DISTRICTS

Sl.No.	State	Area in 1000 sq km	Population lakhs	Major rivers streams	Normal rainfall	Drought Prone Districts * in 1985	Districts in which study was done by C.W.C.**	Districts in which study is taken up by NIH	Remarks
1	2	3	4	5	6	7	8	9	10
1.	Andhra Pradesh	275	535	Godavari Krishna Vamsadhara Nagavelli Pennar	900	Anantpur Kurnool Chittoor Cuddapah Mahboobnagar Prakasam RangaReddy Nalgonda -	Anantpur Kurnool Chittoor Cuddapah Mahboobnagar Prakasam - Nalgonda Hyderabad	Anantpur - Chittoor Cuddapah Mahboobnagar Prakasam - - -	
2.	Gujarat	196	341	Tapi Narmada	350-625	Ahmedabad Rajkot Kutch Amreli Jamnagar Surendranagar Bhavnagar Panchmahals	Ahmedabad Rajkot Kutch Amreli Jamnagar Surendranagar Bhavnagar Panchmahals Banas-Kantha Kheda Bharuch Mehsana	Ahmedabad Rajkot Kutch Amreli Jamnagar Surendranagar Bhavnagar Panchmahals	

*Source : Districts declared drought-prone under DPAP during Seventh Plan.
**Source: 'Brochure on Drought -March 1982', Drought Area Study and Investigation, C.W.C. and Govt of India.

1	2	3	4	5	6	7	8	9	10
3.	Karnataka	192	371	Sharavathi	1355	Bijapur	Bijapur	Bijapur	
				Kali		Tumkur	Tumkur	Tumkur	
				Natravati		Dharwar	Dharwar	Dharwar	
				Varahi		Belgaum	Belgaum	Belgaum	
				Bedthi		Kolar	Kolar	Kolar	
				Aghanashini		Bidar	-	-	
				Krishna		Chikmaglur	Chikmaglur	-	
				Ghataprabha					
				Malaprabha		Chitradurga	Chitradurga	Chitradurga	
				Bhima					
				Tungabhadra		Gulbarga	Gulbarga	-	
				Cauvery		Bellary	Bellary	-	
				Pennar		Raichur	Raichur	-	
				Palar		-	Bangalore	-	
						-	Hassan	-	
						-	Mandya	-	
						-	Mysore	-	
4.	Madhya Pradesh	443	522	Narmada	1140	Betul	Betul	Betul	
				Mahanadi		Shahdol	Shahdol	Shahdol	
				Tapti		Khargon	Khargon	Khargon	
				Mahi		Dhar	Dhar	Dhar	
				Chambal		Jhabua	Jhabua	Jhabua	
				Betwa		Sidhi	Sidhi	Sidhi	
				Sone		-	Datia	-	
				Indrawati		-	Dewas	-	
						-	Khandwa	-	
						-	Shajapur	-	
						-	Ujjain	-	

1	2	3	4	5	6	7	8	9	10
5.	Maharashtra	308	628	Tapti Godavari Krishna	60-200	Ahmednagar Sangli Jalna Dhule Aurangabad Solapur Jalgaon Nasik Satara Beed Osmanabad Pune	Ahmednagar Sangli - - Aurangabad Solapur - Nasik Satara Beed Osmanabad Pune	Ahmednagar Sangli - - Aurangabad Solapur - Nasik Satara Beed Osmanabad Pune	
6.	Rajasthan	342	343	Chambal	59	Udaipur Dungarpur Banswara Ajmer SawaiMadhopur Tonk Kota Jhalawar - - - - - - - -	Udaipur Dungarpur Banswara Ajmer - - - - Barmer Bikaner Churu Jaisalmer Jalore Jalore Jhunjhunun Nagaur Pali	Udaipur Dungarpur Banswara Ajmer - - - - Barmer - - - - Jodhpur - -	

4.0 DEFICIT IN RAINFALL

4.1 General

The most important feature in the meteorology of India is the alternation of seasons known as the monsoons, which is largely determined by geographical position of the country and striking features of relief of land masses outside and within the country. Nearly 90% of the annual rainrfall in the country falls in the months of June to Septemberdue to South-West monsoons. Monsoon rainfall is quite erratic in space and time leading to extreme situations of floods and droughts in the country. Drought in India generally occurs when the monsoon fails. The failure of monsoon is characterised by :-

i) late onset

ii) early withdrawal and

iii) breaks in mosnoon generally during Julv and August which are the principal rainy months in the year.

Realising the importance of rainfall in the drought analysis the early studies of drought mainly took rainfall deviations from normal as a measure of drought. The meteorological drought is characterised as a situation when the rainfall is substantially below its climatological expectations. It is now realised that rainfall amount is not the only criterion but its distribution over time and space is equally important for studying drought situation. The rainfall deficit in a particular year alone may not be sufficient enough to indicate the severity of drought. Statistical analysis of long term and short term data of rainfall have also indicated presence of persistence and trends in a number of cases. The effect of continuous rainfall deficit is also an important parameter in the study of drought.

For rainfed agriculture in many parts of the country occurrence of long dry spells in the monsoon season may cause partial or total crop failure. The scientific studies of drought also require statistical analysis of daily/weekly/ monthly rainfall for idenfification of dry spells and their probabilities of occurrence.

4.2 Rainfall Pattern in Drought Affected Areas

The India Meteorological Department prepares rainfall deparutre maps for the country indicating the departure of rainfall from normal for different seasons and also on annual basis. These maps provice a good idea of general behaviour of rainfall and indicate the pattern of rainfall variation in the country. Two typical maps depicting rainfall departures from normal for monsoon seasons (June to September) for 1984-855 in different meteorological sub-divisions of India are shown in Figs.4.1 and 4.2. The annual rainfall and percentage departures from normal for the four seasons i.e. January-February,March-May,June-Sep and October-December for 14 drought affected meteorological sub-divisions for 1984 and 1985 are given in Appendix III- 1/18.

It could be seen that the rainfall departure during the monsoon season of 1985 was more than that in the 1984 monsoon season in all the sub-divisions excepting Vidarbha and Coastal Andhra Pradesh. While the deficit during 1984 monsoon season varied from 8 to 40% the deficit during 1985 varied from 7 to 56%. The extent of area with rainfall departures in the range of -20 to- 50% was less during 1984 monsoon season as compared to that for 1985 season as indicated in Figs.4.1 & 4.2. It is also seen that the Marathwada, Vidarbha,Coastal Andhra Pradesh, Telangana and Rayalaseema sub-divisions which were in the -20 to -50% range of rainfall departures earlier were also

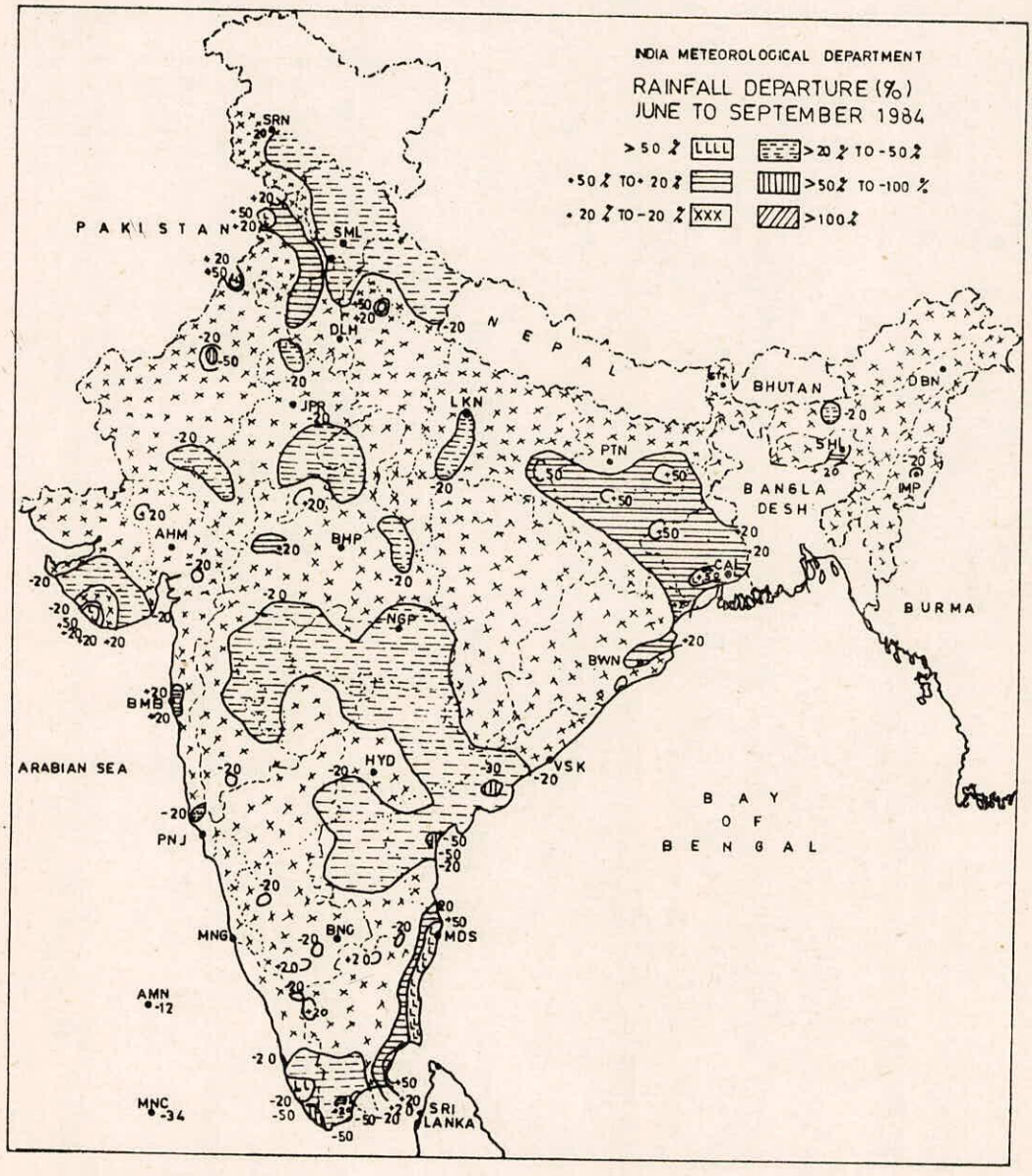


FIG. 4.1-SOUTH WEST MONSOON BEHAVIOUR OVER INDIA 1984

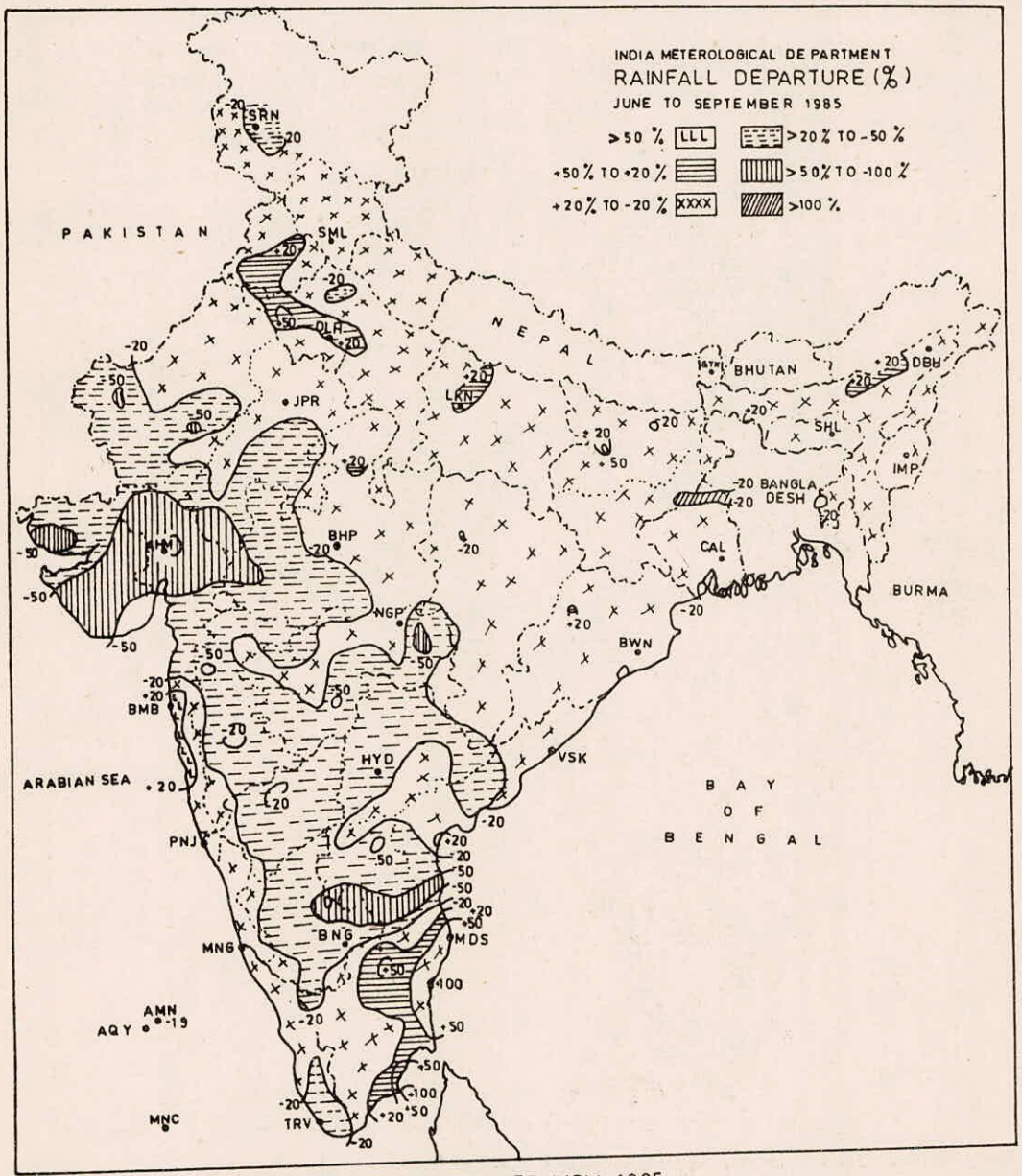


FIG.4.2-SOUTH WEST MONSOON BEHAVIOUR OVER INDIA 1985

in the same range during 1985 monsoon season with the exception of coastal Andhra Pradesh which had only -7% departure during 1985 monsoon.

4.3 Rainfall Departures and Deficits

(Persistence in Rainfall Deficits)

The available rainfall data mostly for the periods 1984 and 1985 have been analysed to determine seasonal rainfall deficits for 1985 and the continuity effect of rainfall deficits and dry spells.

Rainfall deficits in drought affected districts of Andhra Pradesh during 1984-85, were analysed and in Appendix III-2/18 the yearly deficits or excess in rainfall in the districts of Prakasam,Mahboobnagar,Anantapur Cuddapah and Chittoor are shown. Monthly rainfall of last 3 years alongswith normals and departures have also been given in Appendix III-3/18 to 7/18. The districts affected by deficiency of rainfall for one year, 2 years in succession and 3 years in succession are given below:

- Districts recording greater than 20% rainfall deficit in 1985, -Prakasam, Mahboobnagar, Anantpur and Cuddapah.
- Districts recording greater than 20% rainfall deficit in 198 and 1985 - Prakasam, Mahboobnagar, and Cuddapah
- Districts recording greater than 20% rainfall deficit in 1983, 1984 and 1985 - Mahboobnagar district

A map of rainfall deficit during monsoon season of 1984 and and 1985 in Andhra Pradesh is given in Figure 4.3.

From the monthly rainfall departures, it is noticed that the rainfall deficits during the monsoon of 1985 were lesser in magnitude when compared to those in 1984 for Chittor and Prakasam districts. In the remaining drought affected districts the deficits in rainfall

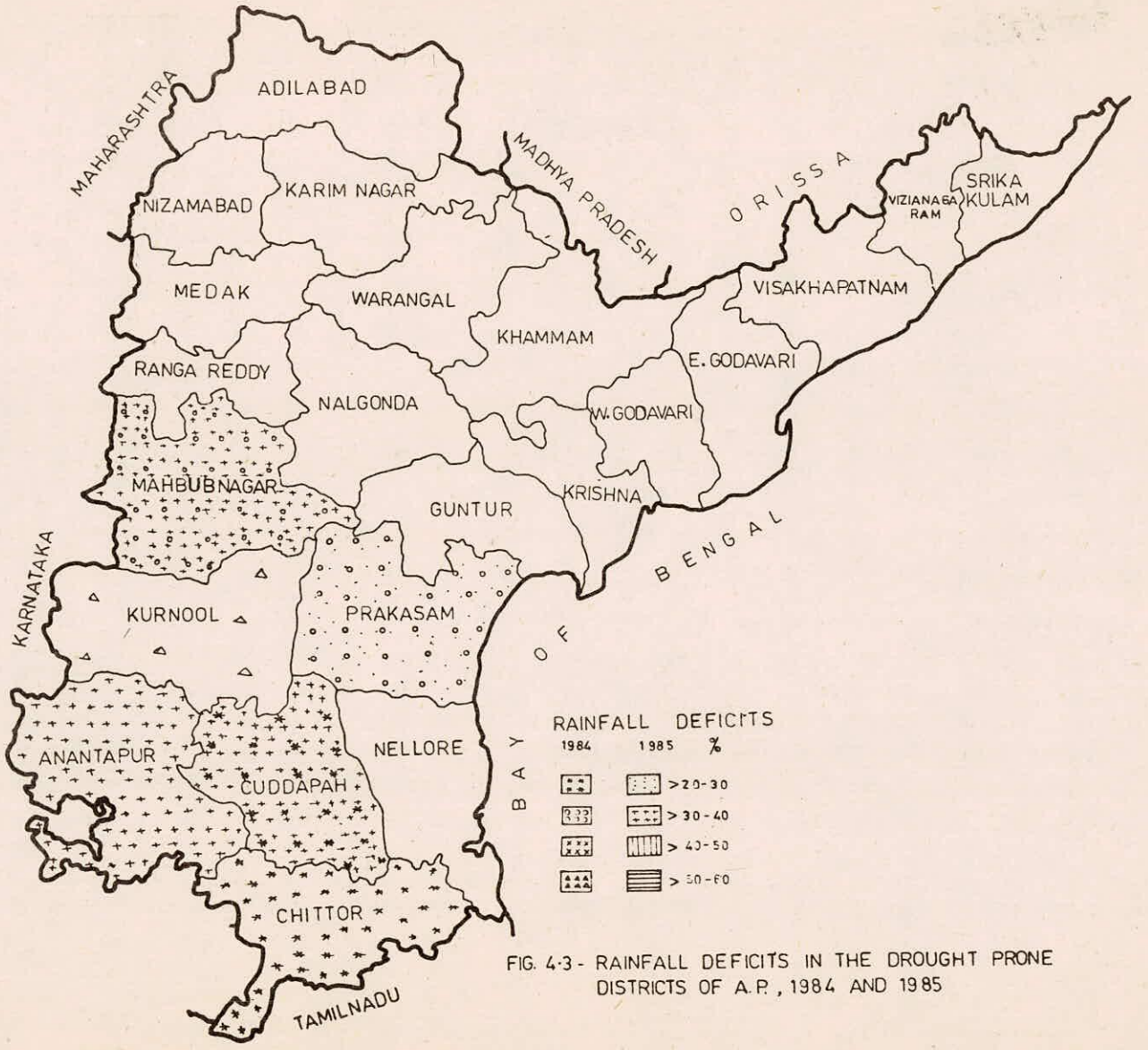


FIG. 4·3 - RAINFALL DEFICITS IN THE DROUGHT PRONE DISTRICTS OF A.P., 1984 AND 1985

during monsoon season of 1985 were more than those in 1984. The highest monthly rainfall observed in each of these districts during the monsoon of 1985 was relatively lesser than that observed in the previous year.

The percentage departure of seasonal(monsoon) rainfall from the normal for the last 5 years(1981-85) in districts of Gujarat is shown in Appendix III 8/18.On the basis of seasonal rainfall deficits, the districts could be categorised as under:-

- Deficit > 20% in: Jamnagar, Rajkot, Bhavnagar, Panch Mahal 1985 only
- Deficit > 20% in: Nil 1985 and 1984
- Deficit > 20% in: Kutch 1983, 1984 and 1985.

From App.III-8/18 it may be seen that Panchmahal district has continuous deficit for the last four years (1982-85) though the magnitudes of deficit were low in 1983 and 1984 whereas 1981 was a surplus year as is evident from the App.III-8/18.Panchmahal, Jamnagar and Rajkot districts had maximum deficit in 1985 during last 5 years with Jamnagar having maximum monsoon deficit of 54%.

A map showing rainfall deficits during the monsoon seasons of 1984 and 1985 in Gujarat is given in Fig.4.4. A map showing rainfall departures during 1985 in Karnataka is given in Figure 4.5

In order to study the variability of rainfall, monthwise rainfall deficits during monsoon season 1985 for the districts of Chitradurga, Tumkur, Bijapur, Kolar and Belgaum are given in Appendix III-9/18 The normals were based on the previous 30 years rainfall data. The failure of rainfall during monsoon 1985 is evident from App.III-10/18. Further, maximum deficits in rainfallwere observed during September to December in all the five districts in 1985. Since Karnataka receives rainfall during both the SW and the NE monsoons, the failure of rains during the latter 6 months of 1985 aggravated the severe drought arising out of deficit rainfall for the third year in succession. The rainfall

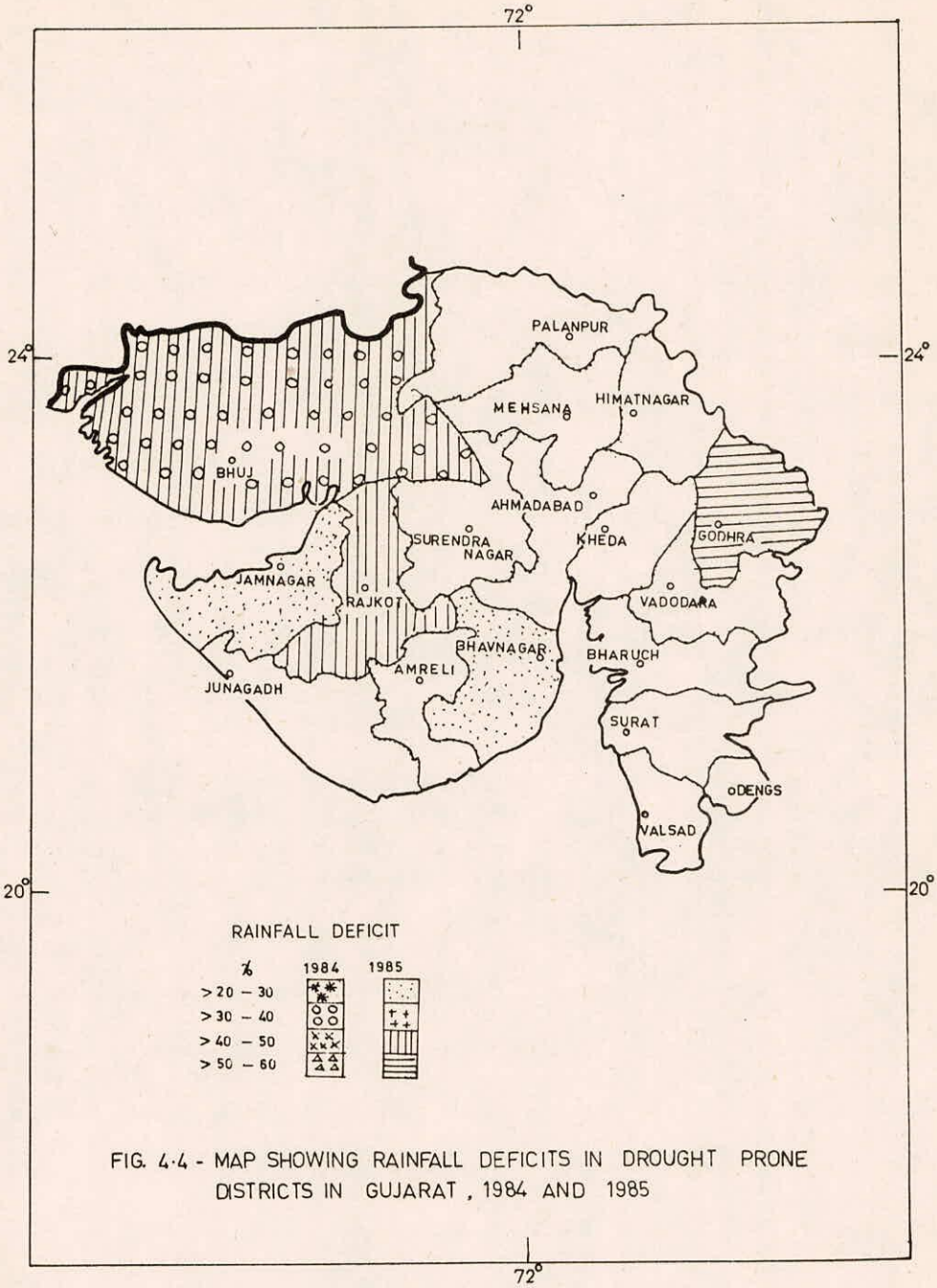


FIG. 4·4 - MAP SHOWING RAINFALL DEFICITS IN DROUGHT PRONE DISTRICTS IN GUJARAT, 1984 AND 1985

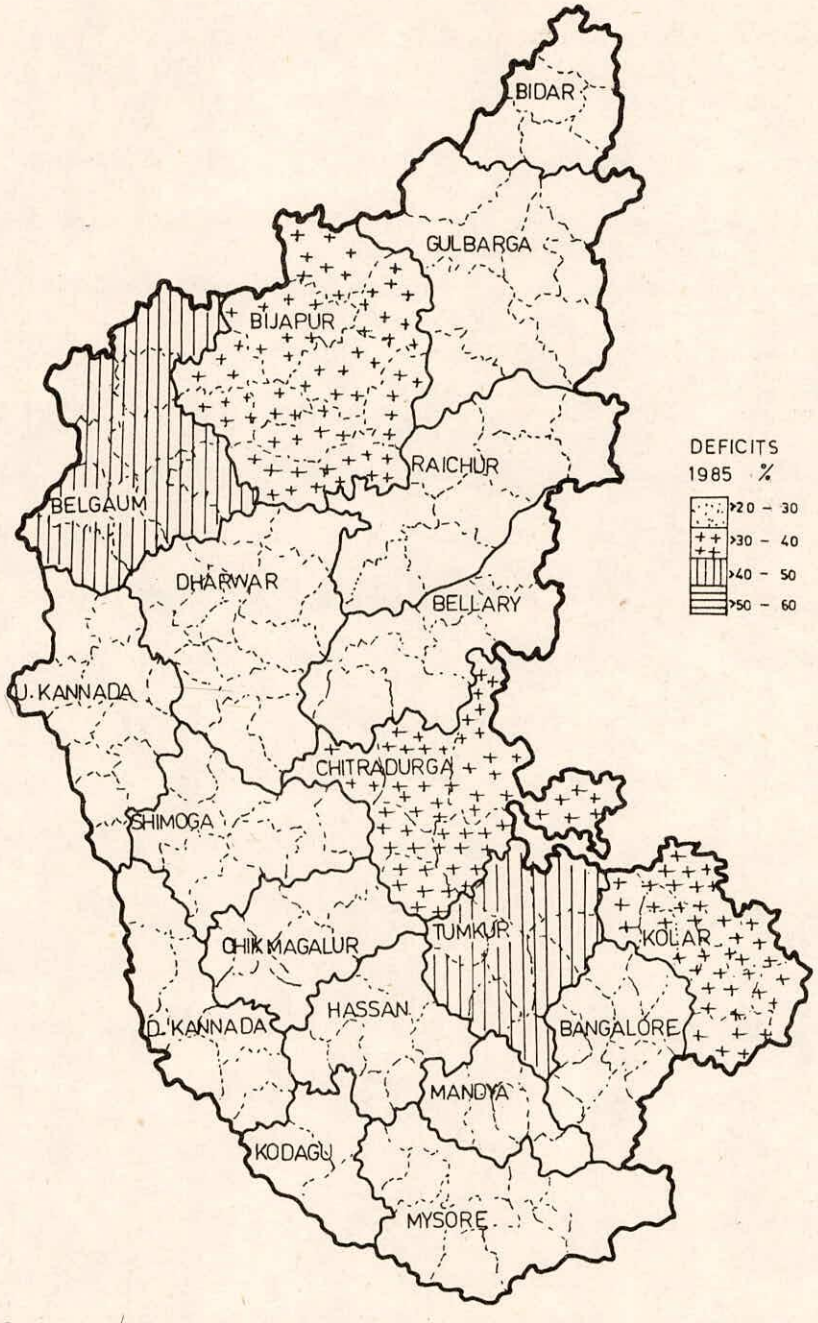


FIG. 45-MAP SHOWING RAINFALL DEFICITS IN DROUGHT PRONE DISTRICTS 1985 OF KARNATAKA

deficits in the study area during previous years could not be studied as the rainfall data for the previous years were not readily available. However, according to the State Directorate of Economics and Statistics, the rainfall pattern during the South-West monsoon(May to September) 1985 led to "one of the worst droughts unprecendented in the last decade".

In Madhya Pradesh, the monsoon in 1985 set in the middle of June. There was hardly any rain in July after the early showers in June. There were some rains in the first two weeks of August. Rains ceased from the third week of August, which led to problems of water scarcity in many parts of the State.

Appendix III-11/18 gives the monsoon seasonal rainfall and its departure from rainfall in the 6 affected districts Dhar, Jhabua, Khargone, Betul, Shahdol and Sidhi. For the districts in Western M.P.-Dhar, Jhabua and Khargone, the rainfall deficit is progressively increasing. Appendix III-12/18 portrays the pattern in which the % departures varied during the past 9 years. These also show the continuity of the drought. While the deficit in 1985 was higher than that of 1984 in Dhar, Jhabua and Khargone, in the remaining three districts,namely, Betul, Shahdol and Sidhi, the deficit in 1984 was more than that in 1985.

Appendix III-13/18 gives the monthly rainfall deficit values during the monsoon season of 1977 to 1985. From the above it can be seen that for major part of the monsoon period, there was deficit in rainfall. It may be noticed from the App.III-13/18 that during the last five year period (1981-85) the occurrences of deficits during the monsoon months increased progressively with time.

The continuity effect of deficit could also be noticed from Appendix III-12/18. Based on the rainfall deficits given in Appendix III-12/18 the districts are classified as below:-

-Deficit >20% only in 1985: Dhar,Jhabua,Khargone,Betul and Shahdol

-Deficit >20% in 1984 and: Khargone

A map of the State showing rainfall deficits during the 1984 and 1985 monsoon season is shown in Fig.4.6. It is observed that the district Khargone is having deficit of rainfall for the last two years in succession. It may be mentioned that due to non-availability of rainfall data, only the rainfall data supplied by IMD for its stations have been considered for analysis in this report.

Maharashtra had good monsoon in 1983. The monsoon rainfall in 1984 and 1985 was below normal. In 1984, onset and withdrawal of monsoon were around the normal dates whereasduring 1985, the monsoon set in late by about 15 days. The districtwise monthly rainfall during the monsoon months(June - September) in 1984 and 1985 is given in App. III- 14/18 15/18 together with the departure from normal. On the basis of rainfall deficit given in these appendices the districts are categorised as under:-

-Deficit >20% only in 1985: Dhule, Pune, Satara, Amaravati

-Deficit >20% in 1984 and Nasik,Ahmednagar,Solapur,Sangli,Aurangabad Jalna, Parbhani,Beed,Nanded,Osmanabad,Latur.

A map of the State showing monsoon rainfall deficit during monsoon season of 1984 and 1985 is given in Fig.4-7. It is noticed from the figure that 11 districts of Maharashtra were having deficit of rainfall for the last two years in succession. The seasonal rainfall departures of Madhya Maharashtra and Vidarbha divisions are shown in Appendix III-16/18. Besides seasonal rainfall deficit, the distribution of rainfall during the season has also to be considered from the agriculture point of view. In 1985, rains during June were deficient especially in the eastern parts of the State delaying the sowing operations.

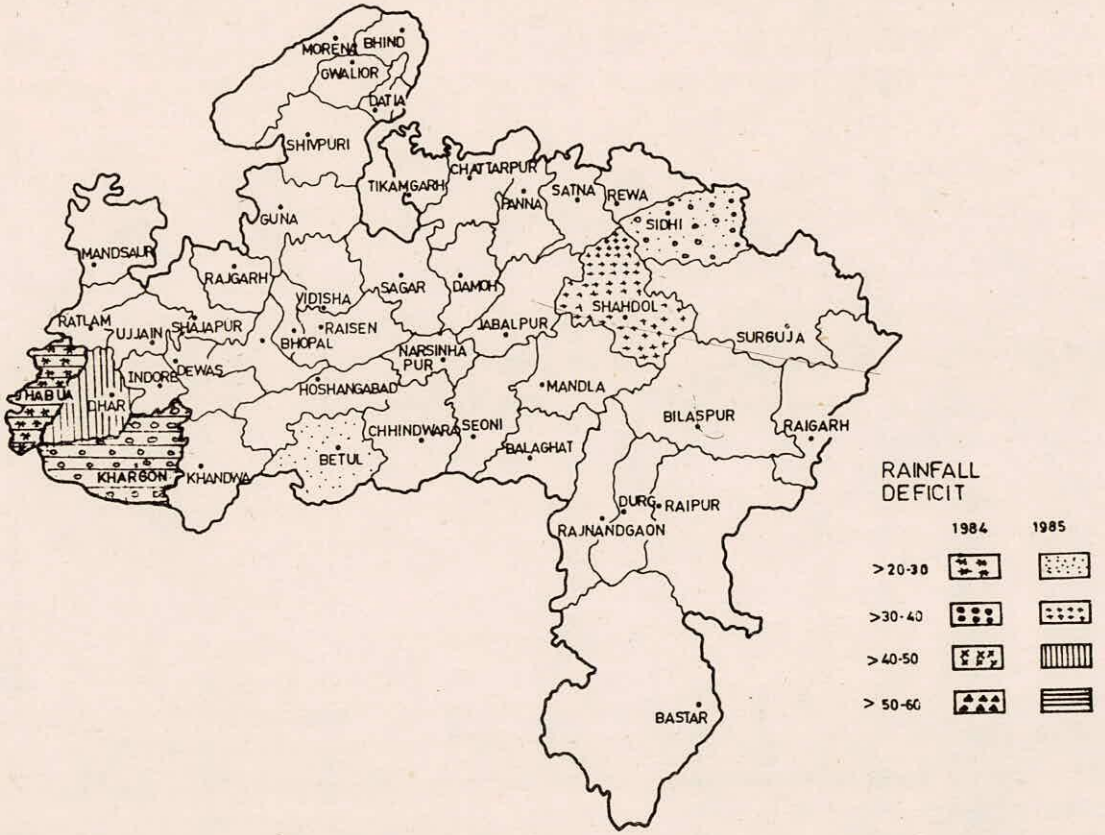


FIG. 4.6-MAP SHOWING RAINFALL DEFICITS IN DROUGHT PRONE DISTRICTS IN MADHYA PRADESH, 1984 AND 1985

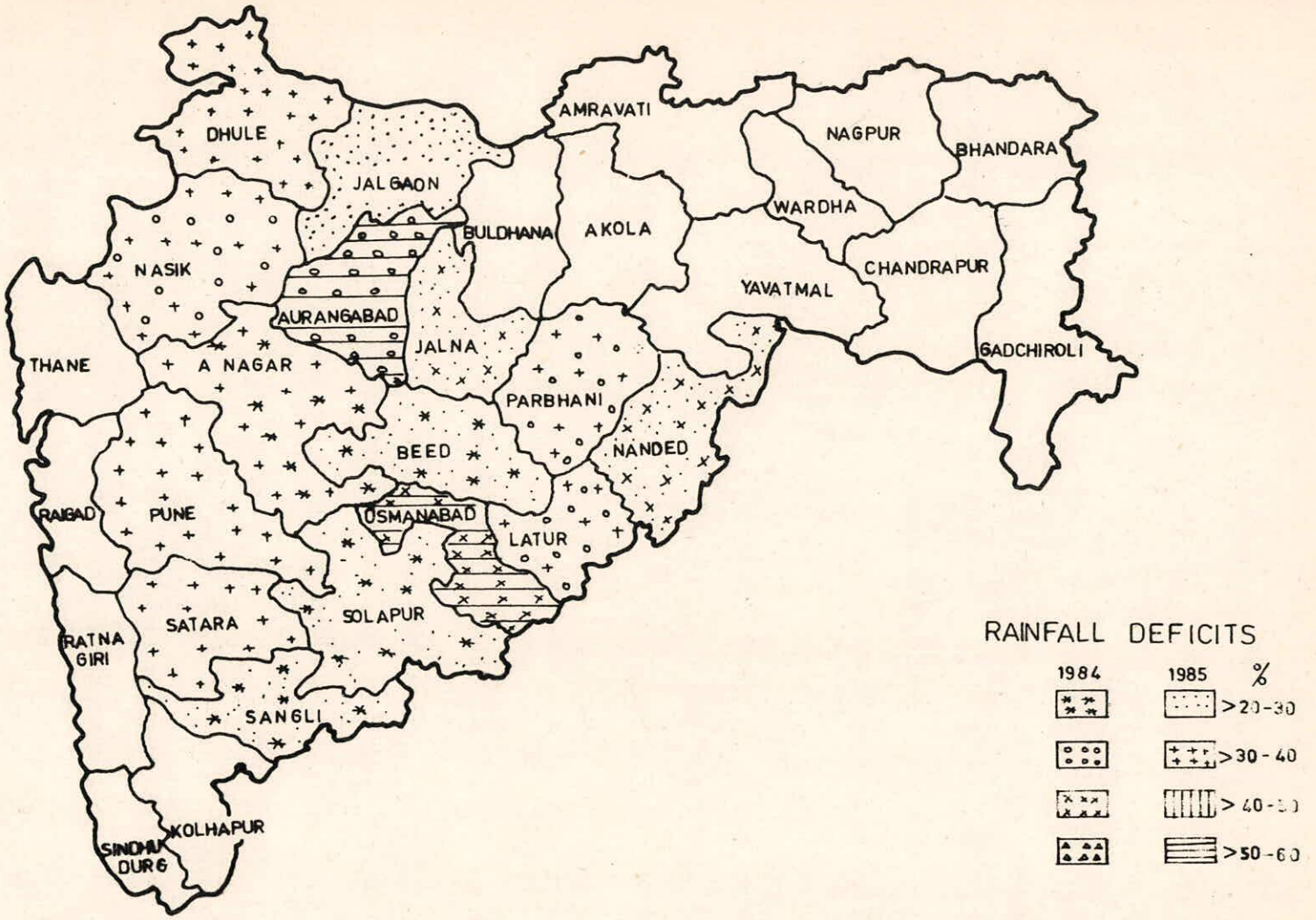


FIG. 4.7 - MAP SHOWING RAINFALL DEFICITS IN DROUGHT PRONE DISTRICTS IN MAHARASHTRA, 1984 AND 1985

Rains during August and September were also below normal with long dry spells. The maximum monsoon rainfall deficit was more(54%) in 1985 as compared to that of 1984 (48.3%) as evident from Appendix-III 16/18. Since the data of 1983 were not readily available, the analysis of only 1984 and 1985 data is presented.

The pattern of rainfall in Rajasthan was quite unusual in 1985 both in amount and its distribution. Monsoon set in late by 2 weeks and also withdrew early. The districtwise monsoon season (June-Sept.) rainfall alongwith percentage departure from normal is given in Appendix III-17/18 from 1979 to 1985 for 10 districts (i.e. 8 drought prone and 2 desert districts). The seasonal surplus and deficit for these districts are shown in Appendices III-18(A)/18 & III-18(B)/18. The amount of deficit and its continuity effect (i.e. whether it is persisting or not) is evident from above App. The districts are classified as below depending upon the persistence of the deficit:

- Deficit > 20% in: Ajmer,Banswara,Dungarpur,Kota,Udaipur in 1985
- Deficit > 20% in: Jodhpur, Tonk,Barmer in 1984 and 1985.

A map of the State shopwing monsoon rainfall deficit is given in Fig.4.8. This indicates that out of 8 drought prone districts, 5 districts had seasonal deficits only during this year whereas Tonk district recorded rainfall deficit in both 1984 and 1985. Barmer and Jodhpur have also been facing rainfall deficit for last two years in succession. The amount of maximum monsoon rainfall deficit observed during 1985 was around 67% in Banswara while in 1984 maximum deficit was around 33% in Sawai-Madhopur. In general 1985 observed relatively maximum monsoon deficits over the last 7 years except in Kota, Sawai Madhopur as is evident from the figure 4.8. There was deficit

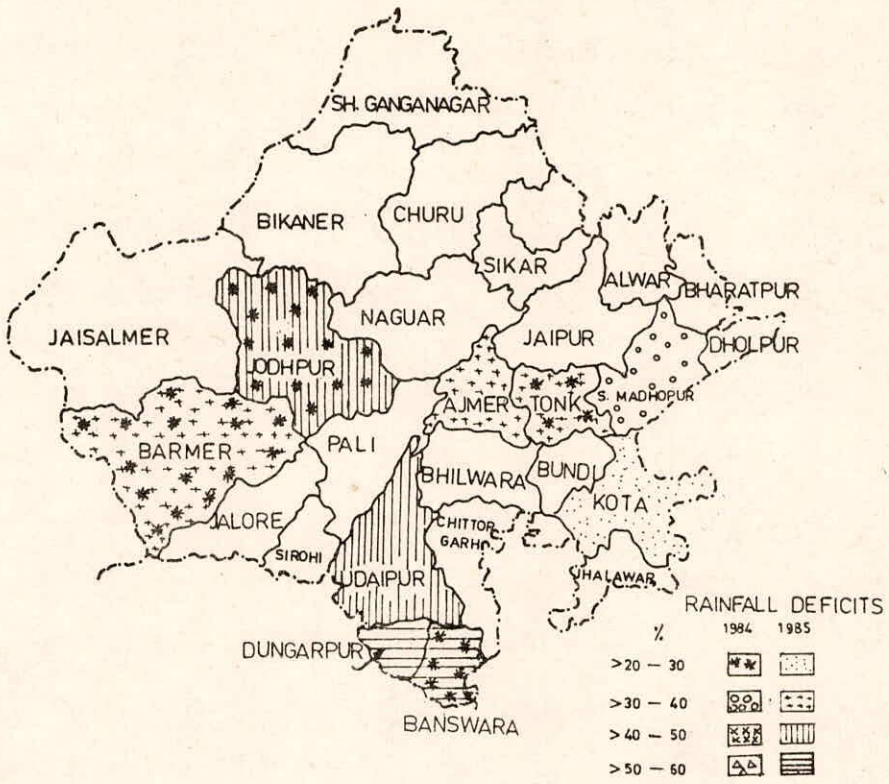


FIG. 4·8 - MAP SHOWING RAINFALL DEFICITS IN THE DROUGHT PRONE DISTRICTS OF RAJASTHAN, 1984 AND 1985

in all the four months in Banswara, Jodhpur, Tonk and Dungarpur districts with maximum deficits in June and September months thus damaging agricultural crops during Kharif. There were long dry spells(3 weeks) in these districts.

From the above description, it is seen that the drought situation in 1985 was severe due to (i) larger rainfall deficit during 1985 and (ii) the continuity of rainfall deficit for the second or third year in succession. Another feature which was noticed is that during 1985 drought has also occured in those districts which are normally unaffected by drought or are not classified under the Drought Prone Area category.

5.0 DEFICIT IN SURFACE WATER

5.1 General

During periods of deficient rainfall the deviation from normal conditions is greater for streamflows than for rainfall. The periods of droughts are generally characterised by high levels of transpiration and evaporation due to high temperatures and these in turn lead to higher abstractions from rainfall and consequent deficits in streamflows. The streamflow represents the runoff from the catchment and reflects the basic effects of rainfall deficiency as well as the change in catchment characteristics, land use, vegetation, transpiration, etc., due to drought conditions. The drought phenomena can, therefore, be better studied from the hydrology of the river basin for which local singularities are eliminated. The deficits in surface water are reflected through low streamflows as well as decline in reservoir storages. The drought severity, frequency and duration is studied by analysing the gross availability of streamflows in different weeks/months, the extent to which the reservoirs have been filled in comparison to their capacities and also the flow duration characteristics of river flows. The runoff characteristics and storages in reservoirs are analysed for periods of various durations using different statistical approaches.

During visits of scientific and technical teams of NIH some data of surface flow and reservoir storages have been collected from different States and the same have been presented in the next section.

5.2 Streamflow

During the field visits, the streamflow data for recent years for different sites in the States of Andhra Pradesh, Gujarat and Rajasthan were not readily available. Further action has been initiated to collect the streamflow data from these States. In the State of Karnataka

the monthly streamflows at Daddi gauging station on the river were available. These have been plotted in the App.IV-1/18 for the year 1983 to 1985. It is seen from the figure that the river flows only during monsoon periods and dries up during non-monsoon period. In 1985, the stream remained almost dry from January to end of May. Both the years 1984 and 1985, the streamflows were much lower than in 1983. The peak discharge in 1984 was observed as 11,000 m^3/sec., while in 1985 it was about 6,500 m^3/sec. indicating general lower rainfall during the monsoon season of 1985. During the months of October to December 1985, the monthly flows in the river were considerably less than the corresponding period flows during the year 1984. The pattern of streamflow variation in this site thus provide a typical indication of streamflow pattern during drought condition.

Streamflows in the various districts of Madhya Pradesh indicate a generally decreasing trend during the last 3 years. The monthly discharge variations during the monsoon periods for the years 1978 to 1985 for the following sites were examined (App.IV-2/18).

1. Mandleshwar site on river Narmada located in Khargon district.
2. Kogaon site on river Kundi located in Khargon district.

In both these sites, the river flows in 1985 indicate a significant decrease in comparison to those for previous years.

Generally, the flows in the Krishna and Godavari rivers in Maharashtra State were below normal and the river beds in most of the streams were dried in October 1985. The monthly discharges for periods 1984 to 1986 for the following sites which are located in drought prone area were examined(App.IV-3/18 & 4/18)

1. Kurandwad site on river Krishna located in Kolhapur district.
2. Narsingpur site on river Bhima located in Solapur district.

3. Wadakbal site on river Sina located in Solapur district

The streamflow during 1985 at both Wadakbal and Narsingpur is significantly lower than that of 1984. There is hardly any flow during early part of 1986. For Kurandwad site, however, the flow is more or less the same both in 1984 and 1985. It appears to be due to only small portion of the catchment of Sina river upto Wadakbal lying in drought prone area, whereas for the other two sites major parts of their catchment fall in drought prone districts of Maharashtra.

The analysis of some of the streamflow data available at different sites in the drought prone areas of various states has indicated a general reduction in streamflows in these areas in the year 1985 and it needs to be studied further with a better data base.

5.3 Reservoir/Tank Levels

The data for surface water deficit study also consists of reservoir levels and the same has been processed and is discussed. Fig.5.1 gives the reservoir levels of selected reservoirs in the drought affected States for the last three years i.e.1983-85. In the State of Andhra Pradesh, the reservoir level data for Pedderu and Bahuda reservoirs in Chittur district are shown in the App.4/18 & 5/18 from the year 1982 to the beginning of year 1986. In both these reservoirs the water levels at the end of year 1985 were lower than the corresponding levels in the previous years. In 1984, the levels at the beginning of monsoon season were relatively higher in both the reservoirs, however at the beginning of 1985 monsoon season these were comparatively lower. The failure of South-West monsoon during 1985 further aggravated the situation leading to further decline in reservoir levels by the end of 1985. The effect of deficits in surface water is thus quite evident from the figures. It shows that there is hardly any water left in the

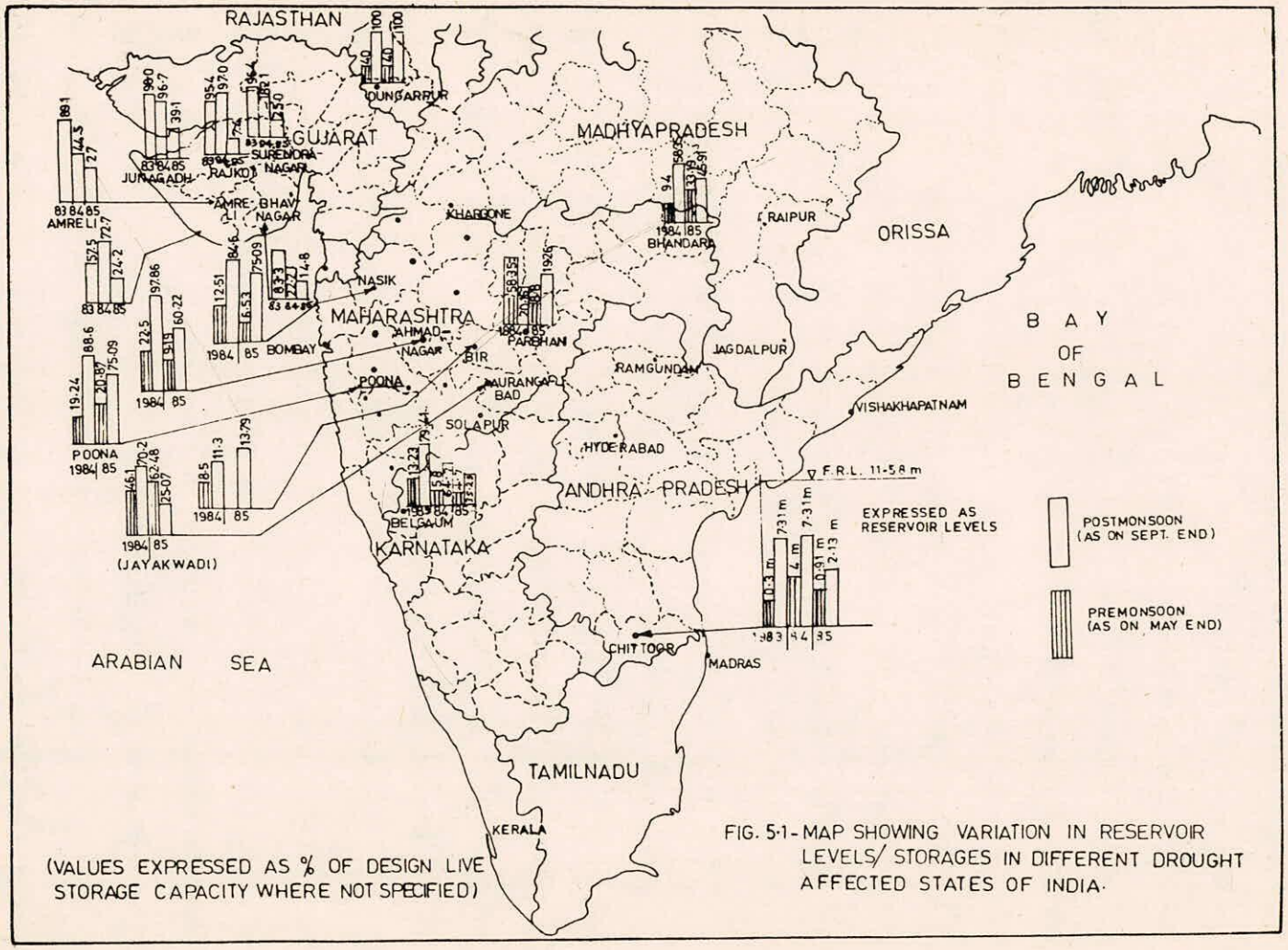


FIG. 5·1 - MAP SHOWING VARIATION IN RESERVOIR LEVELS/ STORAGES IN DIFFERENT DROUGHT AFFECTED STATES OF INDIA.

month of April 1986. The data of other reservoirs in the State were not readily available for 1985-86.

The district-wise water availability in surface water storages for Gujarat State has been shown in bar chart in App.IV-6/18 along with designed live storage capacity for the districts of Amreli, Junagarh, Rajkot and Bhavnagar for periods from 1975-76 to 1985-86. In 1983-84, the availability of water in these reservoirs was close to their live storage capacities as is evident from Appendix IV-6/18 . It is also clearly seen that there has been decreasing trend in the availability of water in different reservoirs during 1984-85 and 1985-86 in most of the districts. Particularly in 1985-86 there has been significant decline in reservoir storage leading to severe shortages for drinking water and irrigation. The district-wise area irrigated from these surface storages for periods from 1975-76 to 1985-86 is given in App.IV-7/18. During 1985-86, hardly any area was irrigated in Rajkot, Jamnagar and Amreli districts as the water stored in the reservoir was quite low being only 8 percent of the designed live storage in Rajkot and about 25 to 28 percent in Jamnagar and Amreli districts. It appears that this water was kept as reserve for use only for domestic purpose rather than for irrigation purposes.

The monthly reservoir storages in the Malprabha and Ghatprabha reservoir in Karnataka have been plotted for the years 1979-85 and are shown in Appendix IV-8/18 and IV-9/18. It is seen from the figures that the status of storages in Ghatprabha reservoir is comparatively better than that of Malprabha reservoir. It is also seen that the Ghatprabha reservoir has filled upto its live storage capacity in all the 4 years since 1982, whereas Malprabha reservoir has filled only upto 80% of its designed live storage capacity in 1983, 70% in 1984 and

40% in 1985. This indicates declining trend of reservoir storages in Malprabha reservoir due to deficits in the streamflows generated in catchments.

Trends of some surface storage reservoirs for medium irrigation projects in Madhya Pradesh for the year 1979-85 are plotted in terms of the reservoir levels in App.IV 10/18 to IV-12/18. The effect on the drought situation in 1985 is clearly evident as the reservoir level has fallen well below the full reservoir level. From the figures it is also observed that the monthly levels in the reservoirs during 1985 are lower than the corresponding levels in the year 1984. It is due to the carry over storages available at the beginning of 1984 season, which has somewhat moderated the effect of 1984 drought. In 1985-86 period, however, no such carry over storage was left the situation thus became much worse due to failure of monsoon in 1985. There is almost no carry over storage left for possible use in 1986 as well and the situation can still become grave if monsoon rains are deficient in 1986 season. For Maharashtra State the position of surface storages in major/medium irrigation projects for the year 1984, and 1985 is given in App.IV-13/18 and IV-14/18. The position of water in a selected reservoir has been plotted in App. IV-15/18 which illustrates the effect of 1985 drought on surface storages. It is seen that the position of sotrages for the reservoirs in district Pune is relatively better in comparison to that for other districts like Aurangabad, Ahmednagar and Beed, which are facing rainfall deficit for second consecutive year.

For some selected irrigation tanks located in drought prone areas of Rajasthan, the position of water levels is shown in bar diagram in App.IV-16/18. The post-monsoon storages in 1985 are significantly lower in comparison to those for previous years and the available water

in the tanks generally around 40 per cent of their live storage capacities. Jaswant Sagar reservoir practically has no water during 1985 and also similar situation prevail in 1984.

The maximum water level attained during monsoon of 1983,1984 and 1985 against FRL in important tanks are given in App. IV-17/18 . It appears from the table that in general maximum water levels attained during 1985 were less as compared to that of 1983 and 1984. Although there was monsoon deficit for both 1984 and 1985 in Tonk district, the reduction in water levels was more pronounced in 1985 due to continuity effect of drought. The yearwise irrigated areas of the tanks in Tonk district show that the larger tanks are affected to somewhat lesser extent due to deficient monsoon as compared to smaller tanks having small catchment areas.

The position of available live storage as percentage of live storage capacity at FRL for selected reservoirs is summarised in App. IV-18/18 to illustrate the general behaviour of the hydrological drought of the current year. It could be observed from the table that in general, there is a decreasing trend in the available water storages in the reservoirs. In Malaprabha reservoir only 4.33% of the designed live storage was available as at the end of January 1986 and the position of storage was similar in the last year also which indicates that there is drought in succession for the second year. The availability of water as at the end of January 1986 was significantly low as is evident from the Appendix. Jayakawadi in Maharashtra had only 16% of designed live storage as at the end of December 1985 as compared to 65% as at end of 1984.

6.0 DEFICIT IN GROUND WATER

6.1 General

Groundwater is a valuable resource which plays an important role in water supply for arid and semi-arid regions. Because of improper management of groundwater aquifers after development, numerous undesirable consequences such as the depletion of aquifers and groundwater mining emerge, especially during drought years. Statistics recently compiled on the use of groundwater and surface water show that in a number of States groundwater is being over-exploited in certain pockets resulting in a fall in the water table. Besides entailing high costs year after year, for the deepening of wells, this results in an increased use of energy for pumping water from greater depths. Therefore, the withdrawal of groundwater should be restricted to average annual recharge. This will conserve water for over exploitation during drought periods. In areas where excessive lowering has taken place, possibilities of aquifer recharge augmentation should be explored and implemented. Conjunctive use planning of surface and groundwater should be practised for optimal use of groundwater to combat drought years.

6.2 Trends of Water Table

The groundwater level graphs have been prepared and studied for selected sites in the drought hit areas of Gujarat Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra and Rajasthan. The hydrographs have been compared with the rainfall trends,

as given in Appendices V-1/12 through V-12/12.

In Andhra Pradesh at station in Markapur taluk the decreasing trend in the groundwater level has been recorded from 1981 onwards which also conincides with the decreasing rainfall in the areas. The hydrograph in Rayachoti taluk shows a conspicuous lowering of water level from 1979 to 1982 with a little rise during 1981-82. This trend also could be assigned to the low rainfall during these years. For other stations it has not been possible to draw any definite conclusions as the data is meagre.

The groundwater hydrographs at selected sites in different districts of Karnataka have been plotted for a period of 10 years (1976-85) as shown in Figure 6.1. The monthly water level data collected by the Department of Mines and Geology, Bangalore has been used for the construction of hydrographs. The hydrographs in the districts of Tumkur, Chitradurga, Kolar and Dharwad show conspicuous decreasing trends after 1981, viz.,the stations Hirehally, Gubbi, Gadag, Bangarpet, Kolar, Alagawadi, and Jagalur. It is inferred that this trend may be due to the increased abstraction of ground water in these areas resulting in continued lowering of water table. The hydrographs at stations Bailhongal, Saudatti Gokak and Dharwad show an increased trend, this is mainly because these stations are located in the Ghataprabha and Malaprabha command areas - these are Sambre, Athani, Medenur, Raibag, Kaujalgi and Khanapur.

The static groundwater levels observed in observation wells have been plotted for selected blocks in the districts of Jhabua and Betul in M.P. These graphs show that the post-

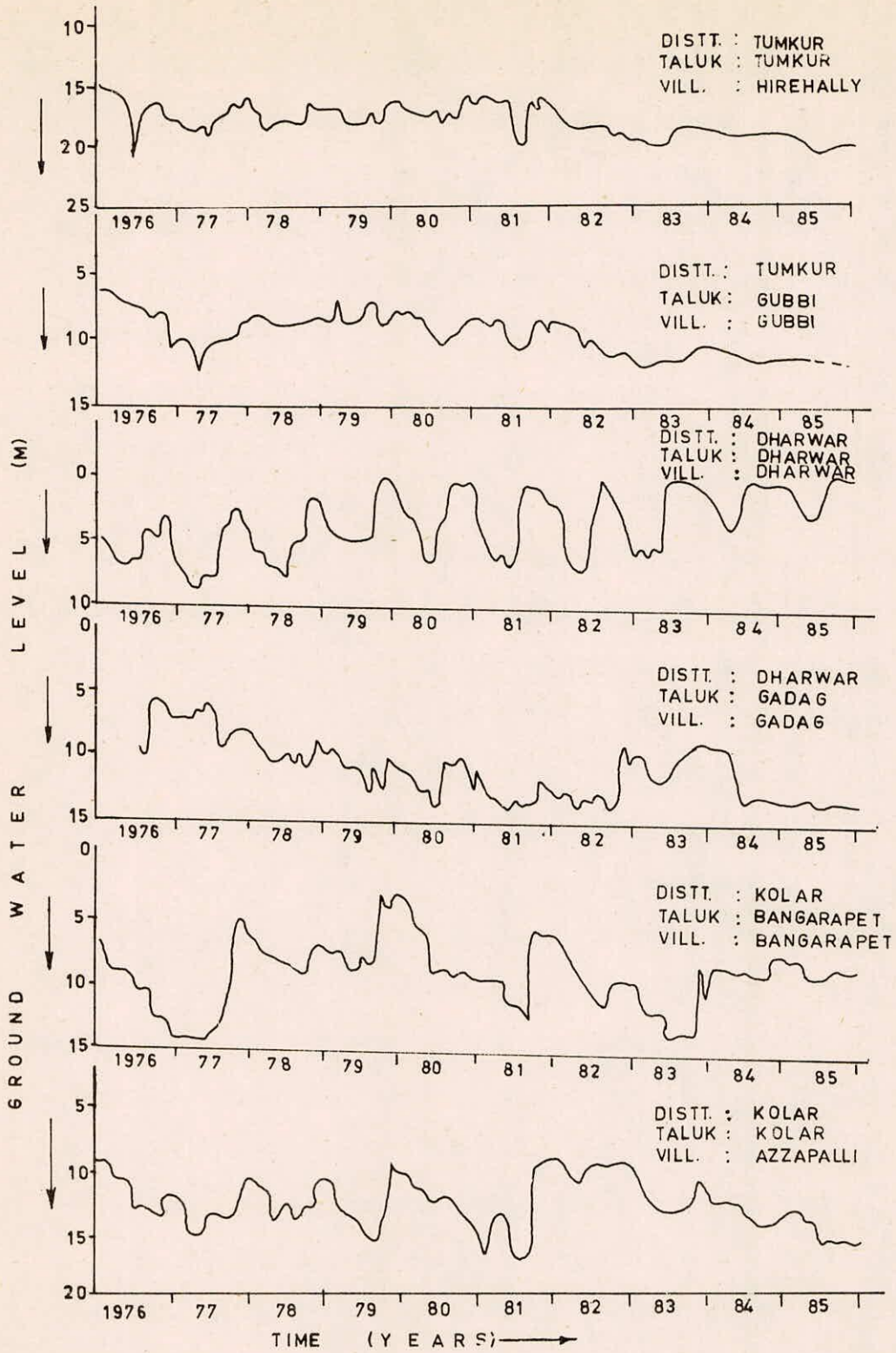


FIG. 6·1 - VARIATION OF GROUND WATER LEVEL (KARNATAKA)

monsoon levels during 1985 have been lowest when compared to the corresponding levels of previous years. For the premonsoon levels also similar behaviour has been observed. In case of district Jhabua, the wells have been dried up indicating the deficient natural rainfall recharge and increased abstraction of groundwater during drought.

In Maharashtra field studies indicate that the groundwater levels have been receding continuously due to reduced rainfall recharge and increased draft from tubewells, borewells and dugwells for irrigation and drinking water purposes. The situation is especially alarming in Pune, Ahmednagar, Sangli, Solapur, Beed, Osmanabad, Parbhani and Aurangabad districts. The depletion in groundwater tables and the problems of wells going dry during the year 1985 is evident in Beed and Ahmednagar districts which are facing drought for second consecutive year. The reason for continuous declining of water table could be attributed to deficient natural rainfall recharge and increased dependance on groundwater during drought. The typical groundwater level fluctuation in relation to rainfall in Ahmednagar district for 1983 1984,1985 has been shown in Fig.6.2

There has been a general view that groundwater table is declining in drought prone areas of Rajasthan due to deficient rainfall recharge and excessive draft. However, no definite conclusions can be made in this report as the ground water data is scanty.

6.3 Drought and Lowering of Water Table

The continued deficiency of rainfall in the Southern States from last few years has led to the depletion of ground water. During these drought years the sustainable source for drinking and other purposes

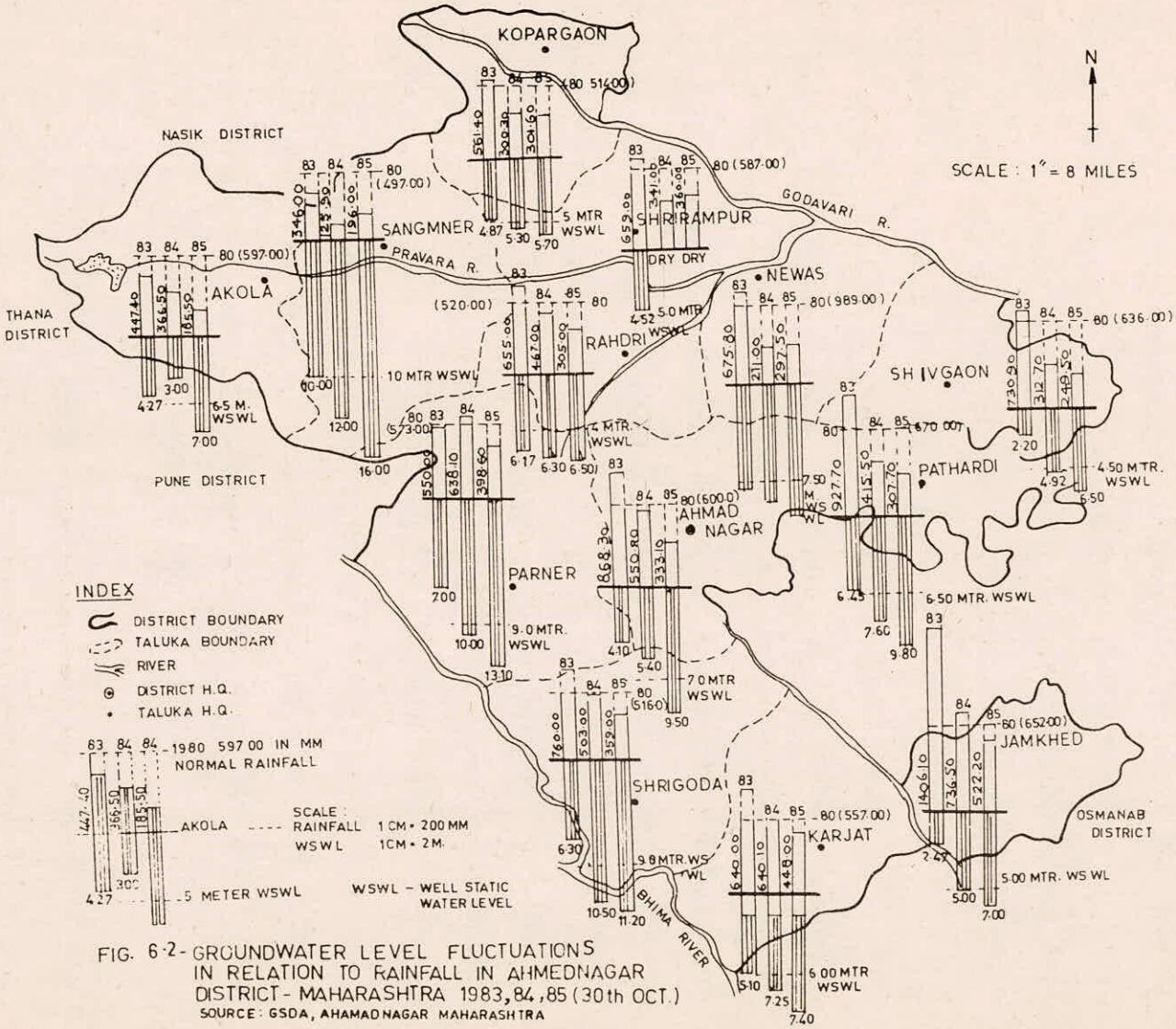


FIG. 6·2 - GROUNDWATER LEVEL FLUCTUATIONS IN RELATION TO RAINFALL IN AHMEDNAGAR DISTRICT - MAHARASHTRA 1983, 84, 85 (30th OCT.)

SOURCE : GSDA, AHAMADNAGAR MAHARASHTRA

has been groundwater. Since groundwater is recharged mainly through precipitation, the over exploitation of this resource year after year has led to decreased groundwater levels. From the field visits it is evident that in many parts of the Karnataka, Andhra Pradesh, Madhya Pradesh and Maharashtra the water levels are continuously declining and the shallow dug wells are going dry. A typical example of over-exploitation can be quoted from Tumkur and Kolar districts in Karnataka. This alarming situation calls for a systematic and planned development of groundwater resources restricted to average annual replenishment through rainfall recharge to meet the water demand during drought years.

7.0 SOIL MOISTURE DEFICIT

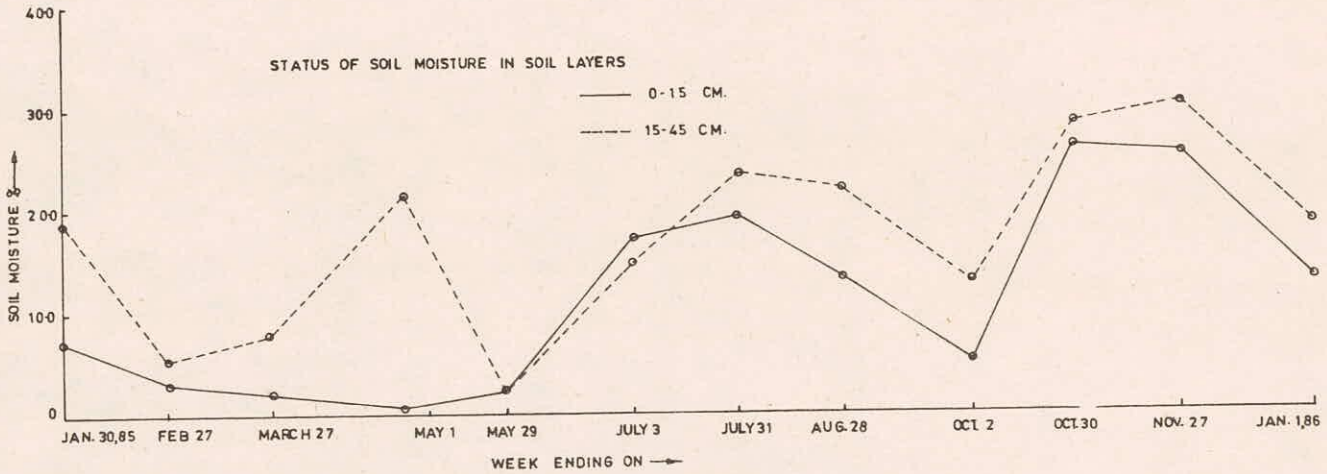
7.1 General

Availability of useful soil moisture to the vegetation appears to be a better indicator for drought analysis and planning drought management strategies. Soil is the store house of water from where plants extract moisture for their evapotranspirational needs. Soil moisture between the field capacity and permanent wilting point is known as the soil moisture which is available to plants. But even in the soil moisture range the entire soil moisture cannot be extracted by the plants. It is a well established fact that the soil moisture beyond a certain limit adversely affects the plant growth and causes wilting of plants. This results in declining agricultural production which is normally taken as a measure of agricultural drought. The severity of drought for a given crop can be studied by defining different levels of soil moisture deficits. The incidence of drought can be characterised by determining the number of days during the growing season of the crop when soil moisture is below a value which is known to impede crop growth appreciably. These threshold values for some of the crops and soil types have been experimentally found out at a number of places in the country. This operational definition which gives soil moisture stress for a crop can be used to analyse drought frequency, severity and duration for a particular crop in a given drought prone area.

7.2 Soil Moisture in Drought Prone Areas

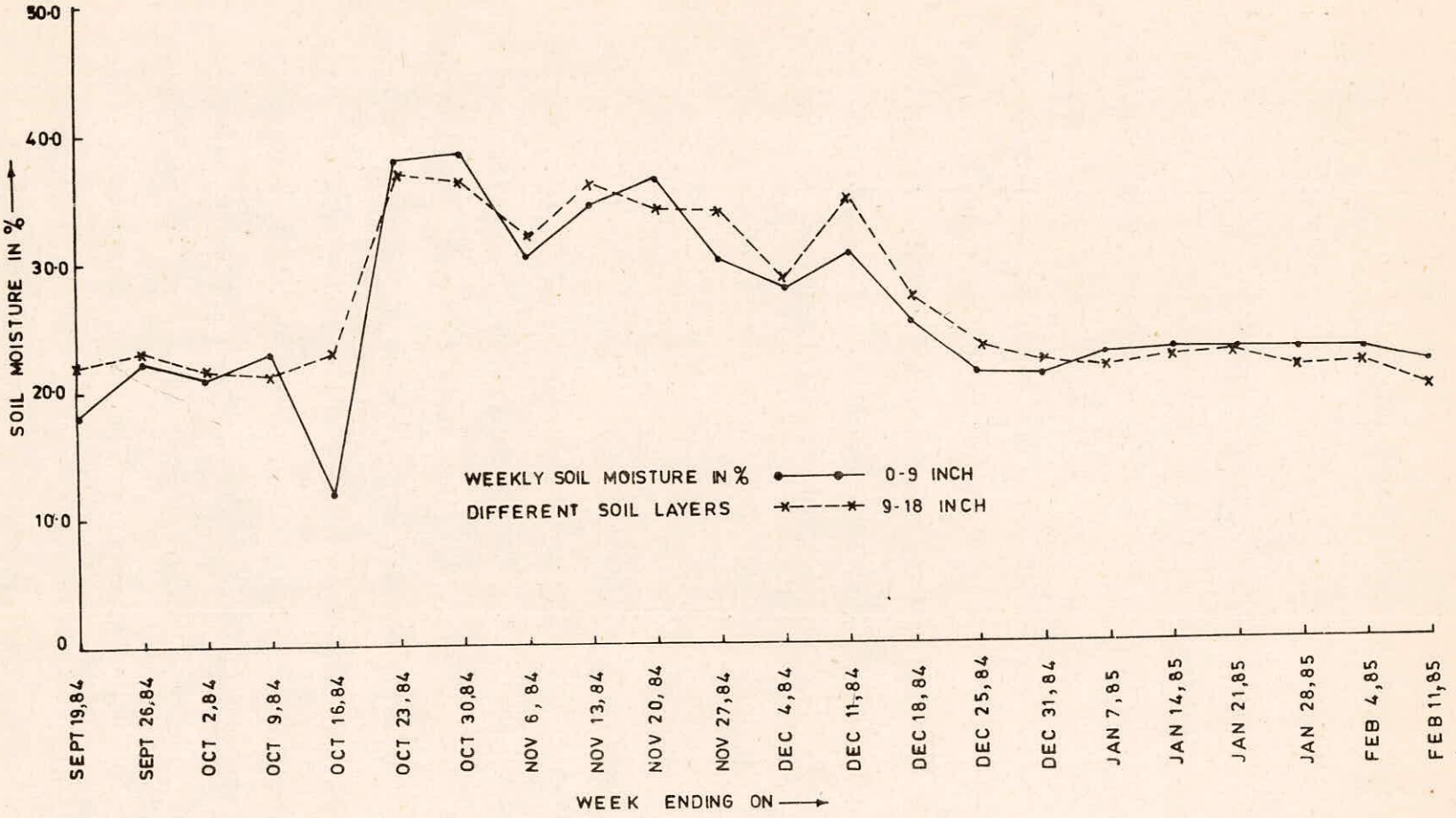
It was observed during the field visits that soil moisture

data is not recorded as a regular routine measurement in drought hit areas. There is need for establishing soil moisture monitoring stations in the country. Mostly the organisations like Agricultural Research Stations of ICAR, Agricultural Universities and IMD are taking measurement of soil moisture on a limited scale. The limited data obtained from Agricultural Meteorology Division, Pune of IMD and Andhra Pradesh Command Area Development Authority, Guntur (A.P.) have been plotted in figures 7.1 and 7.2. However, the data obtained from Guntur represent the data of irrigated field which indicates that there has not been soil moisture stress during the growing season of the crop due to irrigation. There appears to be a marginal effect of drought in the areas receiving assured irrigation. Since the soil moisture data of dry land areas could not be obtained, therefore, it may not be possible to give any conclusion in this regard. Therefore, the need for regular soil moisture measurement in dry land areas is a point to be given emphasis so that soil moisture stress can be used as a tool to analyse drought situation in dry land areas. Efforts are being made to collect the necessary soil moisture data for some of the drought prone areas from Agricultural Research Stations and IMD to incorporate the same in the final report.



DATA RECORD AT AGRIMET OBSERVATORY I.M.D., POONA

FIG. 7.1 - SOIL MOISTURE VARIATION WITH TIME 1985-86 (MAHARASHTRA)



DATA RECORD AT CADA FIELD GUNTUR (A.P.) SOIL MOISTURE ESTIMATION BY GRAVIMETRIC ANALYSIS

FIG. 7·2- WEEKLY VARIATION OF SOIL MOISTURE 1984-85 (A.P.)

8.0 EFFECT OF WATER DEFICIT ON WATER USE

8.1 General

The consequences of deficits in hydrological parameters-reduced rainfall, reduced streamflows, lower groundwater levels, reduced supplies of irrigation water and reduced soil moisture during drought are ultimately reflected in reduced water supplies, decline in fodder and crop production. The shortage of water for domestic and live stock demands, scarcity of fodder and reduced agricultural production could be taken as the indicators to evaluate the extent of drought and its severity. Since water and food are the essential elements of life for the survival of man kind and animals, it is necessary to study the consequences of drought in terms of these variables.

8.2 Water Supply

The general observations during the field visits of the drought affected States is that there arose acute scarcity condition of drinking water for domestic and live stock purposes. The drinking water problem which is more vital and justified as compared to crop production in the situation of severe drought has superseded the irrigation water supply in priority. This aspect has been observed in almost all the drought affected States wherein whatever water was available in the irrigation tanks/reservoir was reserved for the purpose of water supply for drinking purposes. The acute water scarcity has aggravated the rural and urban water schemes due to overstraining. the problem of water scarcity was observed to be relatively more in Rajasthan, Saurashtra, Western Madhya Pradesh, Madhya Maharashtra

and Karnataka where water was transported by tankers and railway wagons from long distances for distribution. The State Governments are implementing new water supply schemes to ease the problem. On account of non-availability of water-demand and supply data it may not be possible to offer any definite conclusions, however, the general impression is that the drought of 1985-86 is unprecedented in terms of drinking water problem. Efforts are being made to collect the required data which will be analysed and presented in the final report.

8.3 Fodder

Another important problem arising out of drought conditions is the scarcity of fodder for the cattle. The drought affected States have been observed to face severe fodder crises.

One of the main reasons for the development of such a crisis is due to the disposal of additional fodder just prior to the arrival of monsoon (in the beginning of June) in anticipation of a good monsoon rain. However, the erratic or total failure of monsoon rains led to insufficient growth of fodder (for grazing) during the post monsoon periods. As a result, the respective State Governments had to intervene to ease the severity of the situation by purchasing fodder from the neighbouring States and supply it in the fodder-scarce areas at subsidised rates. Above stated phenomenon has been observed in almost all the drought affected States. However, the fodder problem is observed to be more acute in the States of Gujarat, Karnataka and western Madhya Pradesh.

8.4 Crop Production

The area and agricultural production of principal crops

in Andhra Pradesh as recorded from 1981 to 1985 have been reported in App.VI-1/6. The data indicates that there is a reduction in the production of cereals and millets in 1984-85 when compared with that of 1983-84. However, the yield of pulses remained the same for the years 1983-84 and 1984-85. Information regarding the agricultural output for the season 1985-86 is being processed by the Directorate of Agriculture, Andhra Pradesh.

The crop wise production of Kharif crops in Gujarat is shown in App. VI-2/6. Kharif groundnut crop has particularly failed due to lack of soil moisture during growth period and thereafter during pod-formation period. The estimated Kharif groundnut production in the State is reported to be of the order of 3.90 lakh tonnes as against the normal (average of last three years) production of 12.98 lakh tonnes. Similarly, the production of Kharif food grain during 1985-86 is estimated at 15.82 lakh tonnes as against normal production (average of last three years) of 31.35 lakh tonnes. Cropwise area and production of Rabi Crops are shown in App. VI-2/6. The data indicate considerable decline in area due to non-availability of irrigation water. The total area under Rabi cereal crops during the year 1985-86 is hardly of the order of 5.76 lakh hectares as against the normal area (average of last three years) 8.35 lakh hectares. The production of Rabi cereals in the year 1985-86 is provisionally estimated at 9.54 lakh tonnes as against the normal production of 15.98 lakh tonnes. Similarly the production of Rabi pulses is provisionally estimated at 0.55 lakh tonnes as against noraml production of 1.31 lakh tonnes. The total production of food grains for the year 1985-86 is provisionally estimated at 25.91 lakh tones excluding summer bajra as against normal production (average of previous three years) of 51.32 lakh tonnes

The crop condition in Karnataka during 1985-86 was reported to be bad when compared to that in 1984-85. The districtwise crop yields of cereals, pulses and oil seeds between 1979 to 1985 have been given in App.VI-3/6. The crop losses in 1985-86 are estimated to be of the order of 50 to 60%. On an assessment of the overall crop prospects during 1985-86, it is observed that the production of food grains is likely to be far below the targets fixed for the season. Tentative estimate of Kharif crop is reported to be 41 lakh tonnes out of an expected target of 66 lakh tonnes. As far as the Rabi crop is concerned the shortfall from the target of 13.67 lakh tonnes is reported to be about 40% judging from the present trends.

The crop condition in Madhya Pradesh during 1984-85 was generally bad. The Agriculture Department officials are of the view that due to prolonged stoppage of rainfall in the monsoon months of 1985, the Kharif crop in the areas of Jhabua, Dhar (excluding Baduawar tehsil) and Barwani sub-division of Khargon district was destroyed. The maize crop has been destroyed and an yield of more than 50% is not expected for jowar and soyabean as indicated by the State authority.

The crop condition in Maharashtra during 1984-85 and 1985-86 was generally bad. The districtwise crop yields of Kharif jowar,bajra and Rabi jowar during 1984-85 crop season are given in App.VI-4/6. The Rabi and Kharifyields during 1985-86 were below normal because of deficient rainfall, lack of soil moisture and lack of adequate irrigation. The rainfed areas were the worst hit. Information in respect of 1985-86 season is still being compiled by the Directorate of Agriculture, Poona and is expected to be available in August 1986. However, the crop yields were reported to be about 25-30% below normal in irrigated areas and nearly 50% below normal in rainfed areas.

Due to deficient rains, lack of soil moisture and inadequate irrigation water the crop production in Rajasthan had suffered during the year 1985 as compared to 1984 and other normal years. The likely production against the targets and achievements of Kharif 1984 is given in App.VI-5/6. Reduction in production of cereals to the order of 50% can be observed from the App.VI-5/6 during Kharif 1985. The expected production is Rabi 1985 against the target is given in App.VI-6/6 which is below the expected production. Table 8.1 summaries the crop production of various drought affected States.

Table 8.1

Area (Lakh ha.) and Crop Production(Lakh tonnes) of Food Grains in Drought Prone States

States	Year						Remarks
	1983-84		1984-85		1985-86+		
	Area	Prod.	Area	Prod.	Area	Prod.	
Andhra Pradesh	92.33	118.80	79.45	96.12	-	-	
Gujarat	49.54	57.43	47.49	52.57	42.19	25.91*	
Maharashtra	-	-	6.82	4.14	-	-	Total of 16 districts
Rajasthan	-	-	-	36.90 (Kharif)	-	16.32 (Kharif)	
					40.00	54.20	(Target)
					33.28	46.49	(Likely achievements)

+ Indicates likely production as estimated by respective States.

* Excluding Summer Bajra

Source: Drought Memorandum of respective States for 1985.

9.0 INTERIM CONCLUSIONS AND PLAN FOR FURTHER WORK

9.1 General

9.1.1 Drought

Drought can be considered as the lack of water with impact to specific user-need(s) in a conceptual supply and demand relationship. During drought, the sub-normal water supplies adversely affect the balance between supply and demand. The overall water availability could form a better index of drought. Drought is a multifacet phenomenon where human activities and needs play an important role. There are different types of drought e.g. meteorological, agricultural and hydrological, however, all are caused due to lack of water availability. For understanding the situation of drought in a real sense, it is not sufficient to go by the variability in the total amount of rainfall alone, but also to analyse and understand the time and space variability in the total hydrologic process of the area. Unless the variability in the surface runoff, stream flow, soil moisture conditions and groundwater levels as well as demand patterns is analysed and understood properly, it is difficult to appreciate the varied nature of impact that a drought situation causes.

9.1.2 Proper data-base

For effective study of hydrological drought as a phenomenon and to plan suitable drought management strategies, relevant data must be readily available. Since drought is a multidisciplinary phenomenon, wide spectrum of data are required. Long term data are required for

prediction of trends while the real time data are required to regularly monitor the drought and assess its impact. In view of the present data situation, there is a need to set up proper data base in the country for drought studies.

9.1.3 Drought monitoring

Regular monitoring of drought causing variables, rainfall, streamflows, reservoir/tank levels, groundwater levels, soil moisture conditions, evaporation and evapotranspiration along with changing water-demand pattern at representative locations is must to properly analyse the drought situation and make short term forecasts about the drought situation using the real time data. Monitoring of on-going drought management measures is also to be considered.

There is a need to properly identify the type of data to be monitored and their formats, frequency and timing of monitoring etc. This would help in deciding the future course of action required to alleviate drought. Since drought monitoring involves multidisciplinary information, suitable mechanism is required to be developed to inter-weave various concerned departments at district and state level to collect, store and disseminate the data from a centralised place.

Network of soil moisture monitoring sites in the drought-prone areas is required to be established as soil moisture variation affects to crop growth directly. Efforts are required to use soil-moisture data for drought analysis and monitoring. Presently at very few places, soil moisture is being measured by IMD, Agricultural Research stations of ICAR and Universities. With the advent of sophisticated equipment like neutron-moisture meter, the regular monitoring of soil moisture may be speeded up. Efforts are also needed to gear up the application of remote sensing techniques for soil moisture monitoring in drought-prone areas.

9.2 Interim Conclusions

On the basis of limited available data and preliminary analysis some interim conclusions have been made which are discussed in this section.

The rainfall patterns of 1984 and 1985 over drought affected meteorological sub-divisions indicate that Saurashtra region had maximum rainfall deficit during the monsoon of 1985 which was of the order of 55% as against 12% in 1984. Maharashtra had monsoon deficit of the order of 30% to 40%. In Karnataka both South-West and North-East monsoons failed during 1985 resulting in severe drought situation. Telangana and Rayalseema region of Andhra Pradesh continue to have rainfall deficits of about 30%. The categorisation of districts on the basis of this years and last year's rainfall deficit indicates that in a number of districts there was continuous effect of deficit i.e. persistance. Mahboobnagar in Andhra Pradesh appears to be having deficit for the last 3 years in succession, Prakasam and Cuddapah for the last 2 years in succession. In Gujarat except the Kutch, the other areas had a deficit of about 50% to 60% in 1985. Due to non-availability of rainfall data in Karnataka for the past few years, no comparative study could be made. In Madhya Pradesh Dhar,Jhabua, Betul and Shahdol recorded a rainfall deficit of about 30% to 40% in 1985 whereas Khargon is having rainfall deficit for the second year in succession. In Maharashtra 11 districts - Nasik, Ahmednagar, Solapur, Sangli, Aurangabad, Jalna, Parbhani, Beed, Nanded, Osmanabad and Latur are having persistent rainfall deficits for the last 2 years in succession. In Rajasthan, Tonk, Jodhpur and Barmer also recorded rainfall deficits for the second year in succession.

In Andhra Pradesh, data of two reservoirs Pedderu and Bahuda

indicate relatively lower reservoir levels during end of 1985 and beginning of 1986 as compared to their corresponding levels of past few years. In Gujarat, the data of surface water storages for Saurashtra region indicate significant reductions during 1985 causing irrigation and drinking water problems. Surface water storages in Rajkot, Jamnagar and Amreli were so poor that no area was irrigated. In Karnataka, Malaprabha reservoir was affected in 1985 drought whereas Ghataprabha reservoir appears to have sufficient water. The flow data of Bhima and Sina (tributaries of Krishna) in Maharashta indicate significantly low flows during 1985 as compared to previous years. The available water in the major and medium irrigation tanks in Maharashtra confirms the severe drought situation. The deficit in reservoir storage (available water as percentage of designed live storage capacity) of the order of 70% to 80% has been observed in some of the cases in Maharashtra. Similar trends were observed in Madhya Pradesh and Rajasthan. The tanks located at Dungarpur and Banswara in Rajasthan had significantly more deficit during 1985. Based on various observations it can be deduced that the deficit in reservoir storages is caused not only due to failure of monsoon in current year but also due to lack of the carry over-storage from the previous years.

The groundwater levels in Prakasam district of Andhra Pradesh show decreasing trends in accordance with the decreasing rainfall trends. However, well-hydrographs in few blocks of Anantpur, Chittoor and Cuddapah districts do not show significant decreasing

trends. The groundwater hydrographs in Karnataka show conspicuous decreasing trends. It is inferred that this might be due to the increased abstraction of groundwater as a result of which the system is tending to adjust to a new equilibrium. Groundwater in western Madhya Pradesh is also observed to be affected. The pre-monsoon levels in the wells located in districts Dhar and Jhabua show drying of wells. The post-monsoon levels are observed to go down progressively with each year indicating insufficient recharge. In Maharashtra, the lowering of groundwater tables and the problem of wells going dry during 1985 is evident from the data of Beed and Ahmednagar which are facing drought for the second consecutive year. Data for other districts could not be obtained. No conclusion can be drawn about Gujarat and Rajasthan as the data were not readily available. Soil moisture data of sufficient magnitude and duration were not available to draw pertinent conclusions. Crop production in general was affected during the Kharif and Rabi 1985-86. This is observed from the available crop yields in different States.

9.3 Future Actions

9.3.1 Programme of the Institute

The Institute plans to take up in-depth analysis of some selected areas both at macro and micro levels (i.e. Taluk/district level) in a systematic and scientific manner which will be presented in final report. In future studies, the aspects of water demand are also intended to be studied while analysing drought. An integrated approach of drought giving weightage to different aspects of water e.g.

rainfall, surface water, soil moisture and groundwater is proposed to be adopted. Study of the existing drought alleviation and management measures and subsequent development of suitable drought management strategies are also proposed in future programmes. The data collection in light of these studies are to be made.

9.3.2 Actions suggested for other organisations

The need for proper data-base, regular drought monitoring, soil moisture monitoring etc have been already emphasized. A drought monitoring cell may be created at district/state levels to look into the job of drought monitoring and coordinating the activities with concerned departments. Each department concerned should have a proper data-format and establish network of monitoring sites to continuously take the stock of situation. There is need to have uniform guidelines also for data collection, compilation and processing. In each concerned department , person(s) should be specifically assigned the job of drought monitoring.

APPENDIX-I

LIST OF THE HYDROLOGICAL AND OTHER RELEVANT DATA COLLECTED

Sl.No.	Aspect		Information
A.	General Information	1.	Map of the state showing drought affected areas
		2.	Map of the concerned districts showing drought affected areas.
		3.	Maps showing locations of rain gauge and stream gauge sites.
		4.	State map showing the location of reservoirs and major,medium and minor irrigation projects.
		5.	Maps showing the distribution of canal network and the canal command areas.
		6.	Maps showing the locations of percolation tanks.
		7.	Maps showing the location of open and tube wells.
		8.	Land use maps for the concerned districts.
		9.	Maps showing different soil types in concerned districts.
		10.	Socio-economic details of the state and districts.
		11.	DPAP/DRDA memoranda and reports.
		12.	Relevant reports prepared on drought by the State Irrigation, Groundwater, Agriculture Public Health and Statistics Departments.
	Hydrological data		
	1. Meteorological data		a. Rainfall data b. Pan evaporation data
	2. Surface water		a. Stream flow/Runoff discharges b. Design details of the major, medium and minor irrigation schemes in the state. c. Rating charts for the major,medium and minor irrigation projects in the state. d. In flows and reservoir/tank gauge levels for the major, medium and minor tanks. e. Discharges/outflows from the major,medium and minor tanks/reservoirs. f. Yearwise area irrigated
	3. Groundwater data		a. Groundwater table observations. b. Draft from wells c. Capacity of pumping units and running hours. d. Pumping test data for aquifer characteristics.
	4. Soils and Crops		a. Soil types and characteristics b. Soil moisture data c. Cropping pattern d. Crops types and varieties e. Consumptive requirements of crops f. Contingency crop planning details g. Crop production
	5. Public Health Engineering		a. Water demand for both urban and rual areas b. Water supply data: i) System of Water supply ii) Capacity

APPENDIX-II

LIST OF OFFICES AND PLACES FROM WHERE DATA AND INFORMATION WERE COLLECTED

ANDHRA PRADESH

Hyderabad	Irrigation Office State Groundwater Board Office Bureau of Economics & Statistics Panchayat Raj and Rural Development Department of Agriculture C.W.C. P.H.E.D.
Mahaboob Nagar	Irrigation Office Deputy Director (Agriculture) Planning Office
Prakasam	Irrigation Circle Office Deputy Director(Agriculture) Deputy Director (Water Management) Panchayat Raj Office
Anantapur	Irrigation Circle Office D.P.A.P. Division I.B.C. D.R.D.A. Office District Planning Office Agricultural Research Station
Chittoor	Irrigation Circle Office Chittoor Irrigation Office (Madanpalli) A.P.I.D.C. Madanpalli D.R.D.A.Chittoor
Cuddapah	Irrigation Circle Office D.R.D.A. Office

GUJARAT

Gandhi Nagar	Secretary and Commissioner (RD),Govt of Gujarat Chief Engineer (Panchayat),Gujarat Secretary Irrigation,Gujarat Superintending Engineer,Gandhinagar Panchayat,Irrigation Circle Chief Engineer,Gujarat Irrigation Department Director,Gujarat Water Resources Development Corpn. Secretary,Gujarat Revenue Department Secretary,CADA,Gujarat Gujarat Water Supply and Sewerage Board
Rajkot	Zilla Panchayat Raj,Rajkot Deputy Director(Agriculture) Superintending Engineer, Minor Irrigation,Rajkot Circle

	Soil Officer, Soil Survey Department
	Superintending Engineer, P.H.E.D.
	Irrigation Department
Ahmedabad	W.R.I. Bhadra Fort
	Director, Agriculture Gujarat State
	Eastern Gauging Division, Central Water Commission
	Flood Control Cell
	Additional Director of Agricultural Sciences
	Deputy Director, Central Flood Forecasting Division
	Central Water Commission
KARNATAKA	
Bangalore	Director, Dept. of Mines & Geology, Govt of Karnataka
	Director, CGWB, South-Western Region
	Director, DPAP/Rural Development
	Chief Engineer, WRDO
	Director, Bureau of Economics and Statistics
	Chief Engineer, Minor Irrigation
	Director Department of Revenue
	Director, Department of Agriculture, Govt of Karnataka
	Directorate of Survey Settlement and Land Records
	Directorate of State, Groundwater Cell, R.C. Road
	C.E., Public Health Engg. & PWD, Govt of Karnataka
	Central Water Commission
Kolar	E.E., Minor Irrigation
	Deputy Commissioner (Special)
	DRDA
	Soil Conservation Department
	Irrigation Department.
Tumkur	E.E., Minor Irrigation
	Deputy Commissioner (Special)
	DRDA
	Soil Conservation Dept.
	Irrigation Dept.
Chitradurga	E.E., Minor Irrigation
	Incharge of the DPAP Projects
	DRDA
	Soil Conservation Dept.
	Irrigation Dept.
Belgaum	E.E., Minor Irrigation
	Incharge of the DPAP Projects
	DRDA
	Soil Conservation Dept.
	Irrigation Dept.
	Asstt. Geologist, SGWC, Belgaum
Dharwad	E.E., Minor Irrigation
	DRDA
	Soil Conservation Dept.
	Irrigation Dept.
Mysore	DRDA, Soil Conservation Dept., &
	Irrigation Dept.

MADHYA PRADESH

Bhopal	Engineer-in-Chief, Irrigation Dept.
	Director(D&H) Bodhi,CDO
	Chief Engineer,State Groundwater Survey Board
	Deputy Commissioner, Rural Development Commission
	Additional Director,Dept of Agriculture
	Dy.Director Statistics,Dept of Agriculture
	Chief Engineer,PHE,Satpura
	Regional Meteorological Centre of IMD
	S.E./E.E./A.E.,Narmada Tapti Basin,Irrg.Dept.,Bhopal
	S.E.,Narmada Control Authority
	Regional Director,Central Groundwater Board
Dhar,Jhabua, Khargone,Betul, Shahdol,Sidhi	District Collector
	District Statistical Officer
	Supdt.Land Records
	S.E.(Irrigation Circle)
	Dy.Director,Agriculture
	Assistant Geohydrologist
	Executive Engineer ,PHED

MAHARASHTRA

Bombay	Irrigation Dept,Maharashtra
	Secretary,Rural Development,Dept.of Agriculture
	Dept of Forest and Revenue
Pune	Asstt.Director,Ground Water Survey & Dev.Agency under Dept.of Rural Development.
	Met. Gr.I.,Drought Research Unit,IMD
	Pune Supdt.Engineer,Poona Irrigation Circle
	Director of Agriculture
	CE.(Irrigation),Zilla Parishad
	Pune Gauging Division, C.W.C.
Aurangabad	Chief Engineer,Aurangabad,Irrigation Circle
	Executive Engineer,Aurangabad Irrigation Circle,
	S.E. Jayakwadi Proj.Stage-I,Aurangabad Irrg. Circle Department
Solapur	Krishi Vidhyapeth,under All India Coordinated Dry Land Farming Project of ICAR,Solapur.
	Zilla Parishad
	DRDA
	Chief Geologists
	Agronomist & Agr.Meteorologist NAPP Scarcity Zone, Mahatma Phule Krishi Vidhyapeth
Beed	Senior Geologist
	GSDA
	Collector's office
	Zilla Parishad
	E.E.Irrigation Department

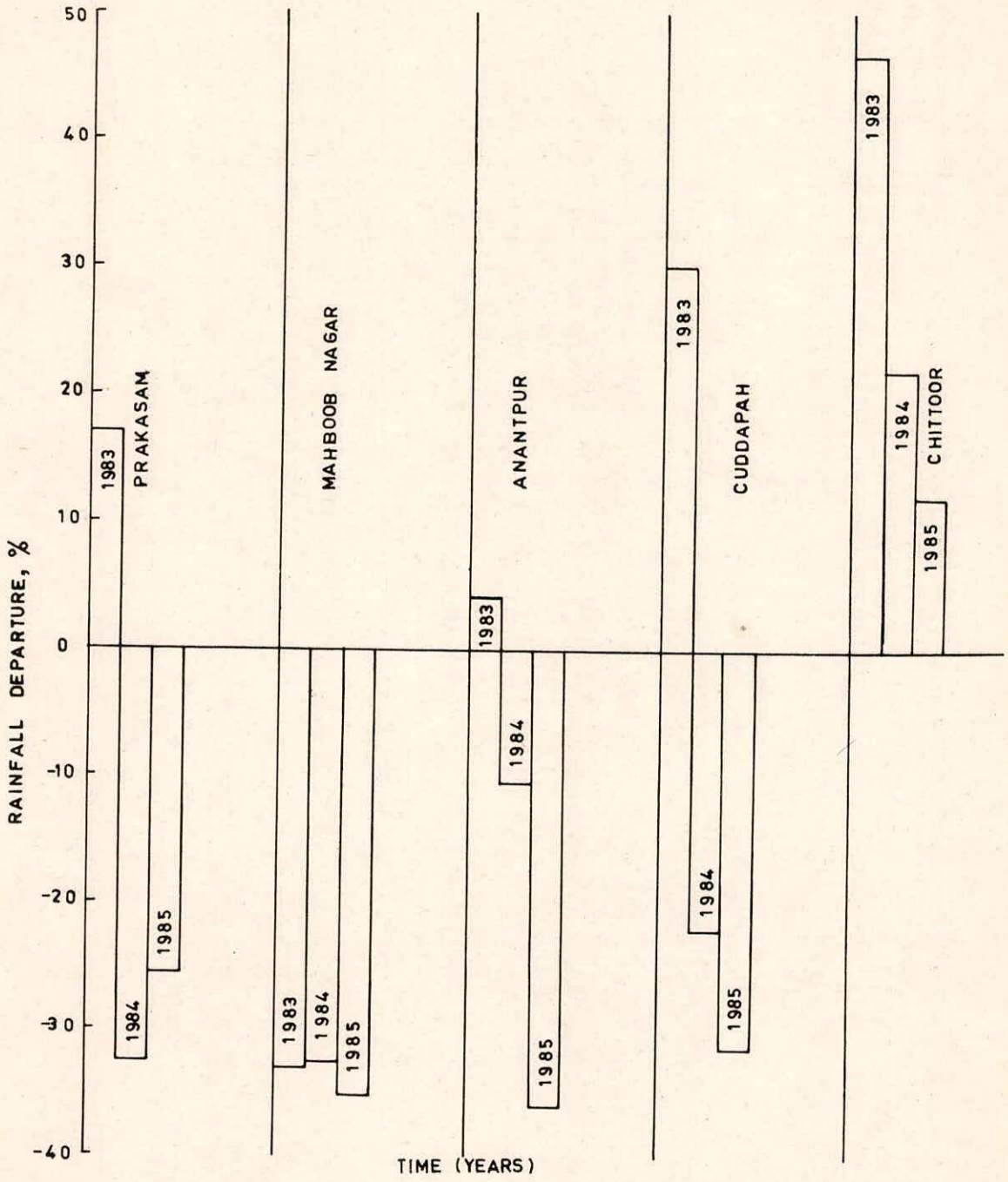
Parbhani	Agriculture Meteorology Dept., Marathwada Agricultural University, Collector's Office and Zilla Parishad
Ahmad Nagar	Zilla Parishad Collector's office
Satara	Collector's Office, GSDA, Zilla Parishad
Sangli	Collector's Office, Zilla Parishad
RAJASTHAN	
Jaipur	Chief Engineer, Irrigation Department Dy.Director(Hydrology), Rajasthan Irrigation Dept. S.E.(Special Schemes), Rajasthan Irrigation Dept. Director, Irrigation Research, Rajasthan Irrg.Dept. Agronomist (Irrigation) Rajasthan Irrigation Dept. Directorate of Agriculture, Rajasthan S.E.(Soil Conservation), Dept.of Agr., Rajasthan Secretary, Special Schemes Organisation, Rajasthan Secretary, Relief Rajasthan Dept of Economics & Statistics, Rajasthan Directorate of Evaluation, Rajasthan Public Health Engg.Dept. Rajasthan Soil Survey Officer, Rajasthan Central Water Commission field office Central Ground Water Board, Regional Office
Ajmer	Irrigation Department
Udaipur	Agriculture Department
Banswara	Soil Conservation Office
Durgarpur	District Rural Development Authority (DRDA)
Barmer	Land Record Office
Jodhpur	Groundwater Department Central Arid Zone Research Institute Chief Engineer, Rajasthan State Ground Water Dept.

ANNEXE

SEASONAL RAINFALL PATTERN IN DROUGHT AFFECTED METEOROLOGICAL SUB-DIVISIONS OF INDIA

Sl. No.	Sub-Divisions	1984								1985							
		Jan. - Feb.		March - May		June - Sept.		Oct. - Dec.		Jan. - Feb.		March - May		June - Sept.		Oct. - Dec.	
		Actual	% Departure	Actual	% Dep.	Actual	% Dep.	Actual	% Dep.	Actual	% Departure	Actual	% Dep.	Actual	% Dep.	Actual	% Dep.
1.	West Rajasthan	8	-8	2	-89	238	-19	0	-97	0	-97	35	96	214	-27	7	-52
2.	East Rajasthan	1	-85	1	-95	584	-9	0	-99	2	-78	14	-29	500	-24	98	191
3.	West Madhya Pradesh	43	123	3	-89	867	-8	11	-79	8	-64	23	0	823	-13	201	282
4.	East Madhya Pradesh	81	108	40	-24	1064	-9	27	-66	38	-16	18	-66	1056	-9	86	14
5.	Gujarat Region, Daman, Dadra and Nagar Haveli	0	-100	0	-100	776	1	1	-95	0	-100	9	-14	364	-56	162	424
6.	Saurashtra, Kutch and Diu	0	-100	0	-100	469	-12	0	-99	0	-100	8	32	238	-55	63	87
7.	Madhya Maharashtra	19	283	13	-72	440	-15	130	26	3	-53	28	-40	344	-32	109	2
8.	Marathwada	24	106	0	-99	433	-33	116	42	5	-62	21	-33	375	-42	72	-11
9.	Vidarbha	55	164	9	-77	592	-40	64	-18	31	34	23	-43	403	-29	138	82
10.	Coastal Andhra Pradesh	48	219	27	-62	400	-27	222	-35	47	176	30	-56	511	-7	407	20
11.	Telangana	6	-41	38	-41	585	-24	98	-10	8	-28	58	-10	551	-29	110	2
12.	Rayalaseema	17	73	39	-42	314	-25	105	-41	11	2	28	-58	288	-31	197	12
13.	North Interior Karnataka	8	-3	37	-49	560	-2	103	-17	7	-28	73	-2	429	-26	115	-7
14.	South Interior Karnataka	8	-15	213	40	356	-5	107	-51	5	-58	105	-31	269	-28	90	-59

Dep. % indicates higher (+) or lower(-) than normal.



DISTRICTWISE PERCENTAGE DEPARTURES OF RAINFALL (A.P.)

MONTHLY RAINFALL DEPARTURE IN PRAKASAM DISTRICT (A.P.)

Year / Month	1983			1984			1985			Re-mark
	Rainfall mm	Normal Rainfall mm	Diff. from Normal	Rainfall mm	Normal Rainfall mm	Diff. from Normal	Rainfall mm	Normal Rainfall	Diff. from Normal	
Jan.	Nil	1.3	-1.3	0.8	1.3	-0.5	39.9	1.3	+38.6	
Feb.	11.3	1.8	+9.5	35.4	1.8	+33.6	Nil	1.8	-1.8	
March	0.8	1.0	-0.2	8.5	1.0	+7.5	11.1	1.0	+10.1	
April	5.6	2.5	+3.1	11.7	2.5	+9.2	5.6	2.5	+3.1	
May	64.2	87.4	-23.2	2.2	87.4	-85.2	9.2	87.4	-78.2	
June	54.2	53.9	+0.3	39.4	53.9	-14.5	64.8	53.9	+10.9	
July	194.8	94.0	+100.8	158.1	94.0	+64.1	106.5	94.0	+12.5	
Aug.	198.9	87.9	+111.0	8.8	87.9	-79.1	51.3	87.9	-36.6	
Sept.	239.7	110.5	+129.2	60.5	110.5	-50.0	79.5	110.5	-31.0	
Oct.	138.0	214.6	-76.6	141.7	214.6	-72.9	185.7	214.6	-28.9	
Nov.	76.6	175.5	-98.9	87.3	175.5	-88.2	79.1	175.5	-96.4	
Dec.	12.6	21.3	-8.7	20.7	21.3	-0.6	N.A.	21.3	-	
Total	996.7	851.7	145.0	575.1	851.7	-276.6	632.7	851.7	-219.0	

Dep. % indicates higher (+) or lower(-) than normal.

MONTHLY RAINFALL DEPARTURE IN M.NAGAR(A.P.)

Year / Month	1983			1984			1985			Re-mar
	Rainfall mm	Normal Rainfall mm	Diff. from Nor-mal	Rain-fall mm	Normal Rain-fall mm	Diff. from Nor-mal	Rain-fall mm	Normal Rain-fall	Diff. from Nor-mal	
Jan.	Nil	5.8	-5.8	Nil	5.8	-5.8	2.4	1.2	1.2	
Feb.	Nil	9.7	-9.7	2.0	9.7	-7.7	Nil	9.7	-9.7	
March	Nil	7.1	-7.1	6.5	7.1	-0.6	8.6	7.1	+1.5	
April	2.4	17.3	-14.9	35.0	17.3	+17.7	20.4	17.3	+3.1	
May	36.4	28.7	+7.7	4.2	28.7	-24.5	12.6	27.0	-14.4	
June	79.8	112.0	-32.2	58.1	112.0	-53.9	60.9	112.0	-51.1	
July	169.4	176.3	-6.9	214.3	176.3	+38.0	162.7	176.3	-13.6	
Aug.	153.6	146.3	+7.3	57.8	146.3	-88.5	40.2	146.3	-106.1	
Sept.	8.0	185.2	-177.2	89.0	185.2	-96.2	114.1	185.2	-71.1	
Oct.	71.3	74.4	-3.1	64.9	74.4	-9.5	79.6	74.4	+5.2	
Nov.	4.4	25.7	-21.3	1.6	25.7	-24.1	Nil	25.7	-25.7	
Dec.	4.1	3.8	+0.3	0.7	3.8	-3.1	9.7	3.8	+5.9	
Total	529.4	792.3	-262.9	534.1	792.3	-258.2	511.2	790.6	-279.4	

Dep.% indicates higher(+) or lower(-) than normal.

MONTHLY RAINFALL DEPARTURE IN ANANTPUR(A.P)

Year / Month	1983			1984			1985			Re-mar
	Rainfall mm	Normal Rainfall mm	Diff. from Nor-mal	Rain-fall mm	Normal Rain-fall mm	Diff. from Nor-mal	Rain-fall mm	Normal Rain-fall	Diff. from Nor-mal	
Jan.	Nil	4.8	-4.8	Nil	4.8	-4.8	1.9	4.8	-2.9	
Feb.	Nil	6.1	-6.1	5.9	6.1	0.2	Nil	6.1	-6.1	
March	Nil	3.3	-3.3	48.4	3.3	+45.1	4.8	3.3	+1.5	
April	0.2	15	-14.8	25.1	15	+10.1	18.0	15.0	+3.0	
May	62.0	15	+47.0	53.3	15	+38.3	31.3	15.0	+16.3	
June	82.9	49.8	+33.1	14.5	49.8	-35.3	39.4	49.8	-10.4	
July	28.5	52.1	-23.6	137.2	52.1	+85.1	75.2	52.1	+23.1	
Aug.	109.8	84.6	+25.2	12.5	84.6	-72.1	24.4	84.6	-60.2	
Sept.	203.2	149.9	+53.3	90.7	149.9	-59.2	38.0	149.9	-111.9	
Oct.	56.1	99.3	-43.2	80.4	99.3	-18.9	99.2	99.3	-0.1	
Nov.	3.6	58.2	-54.6	7.2	58.2	-51.0	13.5	58.2	-44.7	
Dec.	22.3	6.6	+15.7	11.4	6.6	+4.8	2.1	6.6	-4.5	
Total	568.6	544.7	23.9	486.6	544.7	-58.1	347.8	544.7	-196.9	

Dep. % indicates higher (+) or lower(-) than normal.

MONTHLY RAINFALL DEPARTURE IN CUDDAPAH DISTRICT(A.P.)

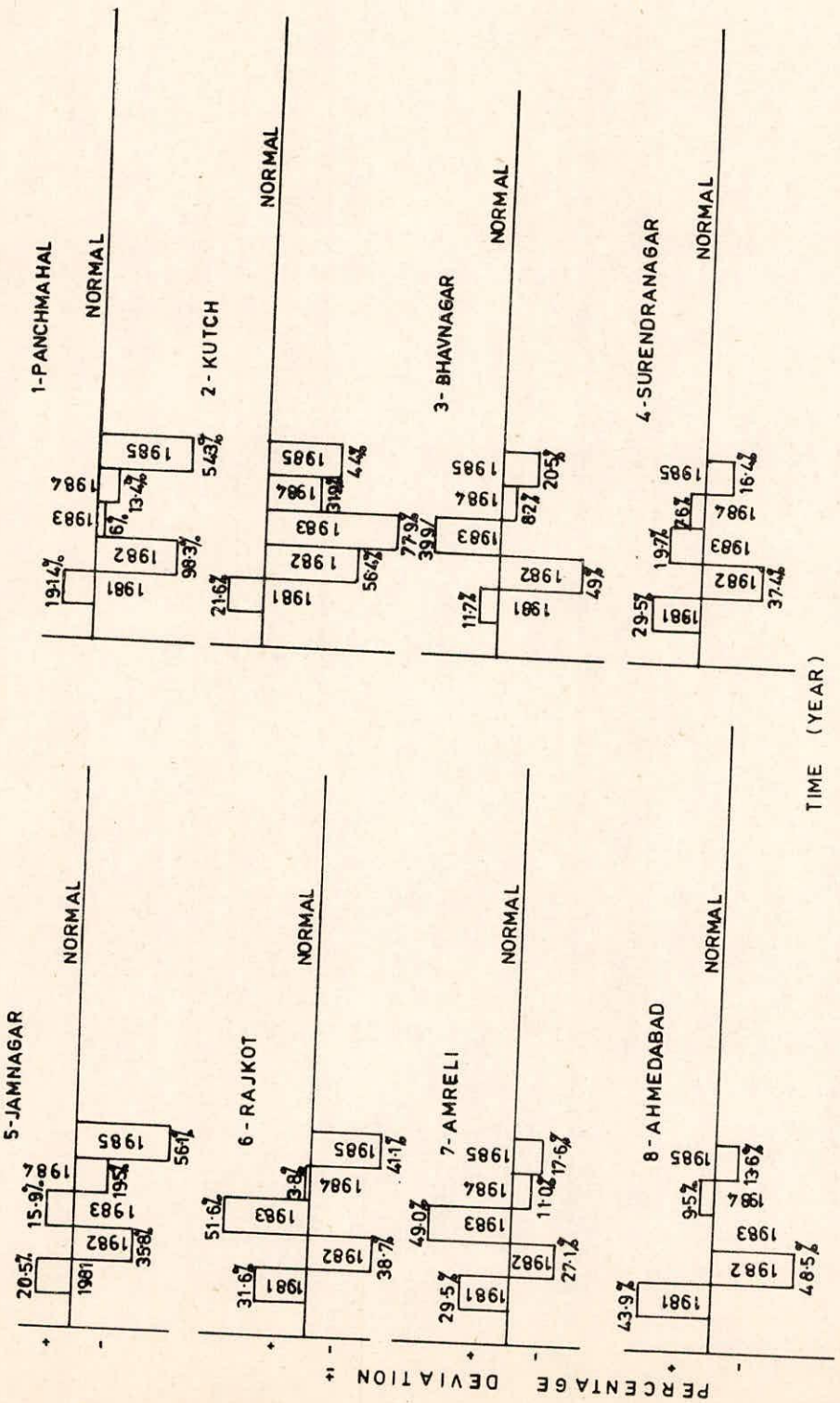
Year / Month	1983			1984			1985			Remark
	Rainfall mm	Normal Rainfall mm	Diff. from Normal	Rainfall mm	Normal Rainfall mm	Diff. from Normal	Rainfall mm	Normal Rainfall mm	Diff. from Normal	
Jan.	Nil	11.4	-11.4	Nil	11.4	-11.4	22.5	11.4	+11.1	
Feb.	1.7	3.3	-1.6	43.3	3.3	+400	Nil	3.3	-3.3	
March	Nil	5.8	-5.8	15.2	5.8	+9.4	1.3	5.8	-4.5	
April	38.2	12.9	+25.3	7.7	12.9	-5.2	15.2	12.9	+2.3	
May	71.7	38.6	+33.1	7.4	38.6	-31.2	5.3	38.6	-33.3	
June	39.1	71.6	-32.5	28.5	71.6	-43.1	54.8	71.6	-16.8	
July	102.4	106.9	-4.5	128.8	106.9	+21.9	126.3	106.9	+79.4	
Aug.	216.0	121.4	+94.6	21.6	121.4	-99.8	52.8	121.4	-68.6	
Sept.	317.9	154.9	+163.0	147.2	154.9	-7.7	21.0	135.0	-114.0	
Oct.	120.7	107.7	+13.0	76.7	107.7	-31.0	125.9	107.7	+18.2	
Nov.	36.9	95.3	-58.4	64.4	95.3	-30.9	43.0	95.3	-52.3	
Dec.	26.6	17.8	+8.8	40.0	17.8	+22.2	30.3	17.8	+12.5	
Total	971.2	747.6	223.6	580.8	747.6	-166.8	498.4	727.7	-229.3	

Dep. % indicates higher (+) or lower (-) than normal.

MONTHLY RAINFALL DEPARTURE IN CHITTOR DISTRICT(A.P.)

Year / Month	1983			1984			1985			Re-mark
	Rainfall mm	Normal Rainfall mm	Diff. from Normal	Rainfall mm	Normal Rainfall mm	Diff. from Normal	Rainfall mm	Normal Rainfall mm	Diff. from Normal	
Jan.	Nil	10.4	-10.4	7.8	10.4	-2.6	23.4	10.4	+13.0	
Feb.	Nil	6.3	-6.3	7.3	6.3	+1.0	Nil	6.3	-6.3	
March	7.2	1.3	+5.9	70.5	1.3	+69.2	5.0	1.3	3.7	
April	5.5	6.3	-0.8	19.1	6.3	+12.8	11.3	6.3	5.0	
May	54.7	45.0	9.7	16.5	45.0	-12.5	19.9	45.0	-25.1	
June	63.6	73.1	-9.5	19.3	73.1	-53.8	62.3	73.1	-10.8	
July	114.3	97.8	+16.5	156.0	97.8	+58.2	165.1	97.8	+67.3	
Aug.	164.8	86.9	+77.9	11.9	86.9	-75.0	94.4	86.9	+7.5	
Sept.	271.9	90.4	+181.5	205.4	90.4	+115.0	50.8	90.4	-39.6	
Oct.	151.6	123.7	+27.9	107.8	123.7	-15.9	108.2	123.7	-15.5	
Nov.	36.2	93.5	-57.3	157.2	93.5	+63.7	190.0	93.5	+96.5	
Dec.	139.1	53.9	+85.2	62.4	53.9	+8.5	42.1	53.9	-11.8	
Total	1008.9	688.6	320.3	841.2	688.6	152.6	772.5	688.6	83.9	

Dep. % indicates higher (+) or lower (-) than normal.



DISTRICTWISE PERCENTAGE DEVIATION IN MONSOON RAINFALL IN GUJARAT STATE

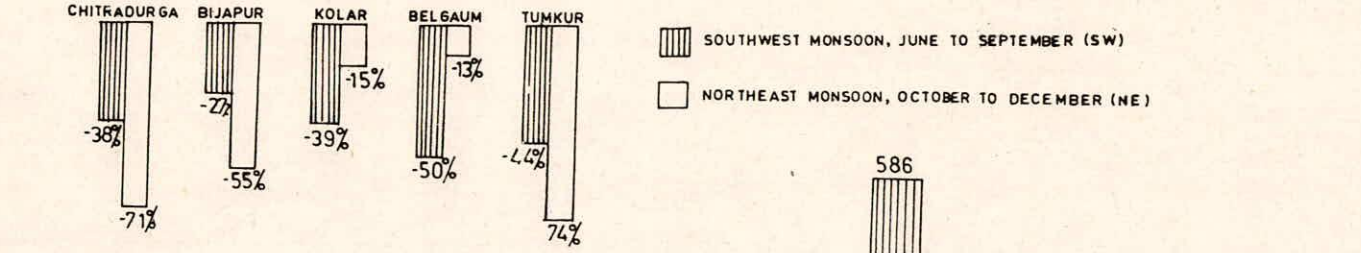
DEPARTURES IN RAINFALL DURING MONSOON PERIODS IN KARNATAKA

SEASONAL DEFICITS IN RAINFALL FOR KARNATAKA, 1985

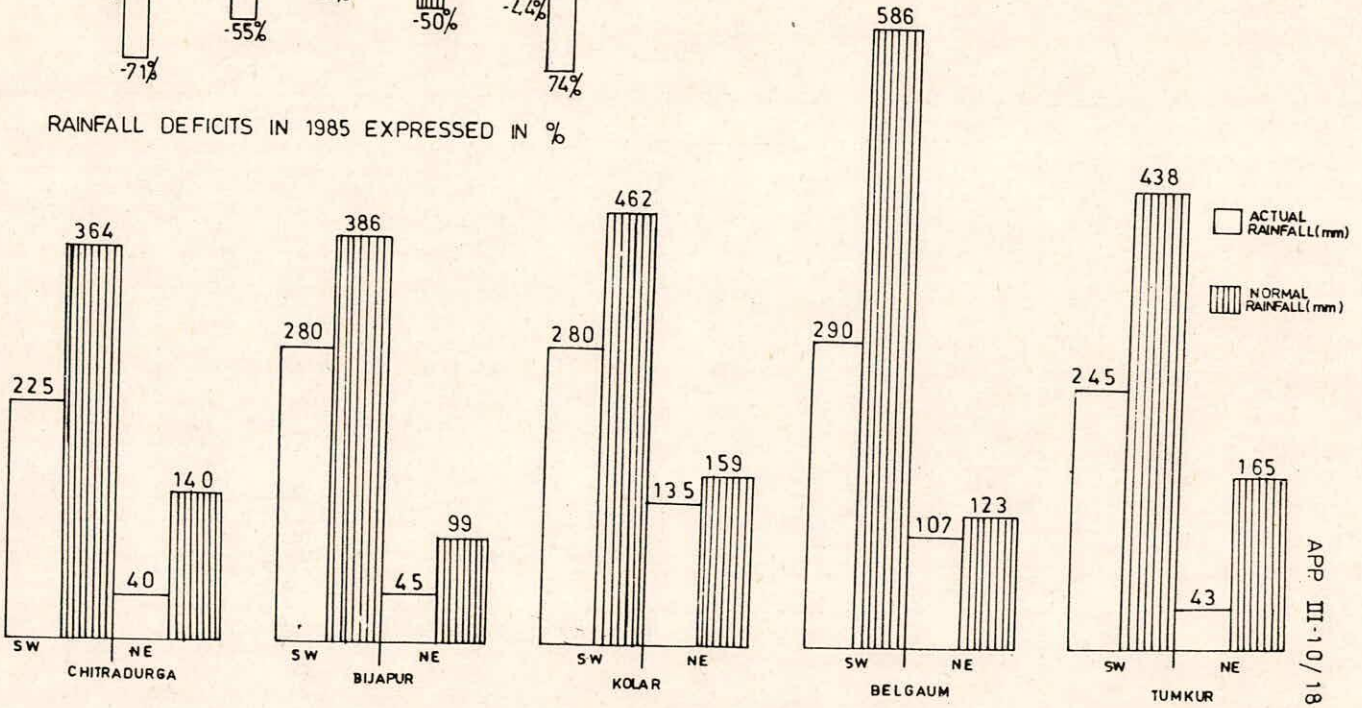
S. No.	MONTH	MONSOON	CHITRADURGA			BIJAPUR			KOLAR			BELGAUM			TUMKUR		
			mm Actual	Normal	% Deficit	mm Actual	Normal	% Deficit	mm Actual	Normal	% Def.	mm Actual	Nor.	% Def.	mm Act.	Nor.	% Def.
1.	June	South West	45			70			45			85			20		
2.	July		40			70			70			75			70		
3.	August		30			45			30			90			15		
4.	September		110			95			135			40			140		
			225	364	-38	280	386	-27	280	462	-39	290	586	-50	245	438	-44
1.	October	North East	35			30			60			102			25		
2.	November		5			10			67			5			15		
3.	December		-			5			8			-			3		
			40	140	-71	45	99	-55	135	159	-15	107	123	-13	43	165	-74

APP. III-9/18

RAINFALL DEFICITS IN KARNATAKA, 1985



RAINFALL DEFICITS IN 1985 EXPRESSED IN %



APP III-10/18

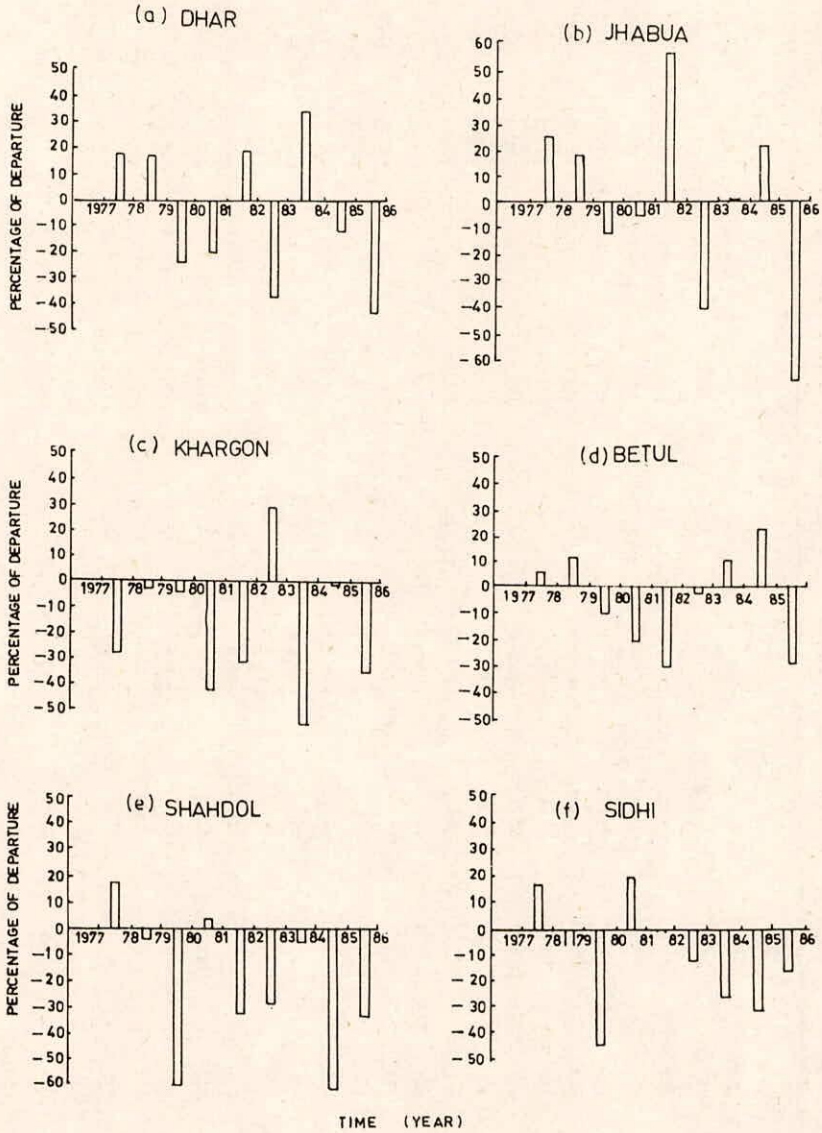
ACTUAL RAINFALL DEFICITS DURING S.W. AND N.E. MONSOON PERIODS OF 1985 EXPRESSED IN MM. (KARNATAKA)

SEASONAL(JUNE - SEPT.) RAINFALL DEPARTURE IN MADHYA PRADESH

SL. NO.	YEAR	DHAR			JHABUA			KHARGON			BETUL			SHAHDOL			SIDHI			REMARKS
		ACT. mm	NOR.	DEP. EXC.	ACT. mm	NOR.	DEP. EXC.	ACT: mm	NOR.	DEP. EXC.	ACT. mm	NOR.	DEP. EXC.	ACT. mm	NOR.	DEP. EXC.	ACT. mm	NOR.	DEP. EXC.	
1.	1977	1000	847	+18%	913	728	+25%	566.2	790	-28%	1102	1034	+6%	1394	1194	+16.7%	1476	1238	16.7%	
2.	1978	990.2		+17%	864		+18%	771		-2.4%	1155		11.7%	1149		-4%	1127		-5.6%	
3.	1979	647.3		-24%	638.3		-12%	454.4		-42%	933		-98%	476		-60%	668		-44%	
4.	1980	676		-20%	694.3		-4.7%	547		-31%	812		-21%	1248		+4%	1438		+20%	
5.	1981	1010		+19%	1126		+54%	1027		+ 30%	718		-31%	797		-33%	1180		-1.2%	
6.	1982	526		-38%	418		-42%	354		-55%	1016		-1.7%	850		-29%	1044		-12%	
7.	1983	1137		+34%	725		-0.4%	722		-8.6%	1152		++11.4%	1134		-5%	880		-26%	
8.	1984	746		-11.9	886		+21%	516		-35%	1279		23.7%	468		-60%	822		-31%	
9.	1985	474		-44%	227.7		-69%	393		-50%	733		-29%	793		-33.6%	1003		-16%	
10.	1986																			

* Deficits are given in negative values and the excess are given as positive.
* ACT. = Actual
* NOR. = Normal
* DEP. = Deficit
* EXC. = Excess

Dep. % indicates Higher (+) or lower (-) than normal.



DEFICIT IN SEASONAL PRECIPITATION (Ist JUNE 30th SEP.)
IN DROUGHT PRONES DISTRICT OF M.P.

MONTHLY (JUNE - SEPTEMBER) DEFICITS IN PRECIPITATION IN MADHYA PRADESH

S.No.	DISTRICT	MONTH	YEARS								
			1977	1978	1979	1980	1981	1982	1983	1984	1985
1.	DHAR	JUNE	+47	-28	-52	+41	+14	-42.3	+21.4	-85	-90
		JULY	-25	+2.6	-69	-62.3	-26	-7.0	-0.1	-50	-48.5
		AUGUST	+67	+102.8	+89	+50	+121	-42	+117	+124	-27
		SEPTEMBER	-1.1	-33.6	-73	-94	-36.7	-78	-6.5	NA	-21.6
2.	JHABUA	JUN	+65.7	-21.6	-35.3	+104.7	+34	-26.9	NA	-83.7	-91.6
		JUL	-10.3	+8.0	-54	-37.6	+20.8	-33.5	+30.8	-32.1	-76.5
		AUG	+26.6	+115.2	+84	+45.4	+127.6	-50.2	+29.8	+167	-52.0
		SEP	+58.5	-65.3	-52.5	NA	+31.25	-61.0	-22.0	-90	-59.7
3.	KHARGONE	JUN	-65.0	-22	+5.1	+108.0	-29.6	-79.0	-66.7	-40.5	-42.0
		JUL	-60.0	-20.6	-62.0	-73.0	-14.0	-27.0	-25.6	-67.1	-24.1
		AUG	+35.0	+118.7	-0-	-11.0	+187.0	-55.0	+76.8	+73.9	-60.0
		SEP	-12.7	-80.0	-93.0	-96.0	-8.7	-80.0	-20.6	-88.0	-88.5
4.	BETUL	JUN	+84.0	+29.0	+7.0	+27.0	-8.2	-15.0	-60.8	-43.6	-5.80
		JUL	-52.0	-7.0	-29.0	-21.0	-33.7	-2.0	-42.5	-50.0	-48.75
		AUG	+15.0	+68.0	+53.0	-4.3	-59.0	+30	+70.8	+222.0	-15.36
		SEP	+42.0	-83.0	-86.0	-88.0	+1.2	-41.7	+82.6	-89.0	-32.0
5.	SHAHDOL	JUN	+260.0	-20.0	-67.0	-18.5	-25.0	-33.6	-72.8	-70.36	-49.6
		JUL	-29.0	-4.4	-47.0	+4	-38.5	-62.6	+28.8	-69.46	-36.23
		AUG	+39.0	-0.1	-57.0	-7.4	-35.6	+33.0	-42.5	+11.1	-20.5
		SEP	-46.0	-42.0	-83.0	+43.5	-25.8	-70.5	+48.85	-84.9	-39.2
6.	SIDHI	JUN	+76.0	+110.0	+12.0	+54.0	-31.7	-62.0	-30.1	-48.55	-33.9
		JUL	-5.0	-37.0	-44.0	+43.0	+46.0	-28.0	-11.15	-50.1	-18.7
		AUG	+22.0	-66.0	-61.0	-15.0	-61.0	+32.9	-52.3	+1.2	-18.4
		SEP	+33.0	-10.3	-57.0	+4.4	+32.3	-61.0	-0.9	-63.6	-11.34

Dep. % indicates higher (+) or lower (-) than normal.

Districtwise Monthly Rainfall of Monsoon Season 1984 for Maharashtra

Name of District	June		July		August		September		Season (June-Sept.)	
	Actual mm	Dep.%	Actual mm	Dep.%	Actual mm	Dep.%	Actual mm	Dep.%	Actual mm	Dep.%
Nasik	113.8	-30.6	212.6	-14.5	210.0	-30.0	210.0.	-17.7	746.4	-30.6
Dhule	59.8	-51.9	171.1	-29.2	247.8	+54.1	109.7	+46.8	588.4	-11.6
Ahmednagar	37.7	-65.5	133.9	+36.0	7.0	-90.8	140.0	-9.0	308.6	-24.9
Pune	171.4	+21.0	308.2	+3.4	129.3	-23.5	161.4	-	775.1	+5.1
Solapur	29.4	-70.0	162.5	+78.7	30.5	-67.3	85.3	-50.8	324.9	-25.0
Satara	224.0	+11.1	455.7	-6.2	-	-	-	-	1088.7	-6.5
Sangli	-	-	-	-	-	-	-	-	286.9	-27.3
Aurangabad	44.3	-68.6	189.6	+7.3	48.3	-72.0	128.5	-18.8	410.5	-36.7
Jalna	88.5	-36.3	156.2	-14.8	38.2	-77.0	90.3	-40.0	373.5	-41.6
Pasbhain	142.4	-0.8	175.0	-26.6	83.7	-62.4	85.9	-49.4	487.4	-37.6
Beed	35.0	-74.8	154.0	+11.8	24.6	-77.9	183.7	-0.8	397.2	-29.8
Nanded	79.0	-54.1	198.1	-34.3	87.3	-63.1	118.9	-35.1	483.5	-45.9
Osmanabad	67.7	-60.2	148.5	+18.7	29.2	-90.2	124.1	+2.5	369.5	-48.3
Latur	84.9	-53.0	188.3	+10.5	39.2	-80.5	145.3	-19.5	457.8	-37.5
Amarariti	27.6	-35.8	246.4	-11.0	392.0	+95.0	29.8	-81.9	785.3	-4.5
Buldhana	100.2	-38.7	110.6	-49.8	97.6	-35.4	46.4	-71.2	363.5	-46.3
Akola	128.5	-12.7	105.2	-57.5	138.0	-17.9	43.7	-72.3	415.7	-42.0

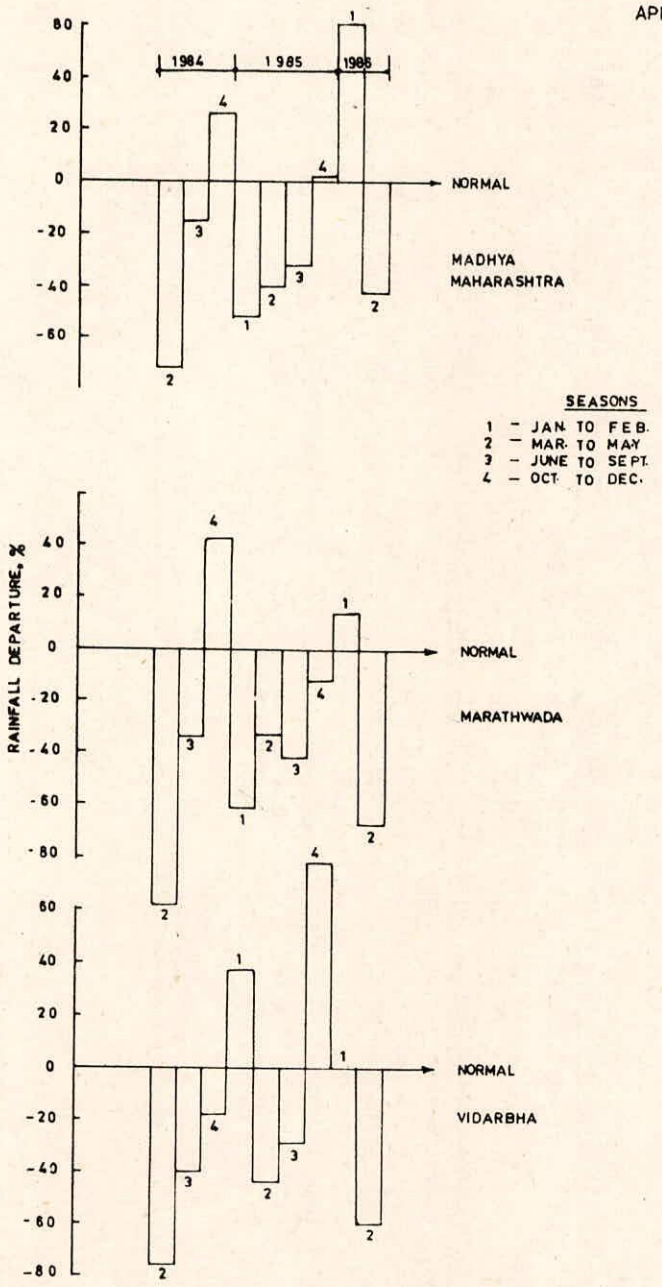
Dep. % indicates higher (+) or lower(-) than normal.

Districtwise Monthly Rainfall of Monsoon Season 1985 for Maharashtra

Name of District	June		July		August		September		Season June - Sept.	
	Actual mm	Dep.%	Actual mm	Dep.%	Actual mm	Dep.%	Actual mm	Dep.%	Actual mm	Dep.%
Nasik	84.6	-45.2	254.0	-26.4	229.9	-36.5	10.3	90.3	578.8	40.2
Dhule	18.9	-84.7	284.4	+14.9	79.4	-50.5	11.2	-85.0	334.1	-44.4
Ahmednagar	83.1	-25.5	75.2	-23.4	14.0	-80.7	38.0	-52.8	210.3	-42.0
Jalgaon	113.2	-14.3	181.1	-13.7	103.8	-30.5	3.1	-95.9	401.2	-29.2
Pune	128.7	-9.0	190.9	-56.1	135.9	-19.5	33.0	-54.1	488.7	-39.1
Solapur	101.0	+3.2	66.0	-27.3	40.3	-56.8	47.5	-45.1	254.8	-29.3
Satara	188.4	-6.4	296.0	-64.0	296.6	-0.9	21.0	-75.8	802.9	-31.6
Sangli	74.5	-4.2	83.4	-28.5	66.8	-20.0	15.7	-72.8	238.8	-28.9
Aurangabad	76.8	-45.7	118.6	-33.7	53.2	-69.2	12.4	-83.8	261.0	-54.0
Beed	173.0	+24.2	118.1	-14.2	18.3	-83.5	33.0	-57.2	342.4	-26.4
Jalna	137.0	-1.1	146.8	-19.9	81.4	-51.0	22.0	-70.7	391.9	-30.6
Nanded	218.1	+26.6	143.5	-52.4	189.3	-20.1	18.7	-81.7	567.6	-30.3
Osmanabad	131.8	-22.5	112.4	-10.1	27.8	-90.5	37.5	-38.1	308.8	-52.8
Latur	143.8	-20.7	153.6	-9.8	48.5	-75.9	63.3	-29.9	409.8	-36.4
Pasbhani	225.3	+56.8	152.7	-35.9	84.1	-62.2	9.1	-89.7	172.2	-30.9
Amaravati	-	-	-	-	-	-	11.6	-86.0	541.0	-24.4
Akola	-	-	-	-	-	-	-	-100.0	608.7	-5.0
Buldhana	142.7	0.0	184.3	-13.9	99.2	-25.8	1.8	-97.6	428.0	-12.5

Dep. % indicates higher (+) or lower (-) than normal.

App.III-15/18

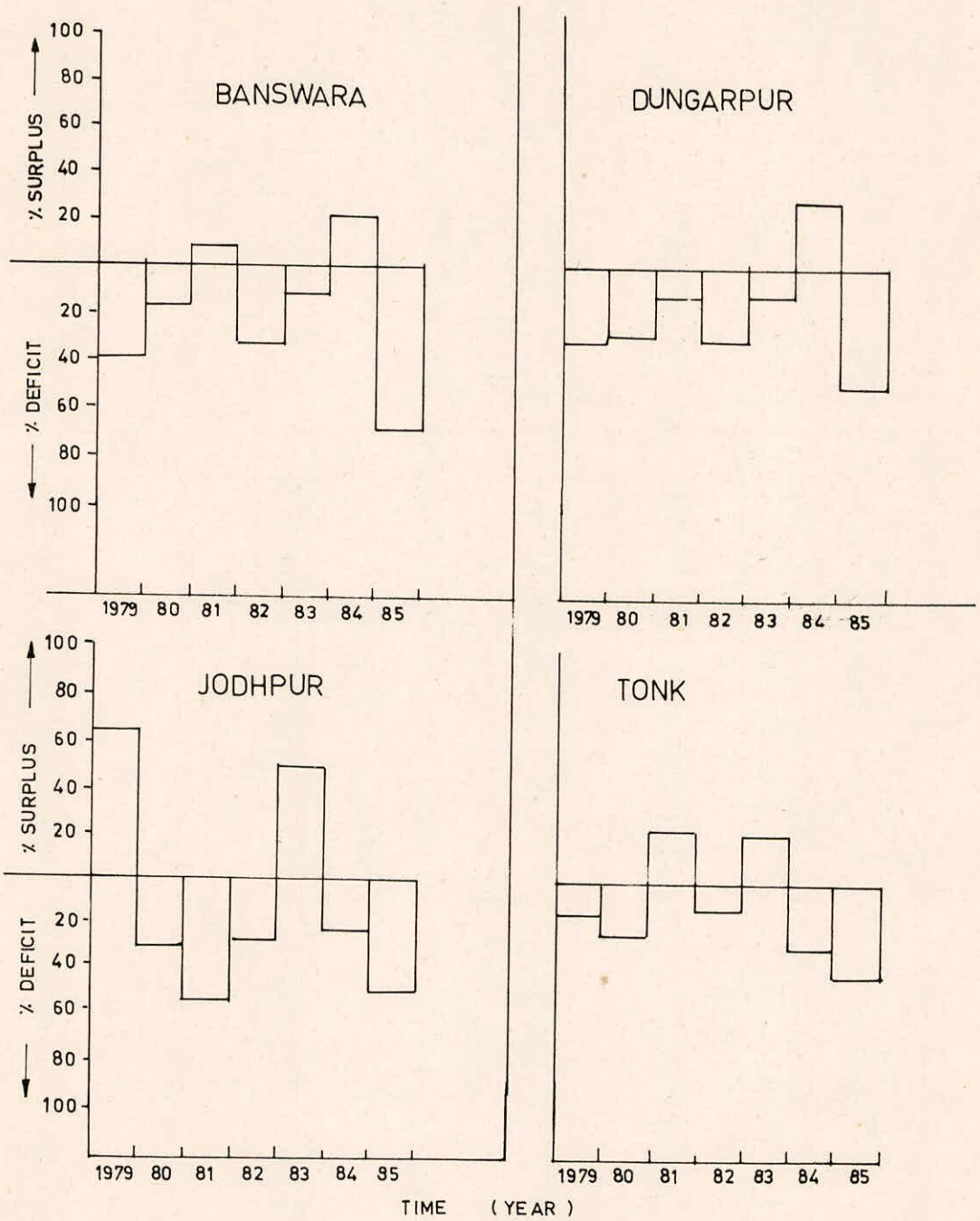


SEASONAL RAINFALL PATTERN IN THE METEOROLOGICAL SUBDIVISIONS OF MAHARASHTRA

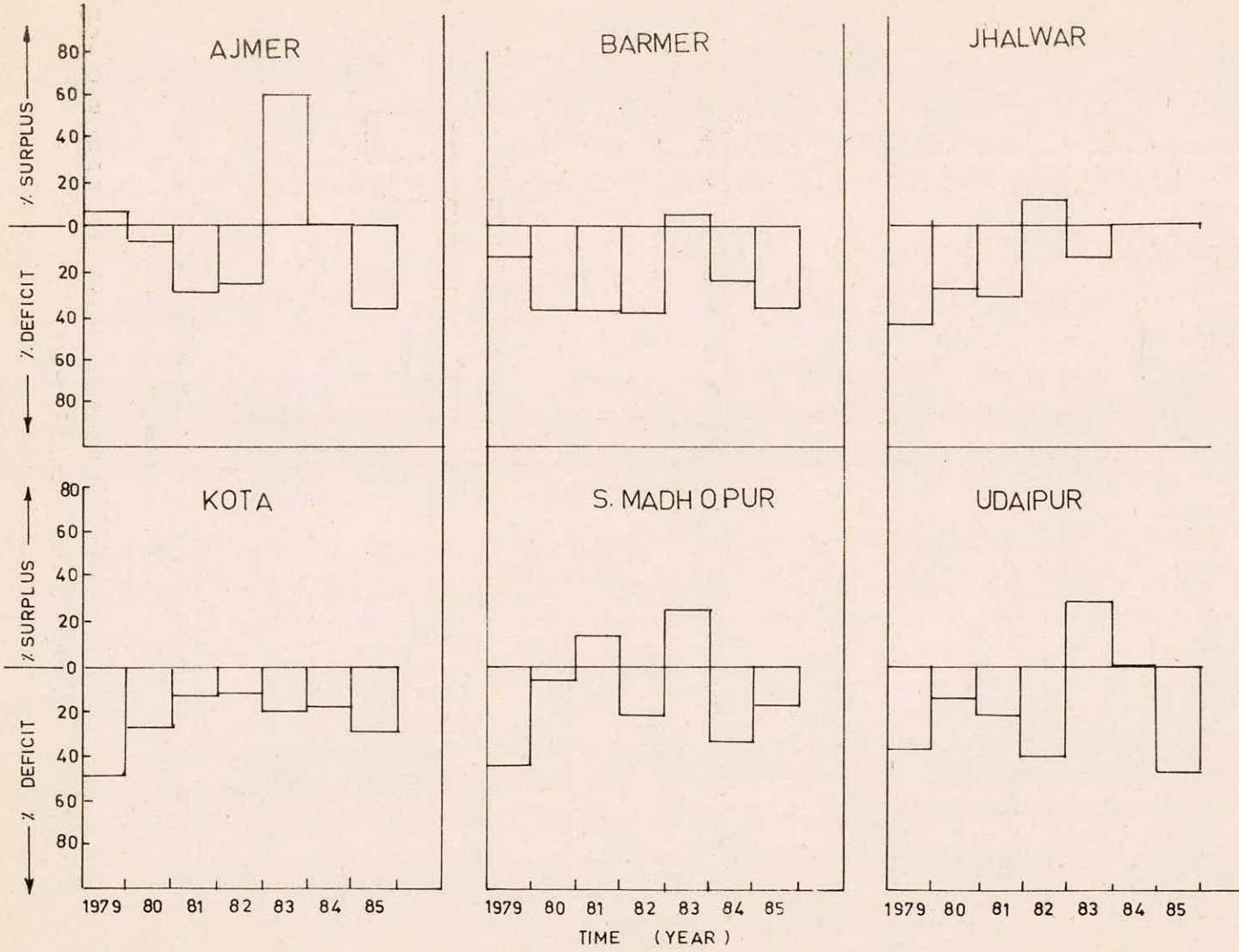
Statement Showing Seasonal Actual Rainfall & %age Departure from Normal (Seasonal) Rainfall (RAJASTHAN)

Sl. No.	Districts	1979		1980		1981		1982		1983		1984		1985	
		Actual Rainfall mm	% Departure	Actual Rainfall mm	% Departure	Actual Rainfall mm	% Departure	Actual Rainfall mm	% Departure	Actual Rainfall mm	% Departure	Actual Rainfall mm	% Departure	Actual Rainfall mm	% Departure
1.	Ajmer	477.9	+6.9	414.18	-7.2	313.2	-29.88	327.99	-26.56	712.41	+59.49	448.7	+0.45	280.4	-37.22
2.	Banswara	543.55	-38.85	736.37	-17.16	958.62	+7.8	599.24	-32.59	739.69	-10.72	1083.78	+21.91	287.86	-67.62
3.	Barmer	211.34	-14.17	153.28	-37.75	151.62	-38.42	150.68	-38.80	258.94	+5.16	184.78	-24.95	154.52	-37.24
4.	Dungarpur	508.725	-30.76	532.75	-27.49	646.73	-11.98	513.95	-30.05	654.03	-10.99	945.83	+28.72	302.78	-58.79
5.	Jhalwar	505.275	-45.19	666.22	-27.74	627.03	-31.98	1032.13	+11.95	787.99	-14.52	924.97	+0.24	922.47	+0.57
6.	Jodhpur	470.46	+62.98	204.5	-29.15	141.96	-50.82	214.9	-35.55	426.44	+47.73	228.5	-20.84	153.97	-46.66
7.	Kota	427.87	-48.75	610.34	-26.90	724.94	-13.18	734.12	-12.08	664.78	-20.38	682.53	-18.26	593.06	-28.97
8.	S.Madhaupur	357.49	-43.82	597.40	-6.12	732.21	+15.05	497.64	-21.8	802.69	+26.12	424.39	-33.33	528.84	-16.9
9.	Tonk	499.76	-13.42	422.16	-23.39	701.56	+21.54	508.64	-11.88	691.78	+19.84	416.14	-27.90	347.1	-39.86
10.	Udaipur	367.16	-37.13	500.64	-14.28	461.62	-20.96	352.58	-39.63	758.2	+29.81	587.25	+0.54	307.55	-47.34

Dep. % indicates higher (+) or lower (-) than normal.

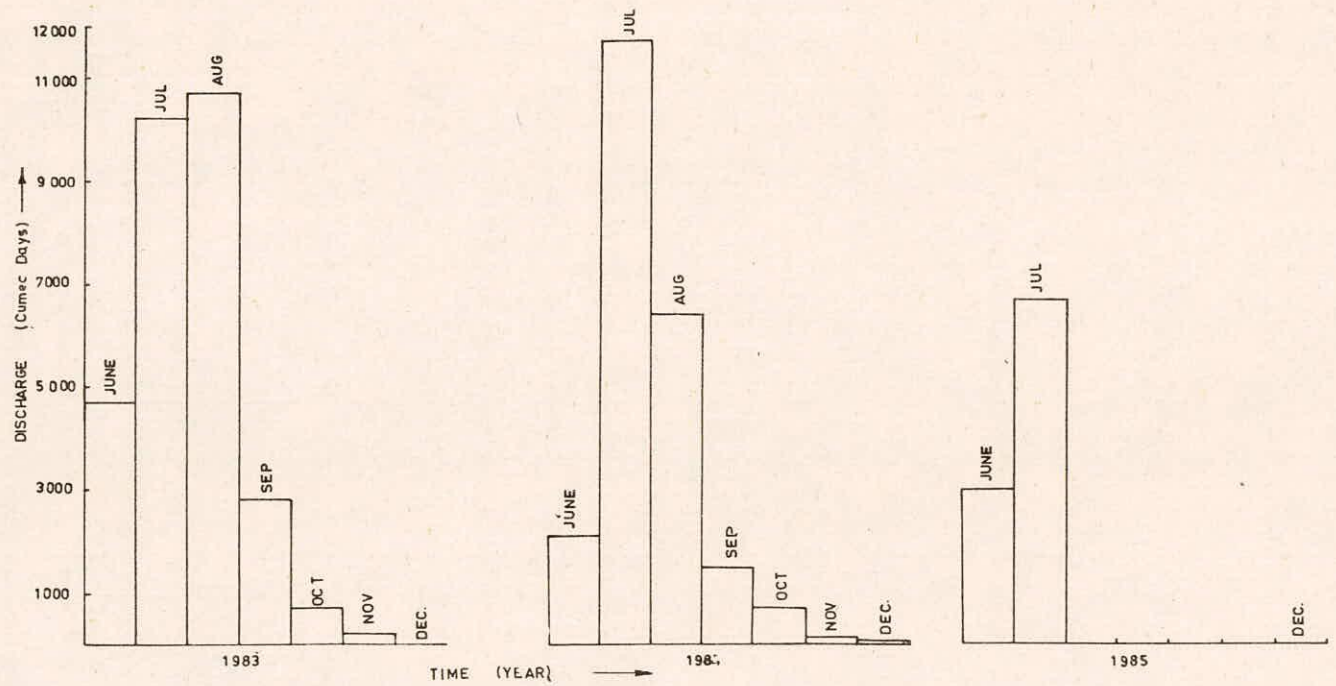


DISTRICT WISE SEASONAL (MONSOON) PERCENTAGE DEPARTURES (RAJASTHAN)



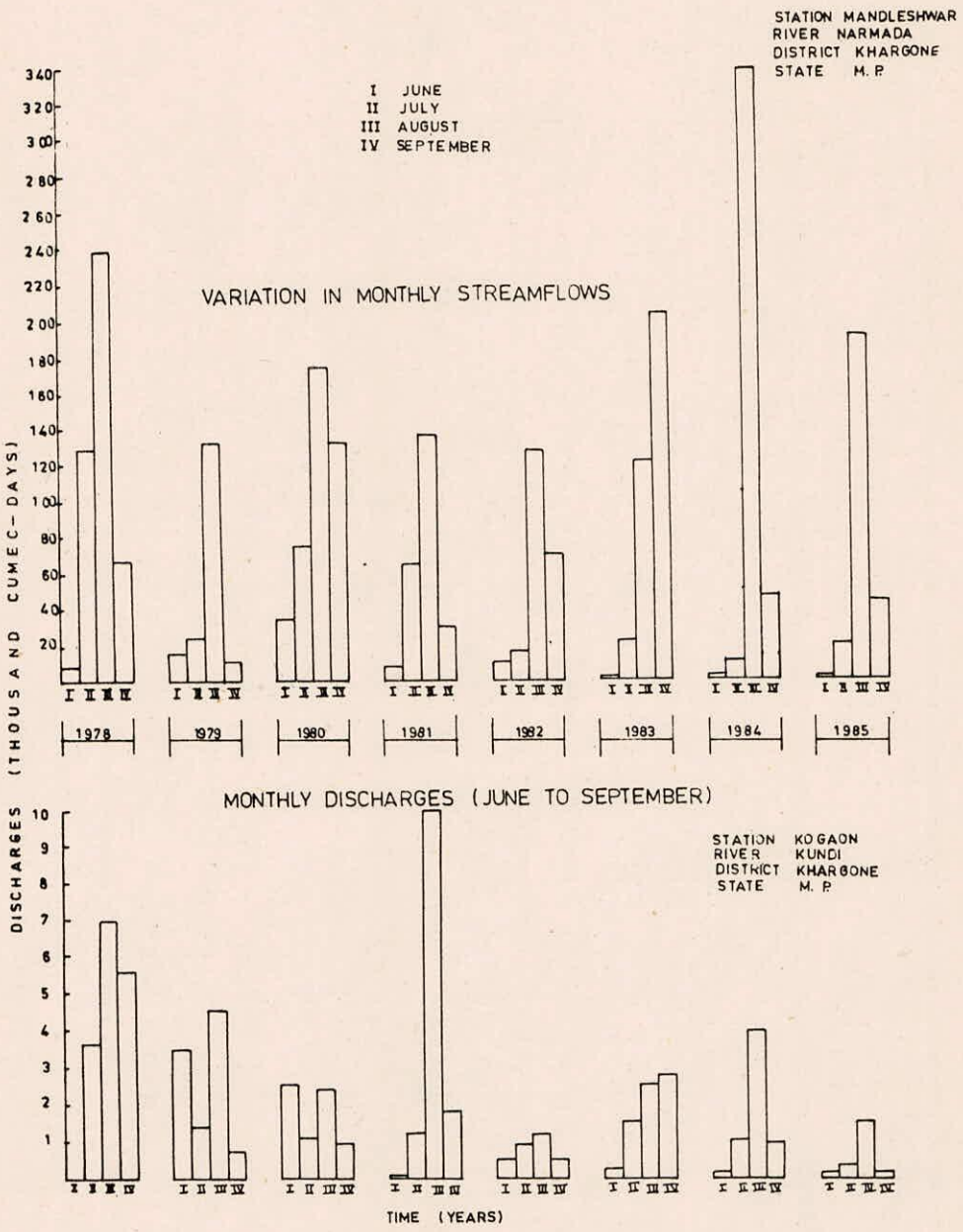
DISTRICT WISE SEASONAL (MONSOON) PERCENTAGE DEPARTURES (RAJASTHAN)

APP III-18(B)/18

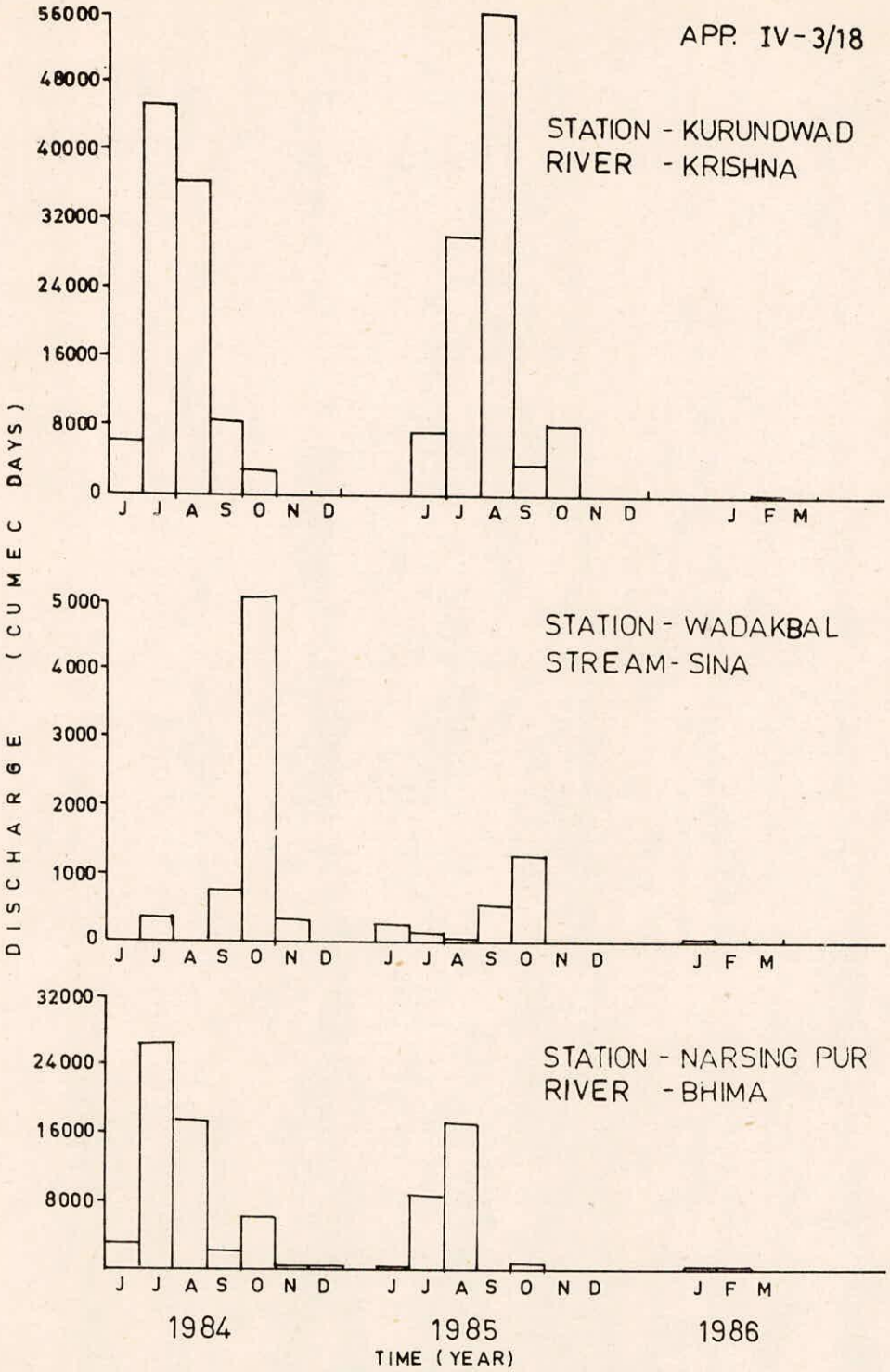


STATION - DADDI , STREAM - GHATAPRABHA

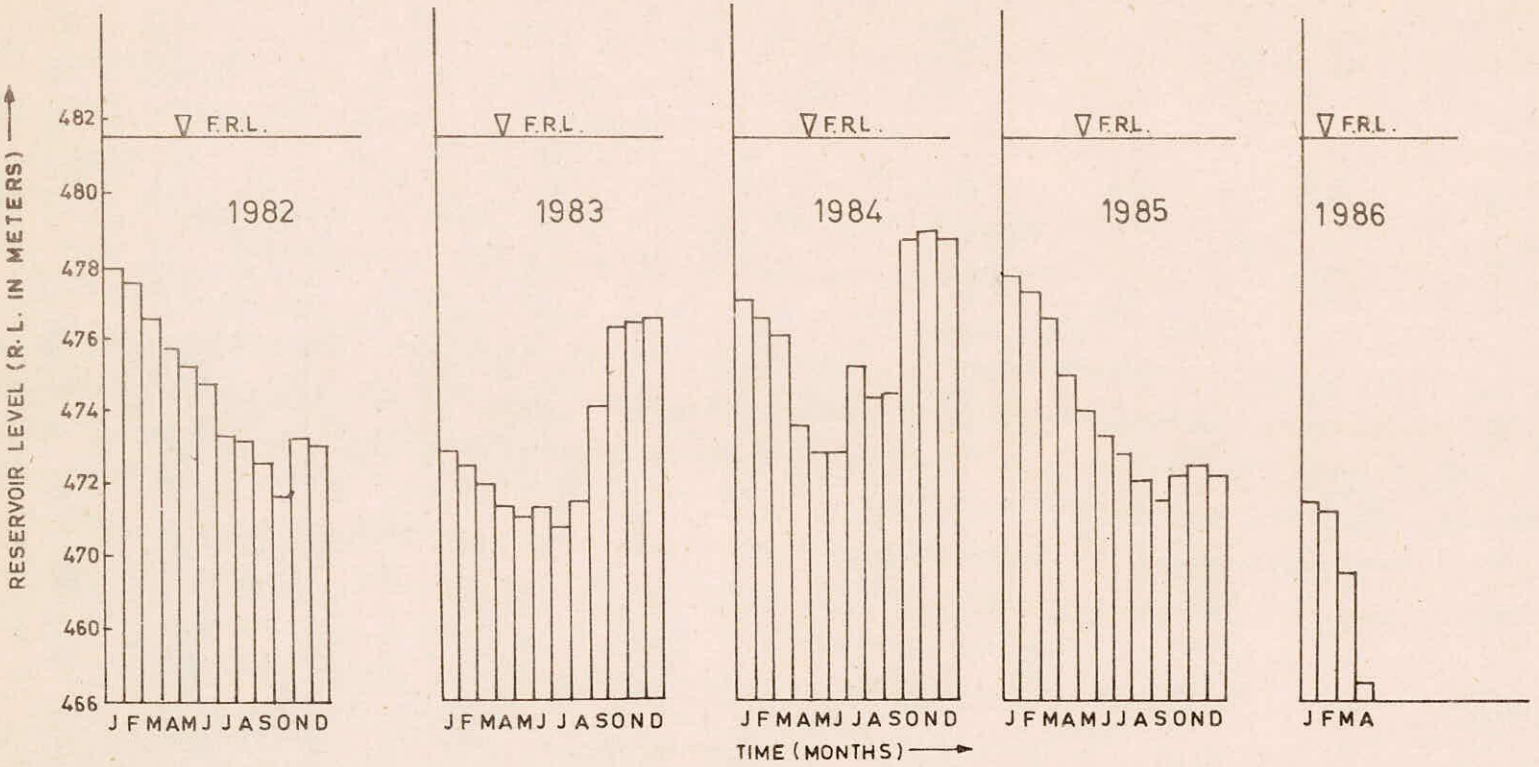
VARIATION OF STREAM FLOW WITH TIME (KARNATAKA)



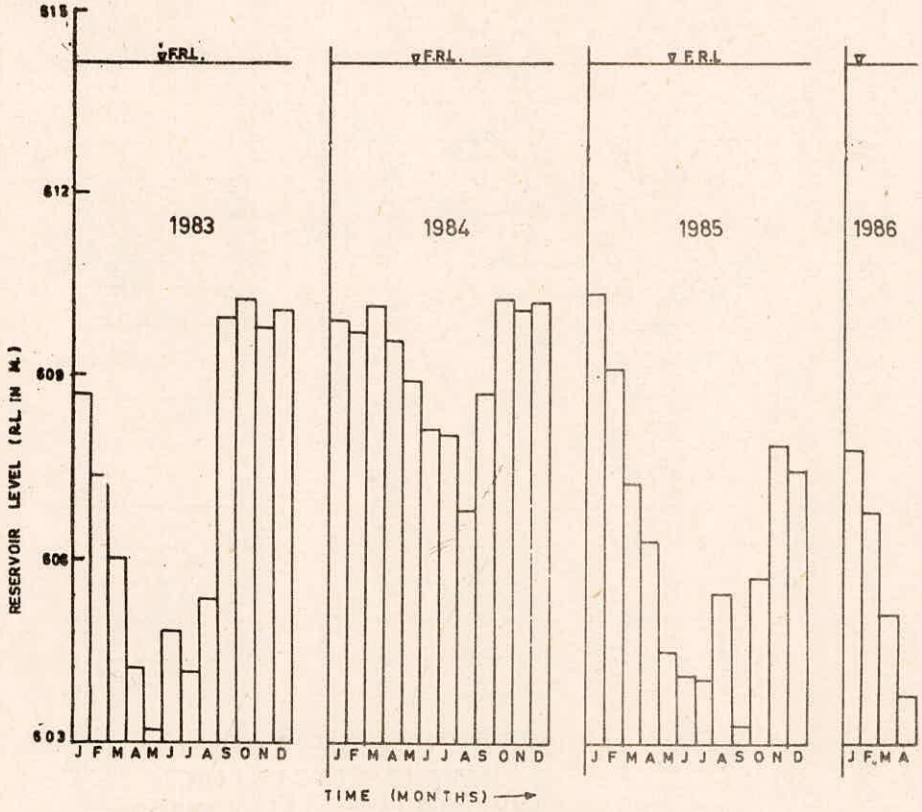
MONTHLY VARIATION OF STREAMFLOWS (JUNE - SEPTEMBER)



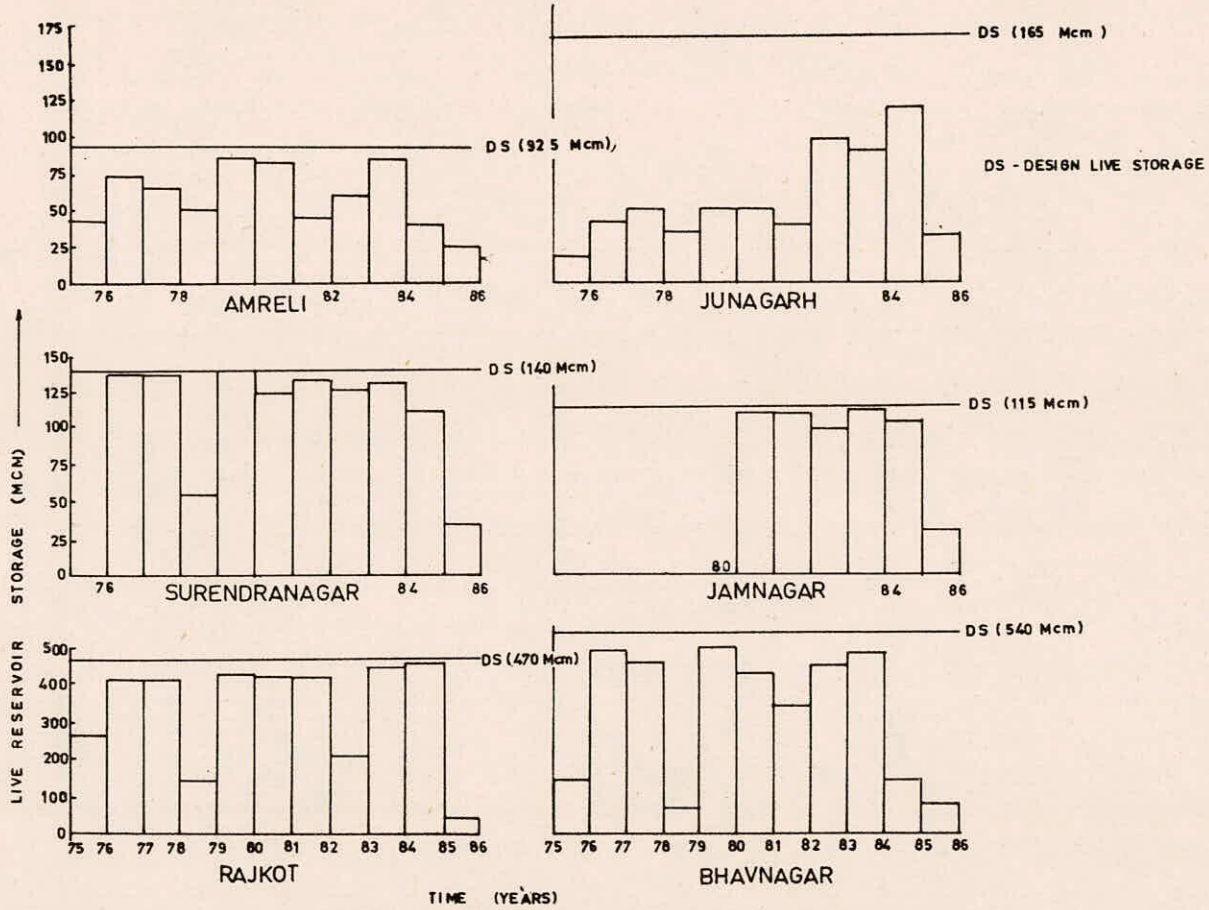
YEARLY VARIATION OF DISCHARGE (MAHARASHTRA)



VARIATION IN RESERVOIR WATER LEVELS, PEDDERU RESERVOIR IN DISTT. CHITTOOR ANDHRA PRADESH



VARIATION IN RESEVOIR WATER LEVELS, BAHUDA RESERVOIR IN DROUGHT PRONE DISTRICT CHITTOOR, ANDHRA PRADESH



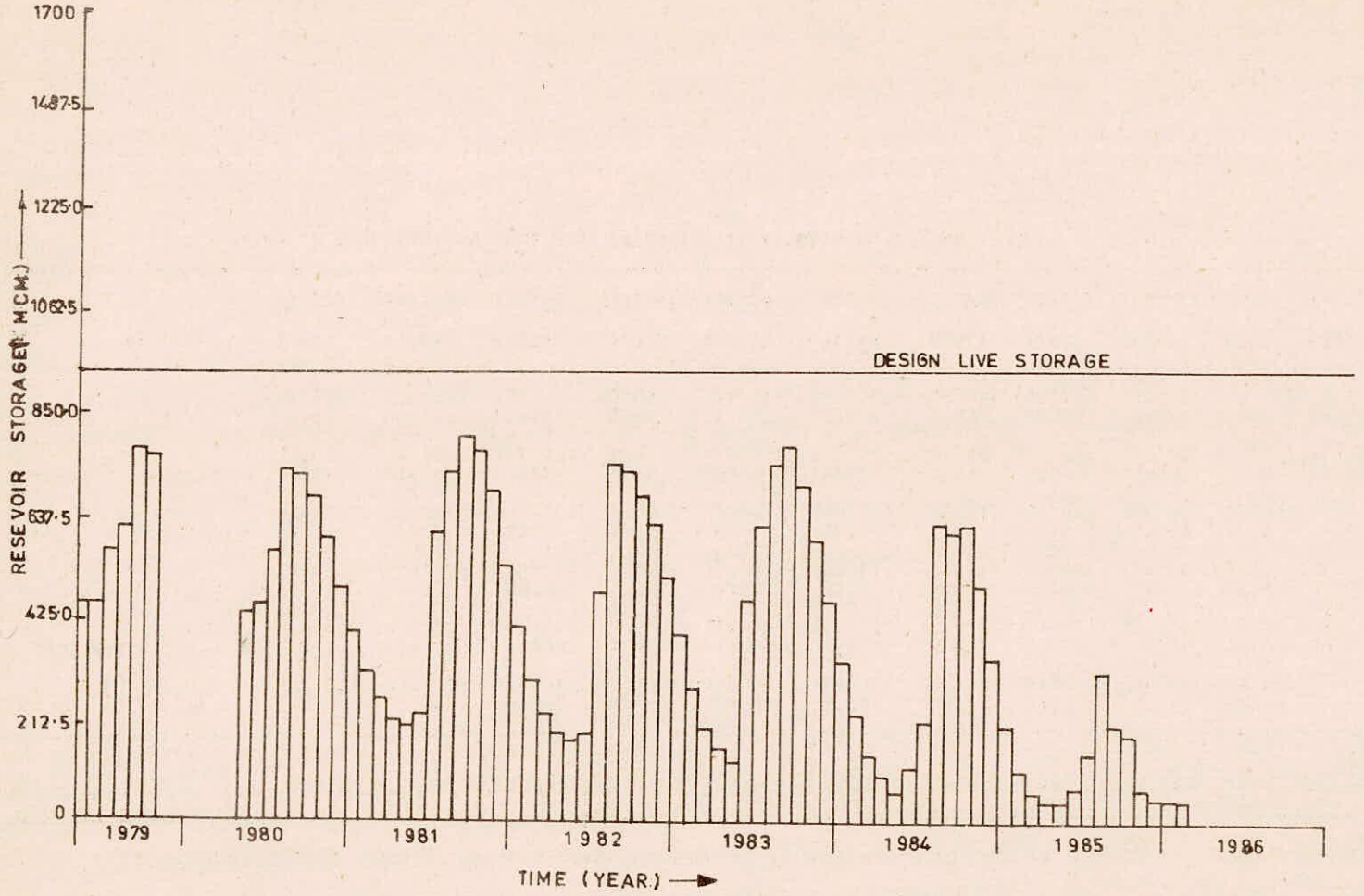
DISTRICT WISE TOTAL ANNUALLY AVAILABLE STORAGES (GUJARAT)

DISTRICTWISE ABSTRACT OF AREA IRRIGATED FROM SURFACE STORAGES IN LAST 10 YEAR IN SAURASHTRA(GUJRAT).

Sl. No.	Name of District	Design Irrigation Potential (Ha.)	Area Irrigated (Ha.) 1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
1.	RAJKOT	41252	22719 (55.07)	28909 (70.08)	35563 (86.21)	12867 (31.19)	24960 (60.51)	28754 (69.70)	33388 (80.94)	23060 (55.90)	27345 (66.29)	21410 (51.90)	-
2.	SURENDRANAGAR	9986	9915 (99.29)	8701 (87.13)	13397 (134.16)	10158 (101.72)	17066 (170.89)	15530 (155.52)	18391 (184.17)	17886 (179.11)	12692 (127.10)	10891 (109.06)	1728 (17.30)
3.	JAMNAGAR	11866	5692 (47.97)	6477 (54.58)	8578 (72.29)	5358 (45.15)	9138 (77.01)	5118 (43.13)	9201 (77.75)	5674 (47.82)	6462 (54.46)	6169 (51.99)	-
4.	AMRELI	12723	3262 (25.64)	3518 (27.65)	5100 (40.08)	5986 (47.05)	6901 (54.24)	8678 (68.21)	5909 (46.44)	5441 (42.77)	11048 (86.83)	2019 (15.87)	-
5.	JUNAGADH	30075	1016 (33.78)	2482 (8.25)	3512 (11.68)	2695 (8.96)	4015 (13.35)	3592 (11.94)	3770 (12.54)	5096 (16.94)	5650 (18.79)	5460 (18.15)	2474 (8.23)
6.	BHAVNAGAR	54599	8310 (15.22)	25959 (24.54)	34647 (63.46)	1687 (3.09)	41502 (76.01)	29466 (53.97)	19182 (35.13)	35645 (65.29)	44031 (80.64)	4907 (8.99)	1909 (3.50)
	TOTAL	160501	50914 (31.72)	76046 (47.38)	100797 (62.80)	38751 (24.14)	103582 (64.54)	91138 (56.78)	89841 (55.98)	92802 (57.82)	107229 (66.81)	50856 (31.69)	6111 (3.81)

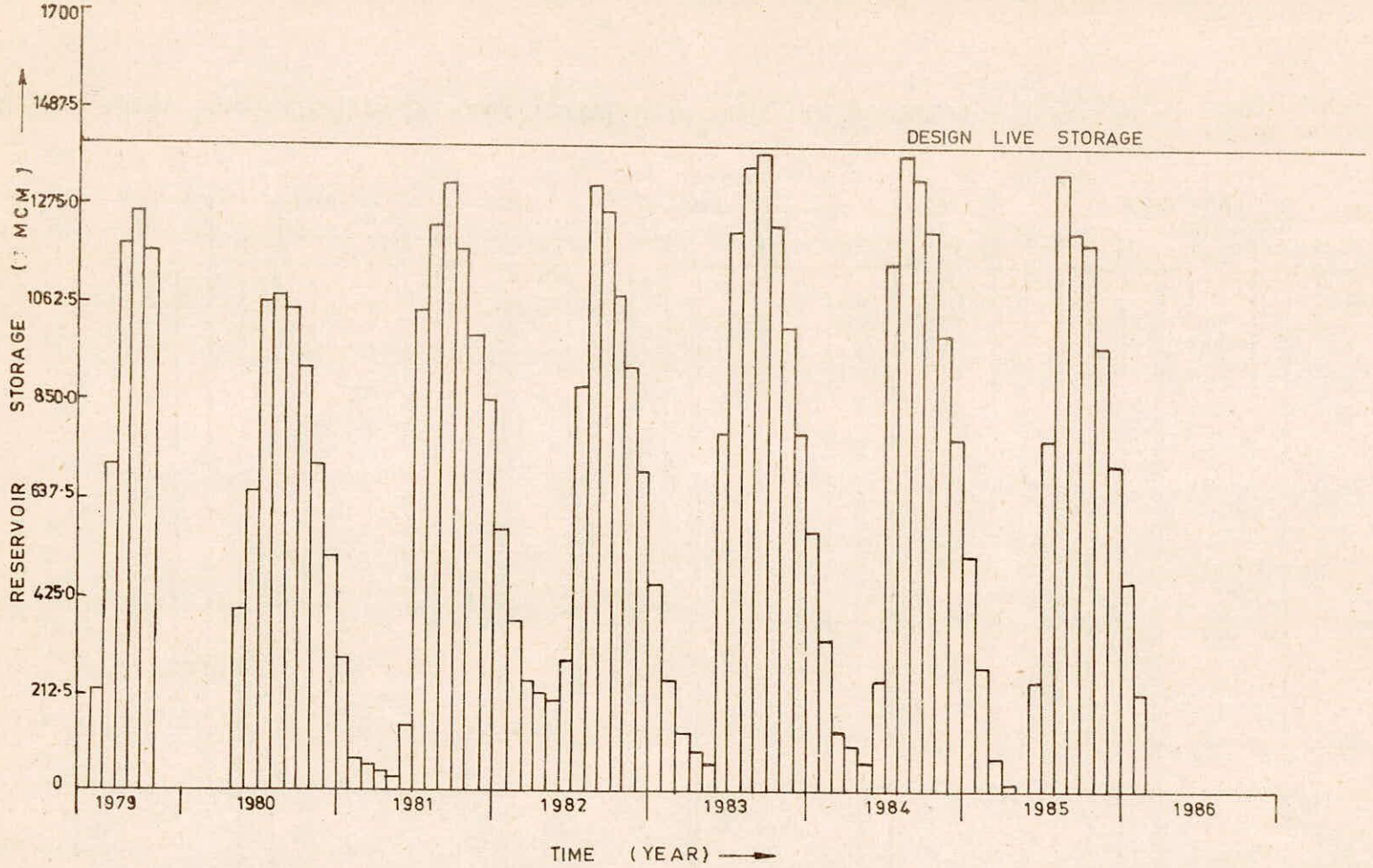
Value in Brackets indicate %age of Design Irrigation Potential

App.IV-7/18



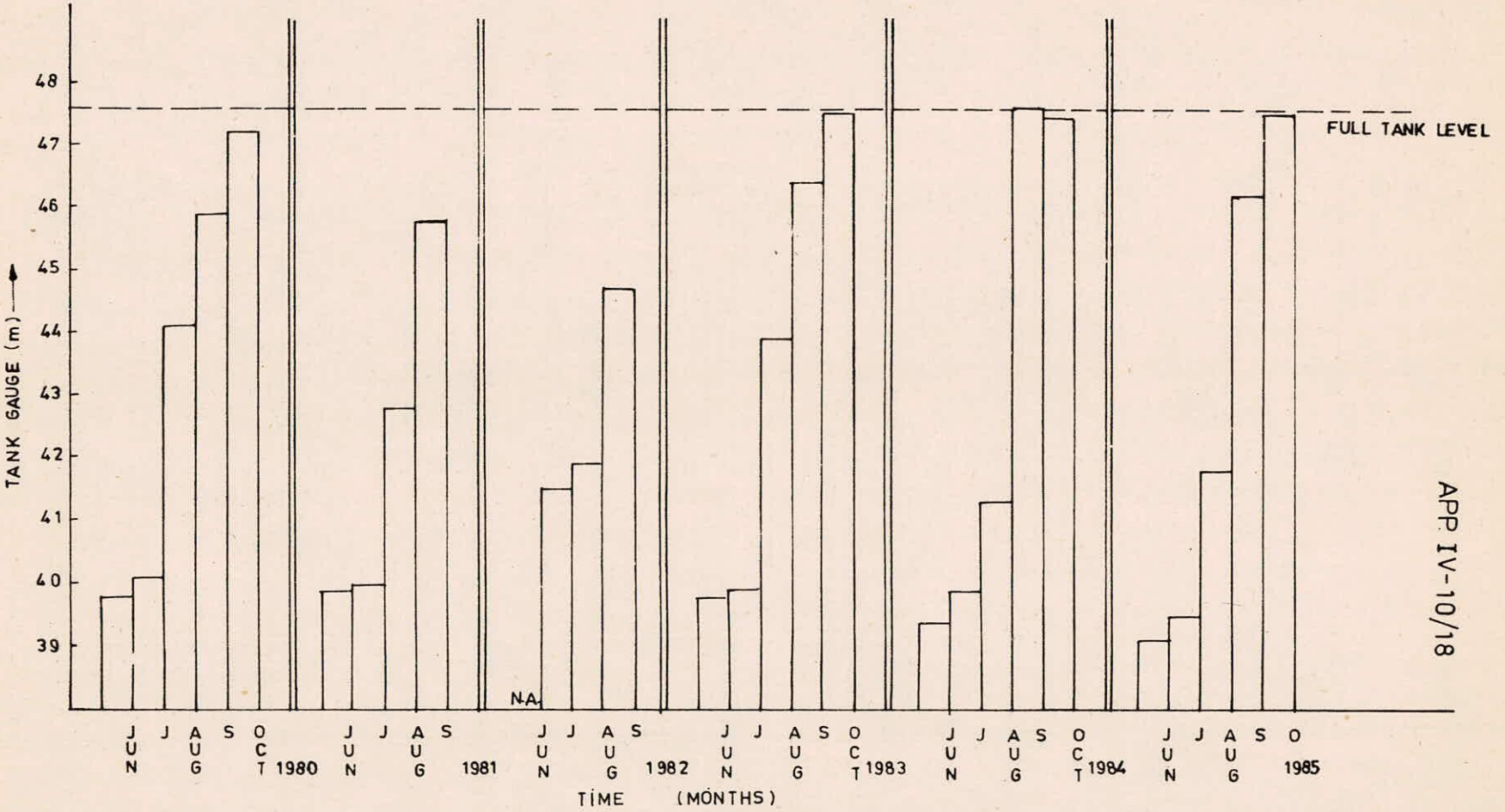
MALAPRABHA RESERVOIR

VARIATION OF RESERVOIR STORAGE WITH TIME (KARNATAKA)

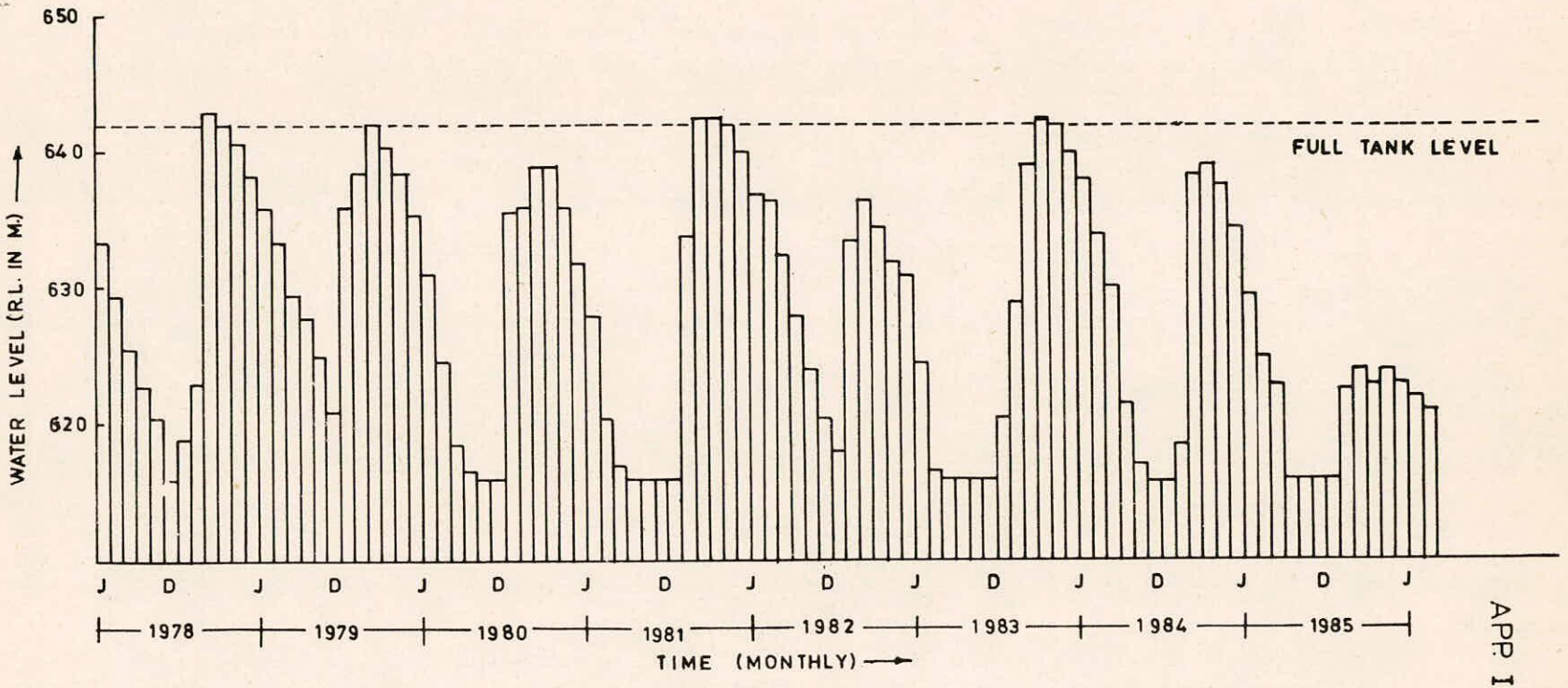


GHATAPRABHA RESERVOIR (KARNATAKA)

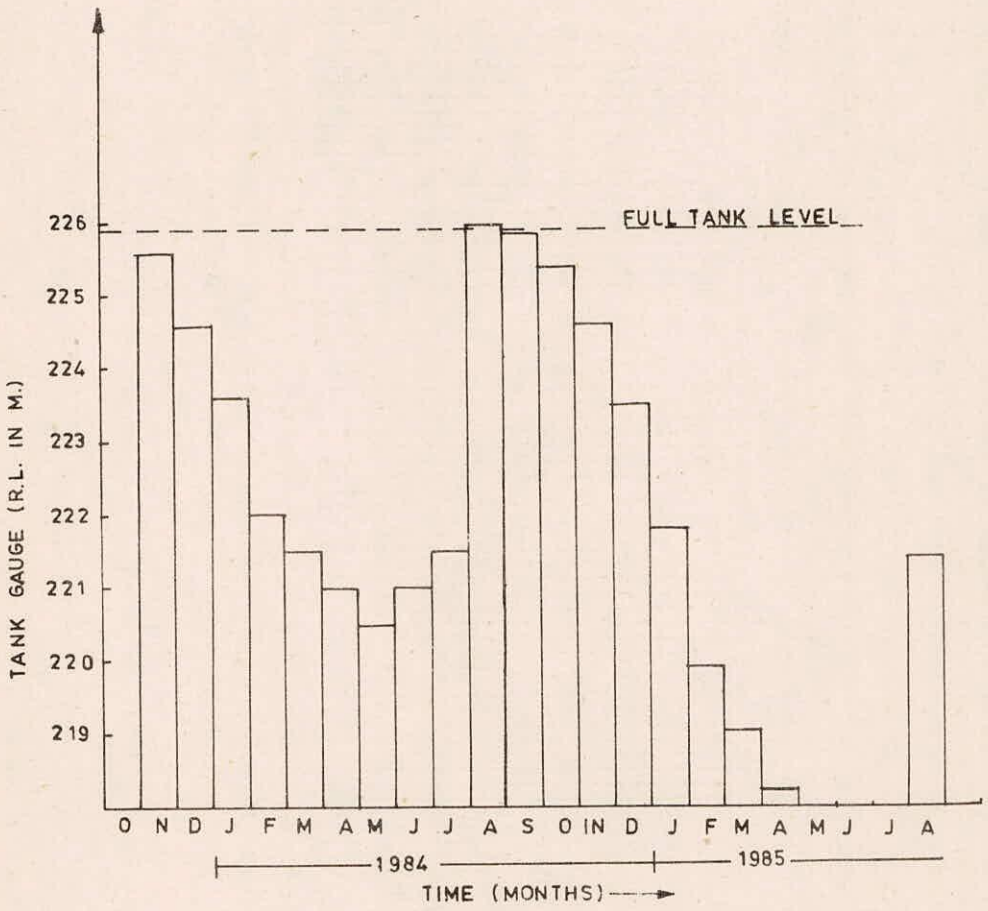
VARIATION OF RESRVOIR STORAGE WITH TIME



JOHILLA MEDIUM TANK VARIATION OF TANK GAUGE WITH TIME (SEASONAL)



SATAK MEDIUM TANK VARIATION OF TANK GAUGE WITH TIME



SAKALDAMEDIUM TANK,VARIATION OF TANK GAUGE WITH TIME

Statement Showing Position of Major Irrigation Storages in Drought Affected Areas - 1994 (MAHARASHTRA)

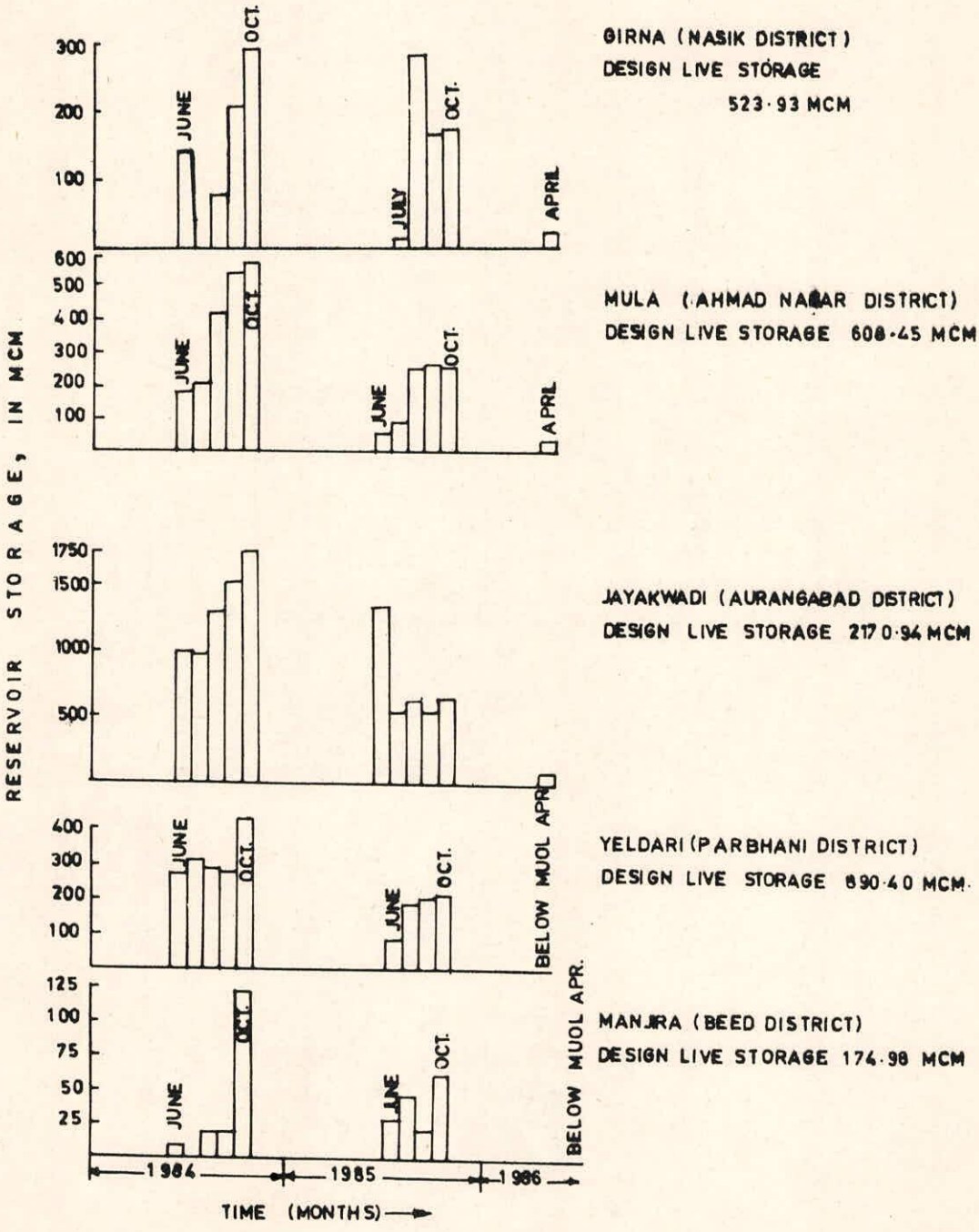
Sl. No.	Name of Reservoir	District	Designed Live Storage mcm	Storage on 15th June		Storage on 15 July		Storage on 15 Aug.		Storage on 15 Sept.		Storage on 15 October	
				Actual mcm	% of Designed	Actual mcm	% of Designed	Actual mcm	% on Designed	Actual mcm	% of Designed	Actual mcm	% of Designed
1.	Tanaji Sagar	Pune	294.93	59.05	20.0	187.99	63.7	273.18	92.6	294.9	100.0	294.93	100.00
2.	Khadakwasla	Pune	76.06	36.24	47.6	32.43	42.6	32.71	43.0	76.06	100.0	74.31	97.7
3.	Bhatghar	Pune	665.50	101.01	15.2	371.55	55.8	652.85	98.1	665.57	100.0	665.57	100.0
4.	Vir	Pune	266.40	41.31	15.5	99.51	37.3	257.46	96.64	271.78	100.0	270.82	100.0
5.	Pawna	Pune	303.84	44.35	14.6	126.86	41.8	209.14	68.8	221.59	72.9	218.61	71.8
6.	Kukadi	Pune	290.00	7.90	2.7	29.78	10.3	133.42	46.0	171.37	59.1	177.15	61.0
7.	Yedgaon	Pune	79.276	N.A.		NA		NA		NA		NA	
8.	Wadaj	Pune	33.20	NA		NA		NA		NA		NA	
9.	Dhon	Safara	355.10	80.47	22.7	172.14	48.5	296.76	83.6	323.94	91.2	331.05	93.2
10.	Darna	Nasik	215.86	28.74	13.3	139.14	64.5	213.96	99.1	219.34	100.0	219.82	100.0
11.	Gangapur	Nasik	200.93	15.70	7.8	60.90	30.3	188.45	93.8	203.76	100.0	203.76	100.0
12.	Karanjwan	Nasik	170.24	5.32	3.1	5.38	3.2	76.17	44.7	133.43	77.3	154.55	90.8
13.	Girna	Nasik	523.93	113.20	21.6	37.18	7.1	79.74	15.2	207.13	39.5	292.46	55.8
14.	Chankapur	Nasik	74.57	7.24	9.6	8.57	11.5	69.22	92.8	79.92	100.0	79.92	100.0
15.	Ozarkhad	Nasik	60.32	NA		NA		NA		NA		NA	
16.	Waghad	Nasik	72.23	NA		NA		NA		NA		NA	
17.	Ghod	Ahmednagar	172.12	53.12	30.6	33.49	19.5	30.56	17.8	136.57	79.3	154.84	89.9
18.	Bhandardan	Ahmednagar	312.42	23.98	7.7	100.76	32.3	263.69	84.4	392.6	126.0	312.6	100.0
19.	Mula	Ahmednagar	608.45	178.68	29.4	215.41	35.4	420.2	69.1	537.41	88.3	572.77	94.1
20.	Jayakwadi	Aurangabad	2170.94	1000.82	46.1	971.33	44.7	1308.00	60.3	1523.53	70.2	1743.84	80.3
21.	Yeldari	Parbhani	890.40	277.26	31.1	311.78	35.8	287.51	32.3	283.47	31.8	431.24	48.4
22.	Siddheswar	Parbhani	243.20	208.22	85.6	209.15	86.1	63.09	25.9	20.58	8.5	35.39	14.6
23.	Manjra	Beed	174.98	14.85	8.5	3.95	2.3	19.81	11.3	19.81	11.3	123.5	70.6
24.	Idiadoh	Bhandara	225.12	21.19	9.4	17.37	7.7	74.25	33.0	124.34	55.2	80.64	35.8
25.	Shirpur	Bhandara	192.45	NA		16.14	8.4	62.03	32.2	118.35	61.5	38.94	18.0
26.	Isapur	Yeohmal	865.00	NA		NA		NA		NA		NA	

Statement Showing Position of Storage in Major/Mellum Irrigation Projects in Drought Affected Area of Maharashtra for 1985

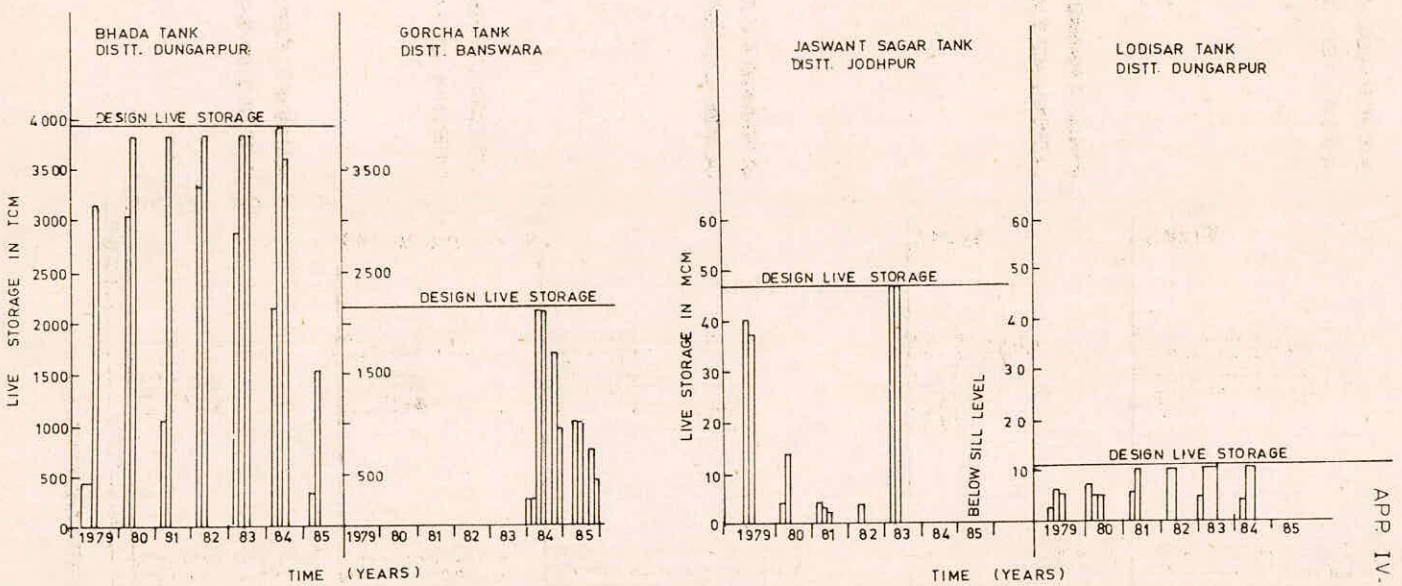
Name of Reservoir	Districts	Design live storage MCM.	Storage on 15th June Actual MCM	Storage on 15th June % of Designed	Storage on 15th July Actual MCM	Storage on 15th July % of Design	Storage on 15th August Actual	Storage on 15th August % of Design	Storage on 15th Sept. Actual MCM	Storage on 15th Sept. %of Design	Storage on 15th Oct. Actual MCM	Storage on 15th Oct. % of Design	Storage as on 30th April 1986 Actual MCM	Storage as on 30th April 1986 % of Design
1.Tanji Sagar	Pune	294.93	N.A.	N.A.	138.89	55.85	280.29	95.83	294.96	100	294.96	100	61.23	20.8
2.Khadakwasla	Pune	76.06	28.88	38	37.01	48.65	53.83	70.82	75.58	100	75.58	99.34	3.43	4.5
3.Bhatghar	Pune	665.50	21.35	3.20	258.42	38.83	586.65	88.15	652.83	98.20	665.57	100	104.87	15.8
4.Vir	Pune	266.40	18.96	7.12	120.15	45.10	261.25	98.03	217.45	81.58	222.63	83.57	59.0	22.2
5.Pawna	Pune	303.84	91.04	29.96	113.50	37.38	72.18	23.81	77.95	26.00	222.3873.20		123.06	40.5
6.Kukadi	Pune	290.00	38.82	13.39	65.61	22.62	153.03	52.77	173.51	59.67	180.13	62.07	288.24	99.4
7.Yedgam	Pune	79.276	35.56	42.34	27.63	34.85	24.37	30.74	44.14	55.70	51.46	64.92	30.53	38.5
8.Wadaj	Pune	33.20	5.79	17.45	14.85	43.22	19.06	24.04	22.77	69.70	34.98	100	11.83	35.6
9.Dham	Pune	355.10	55.56	15.55	133.72	37.66	295.66	83.26	302.29	85.08	311.28	87.66	127.50	35.9
10.Dauna	Nasik	215.86	7.19	3.33	81.83	38.81	213.96	97.31	199.71	88.38	219.82	100	20.41	9.5
11.Gangapur	Nasik	200.93	4.64	2.30	35.51	42.55	181.99	90.57	195.07	97.01	203.76	100	53.85	26.8
12.Karanjwan	Nasik	170.24	0.99	0.58	13.02	7.70	103.64	60.08	96.45	56.47	95.43	56.07	4.53	2.6
13.Girna	Nasik	523.93	N.A.	N.A.	14.51	2.78	283.24	54.08	167.51	32.06	172.52	32.92	25.07	4.8
14.Chantrpur	Nasik	74.57	3.76	5.04	10.72	14.38	73.14	98.08	71.40	95.71	71.07	95.44	27.7	32.1
15.Ogarkhed	Nasik	60.32	14.38	23.84	17.45	28.95	43.42	71.98	47.19	78.28	49.14	81.46	7.27	12.1
16.Waghad	Nasik	72.23	2.88	4.12	3.78	5.23	57.31	93.18	55.95	77.78	54.01	74.77	9.1	12.6
17.Ghod	Ahmednagar	172.12	23.25	13.50	25.78	14.97	66.32	38.53	94.44	54.44	114.58	66.57	114.5	66.5
18.Bhandandara	Ahmednagar	312.42	9.71	3.10	80.93	25.90	228.18	73.04	233.22	73.74	223.05	71.40	45.81	14.7
19.Mula	Ahmednagar	608.45	66.82	10.98	91.77	15.08	262.01	51.53	268.90	52.95	258.33	42.45	48.47	7.6
20.Joyakawadi	Aurangabad	2170.94	1356.46	62.48	551.98	25.42	635.23	33.74	546.44	25.07	653.51	30.10	114.72	5.9
21.Yeldari	Parbhani	890.40	4.94	0.55	96.67	10.75	190.27	21.37	211.08	23.71	216.20	24.28	Below M.D.D.L.	-
22.Siddheshwar	Parbhani	243.20	41.55	17.09	49.82	20.49	66.99	27.54	35.29	14.81	35.29	14.51	-	-
23.Mayra	Beed	174.98	N.A.	N.A.	30.60	46.05	48.78	27.88	23.92	13.79	38.39	21.94	Below M.D.D.L.	-
24.Itiadoh	Bhandara	225.12	74.71	33.19	46.24	20.54	121.79	54.18	114.15	50.67	119.25	52.95	-	-
25.Shirpur	Bhandara	192.45	N.A.	N.A.	28.87	12.82	21.09	36.94	79.08	41.15	105.84	55.00	-	-
26.Isapur	Yeotmal	965.0	231.85	24.03	307.47	31.86	344.08	35.62	303.21	31.42	306.93	31.82	-	-

M.D.D.L. = Minimum Draw Down Level

App.IV-14/16



SEASONAL (MONSOON) VARIATION OF RESERVOIR STORAGE (MAHARASHTRA)



YEARLY STORAGES AVAILABLE (RAJASTHAN)

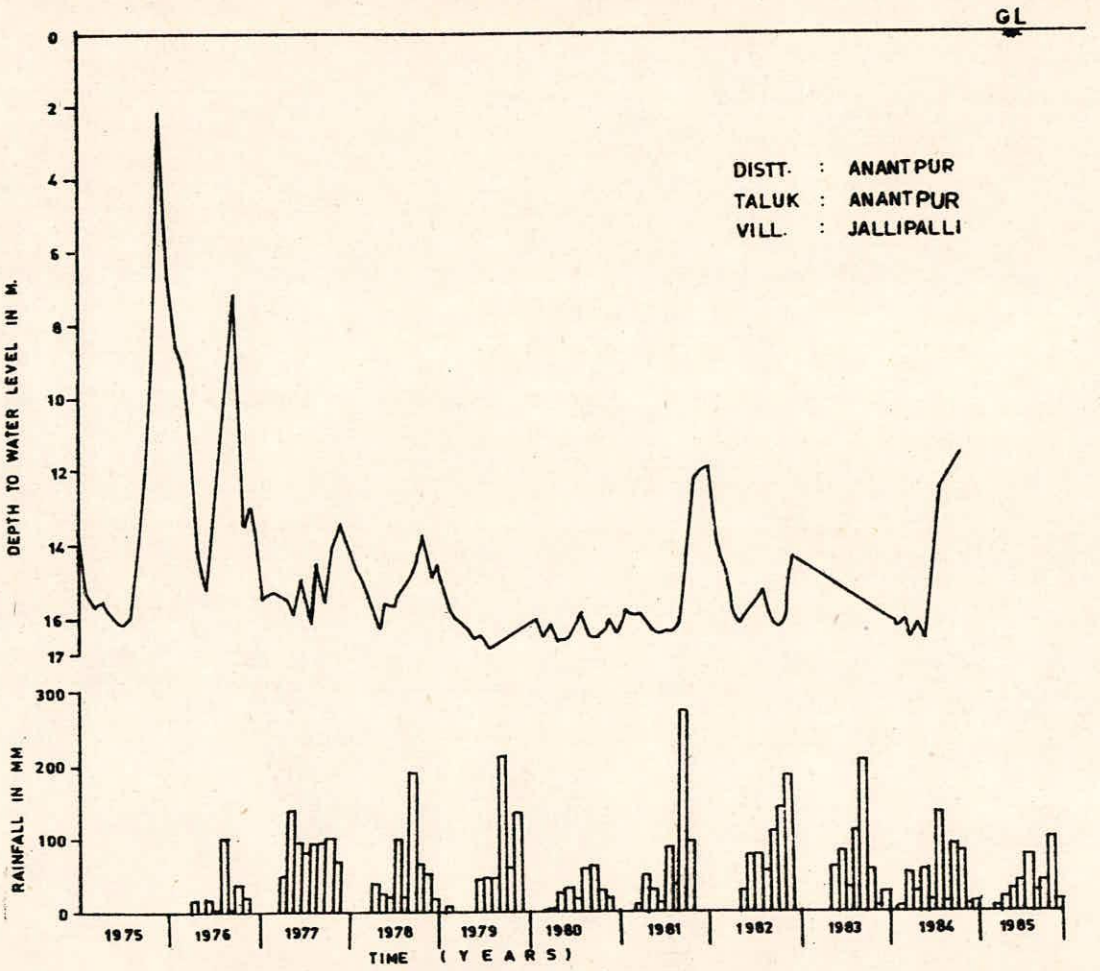
APP. IV-16/18

Statement showing maximum water level attained during Mansoon of 1983, 1984 & 1985 against FTL in important tanks (RAJASTHAN)

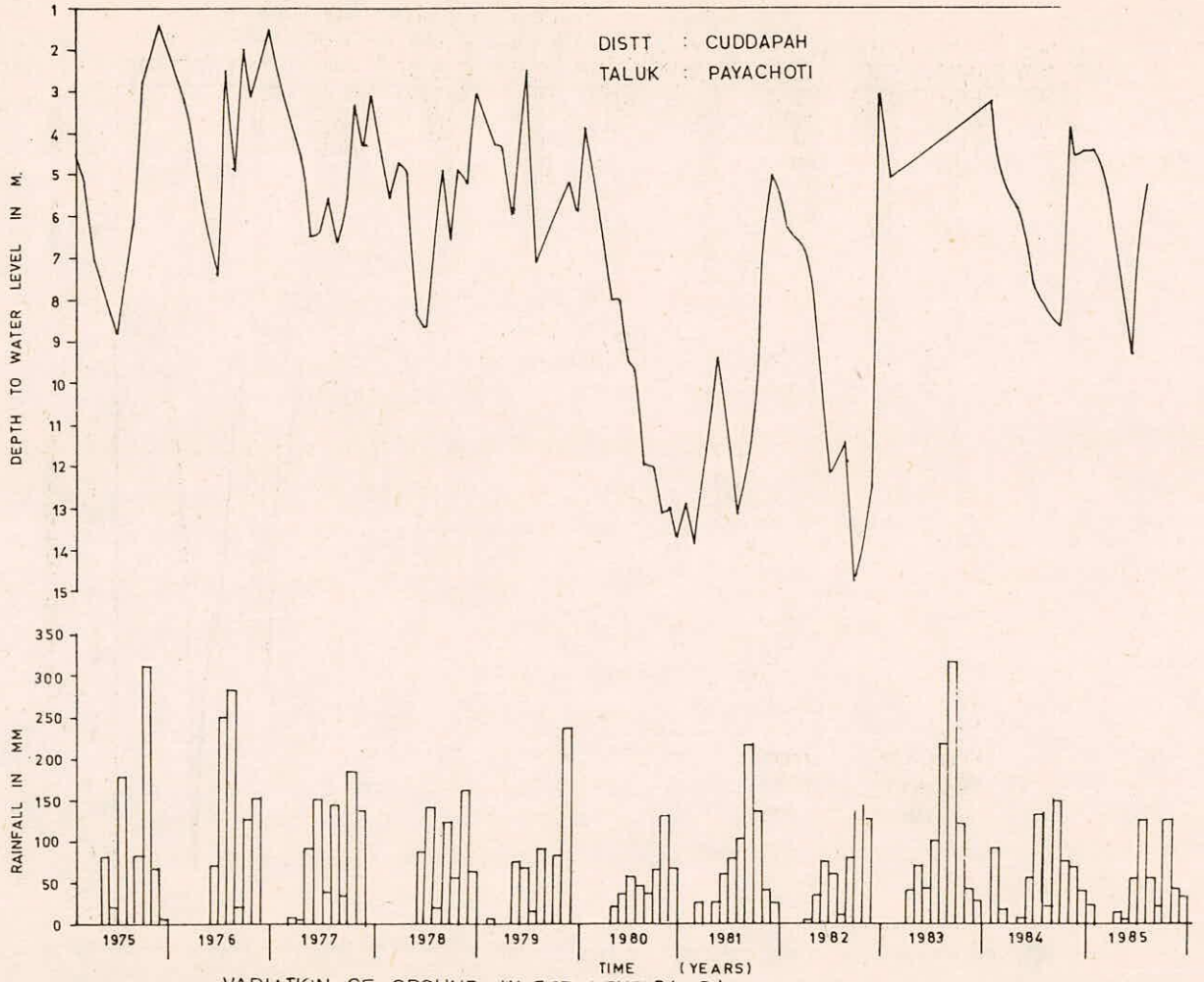
.No.	District	Name of tank	FTL (m)	upto 30th Sept.1983 (m)	upto 30th Sept.1984 (m)	upto 30th Sept.1985 (m)
1.	Ajmer	Narain Sagar	4.97	4.71	1.46	1.68
		Lasadia	3.43	3.58	3.45	3.00
2.	Jodhpur	Jaswantsagar	8.69	9.38	2.74	2.23
3.	S.Madhopur	Morel	9.30	10.41	6.09	9.91
		Juggar	8.23	8.43	8.54	7.96
		Kalisil	7.62	8.66	7.27	8.23
		Dheel	4.88	4.88	4.90	4.57
		Morasagar	5.18	5.18	3.35	5.39
		Surwal	4.27	4.62	2.13	1.73
		Mansarovar	8.23	8.23	4.88	4.94
		Bishansamand	7.93	7.93	3.23	4.83
		Deopura	7.32	7.32	6.07	5.34
4.	Tonk	Gadwa	5.79	5.92	4.37	2.34
		Mashi	3.05	4.16	3.28	3.45
		Chandsen	6.10	6.09	3.99	4.55
		Tordisagar	9.15	9.12	6.27	5.34
		Galwania	4.27	4.27	3.56	2.67
		Motisagar	5.18	4.90	5.72	3.18
5.	Dungarpur	Lodisar	8.23	8.31	7.19	1.01
6.	Udaipur	Rajsamand	9.15	5.70	1.10	1.65
		Chandrabhaga	5.64	3.20	-	-
		Nandsamand	9.76	5.18	9.6	9.79
		Matajikakhera	5.18	4.95	0.82	0.61
		Bharai	5.18	5.30	2.10	2.67
		Jaisamand	8.38	11.49	6.71	4.45
		Daya	12.0	11.49	2.06	1.47
		Udaisagar	7.32	7.32	4.80	2.62
		Bagolia	6.55	5.46	1.20	2.82
		Vallabhagar	5.95	5.95	1.45	3.14

Sl. No.	Name of the Reservoir	Location	Live Capacity at FRL TMCUM	AVAILABLE WATER IN LIVE STORAGE AS % OF LIVE CAPACITY AT FRL IN TM CUM										
				1983			1984			1985			1986	
				31st Oct.	31st Dec.	Difference	31st Oct.	31st Dec.	Difference	31st Oct.	31st Dec.	Difference	31st Jan.	
1.	Srisailan	A.P.	8.288	31.08	17.92	13.16	99.82	76.07	23.75	97.48	73.18	24.30	66.88	
2.	Ukai	Gujarat	7.100	95.13	67.21	27.92	58.68	42.49	16.18	30.39	22.15	8.24	18.66	
3.	Malap harbha	Karnataka	0.972	72.22	47.53	24.69	64.20	35.39	28.81	19.55	4.94	14.61	4.53	
4.	Bhadra	Karnataka	1.785	79.66	70.25	9.41	91.71	80.34	11.37	70.87	54.01	16.86	48.01	
5.	Hemavathy	Karnataka	1.013	93.58	77.30	16.29	92.20	46.89	45.31	53.31	33.56	19.74	30.90	
6.	Tawa	M.P.	2.049	64.13	40.85	23.28	75.20	52.90	22.30	94.78	77.50	17.28	65.59	
7.	Jaya Kawedi	Maharashtra	2.171	93.14	81.90	11.39	79.87	65.18	14.69	27.87	19.44	8.43	16.12	
8.	Bhima	Maharashtra	1.415	99.65	93.71	5.94	99.51	90.04	9.47	57.46	39.29	18.16	37.17	

TM CUM = Thousand Million Cubic Meter

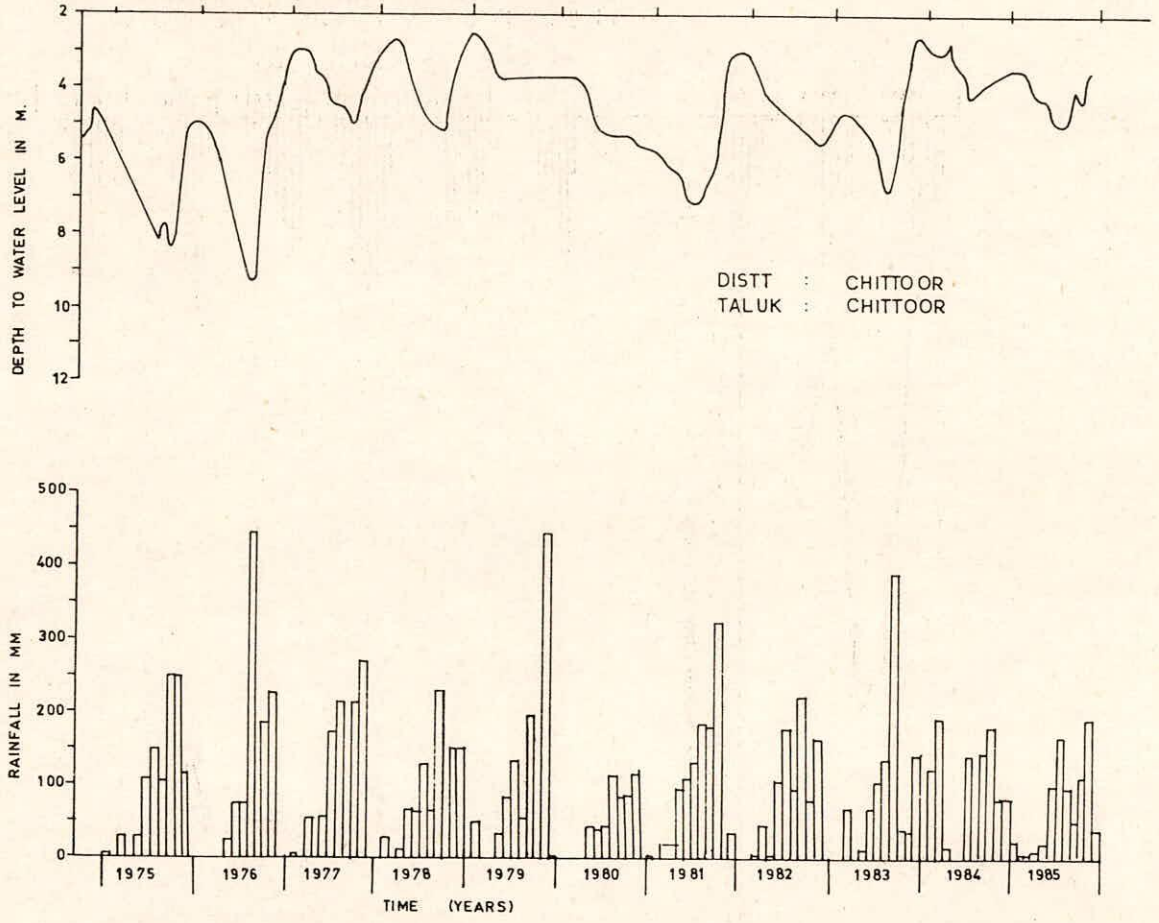


VARIATION OF GROUND WATER LEVELS (A.P)
ALONG WITH RAINFALL



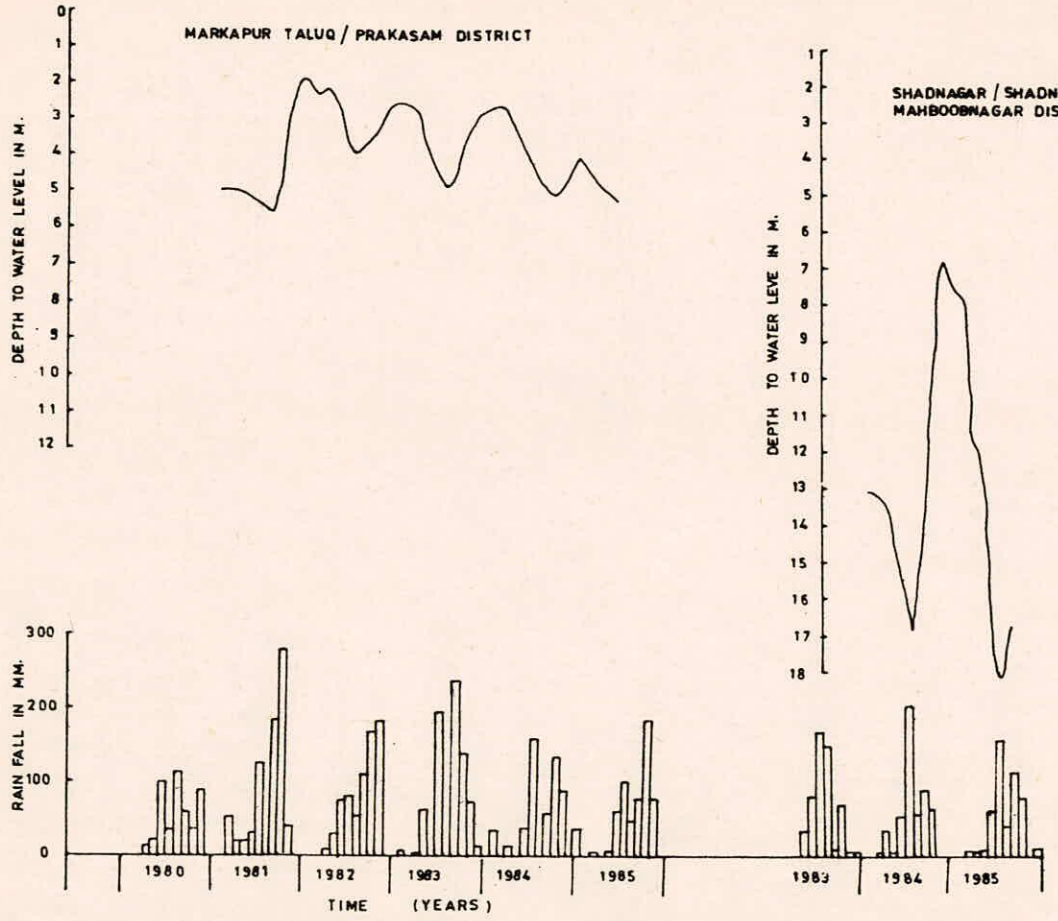
VARIATION OF GROUND WATER LEVELS (A.P.)
ALONG WITH RAINFALL

APP. V-2/12

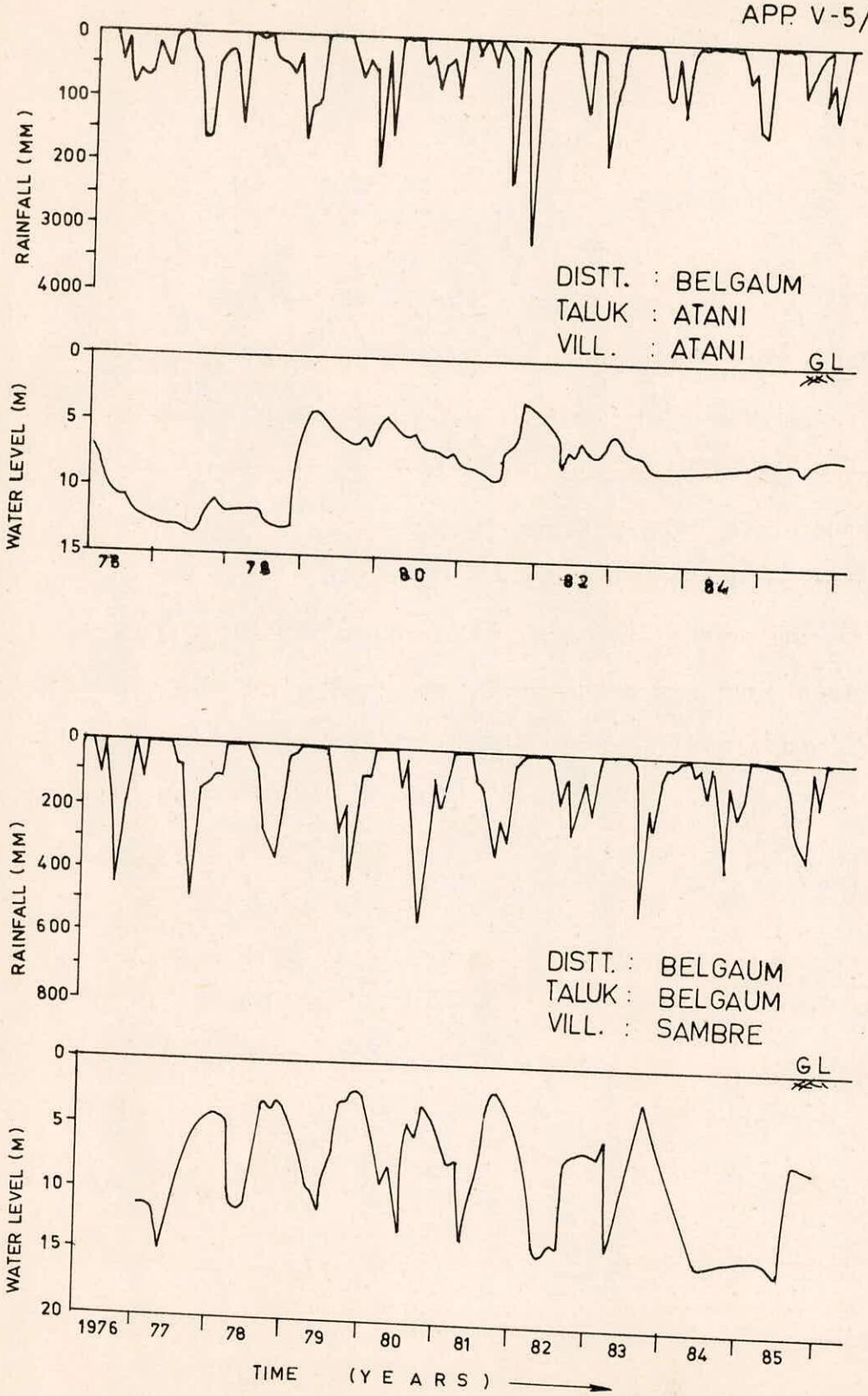


VARIATION OF GROUND WATER LEVELS (A.P.)
ALONG WITH RAINFALL

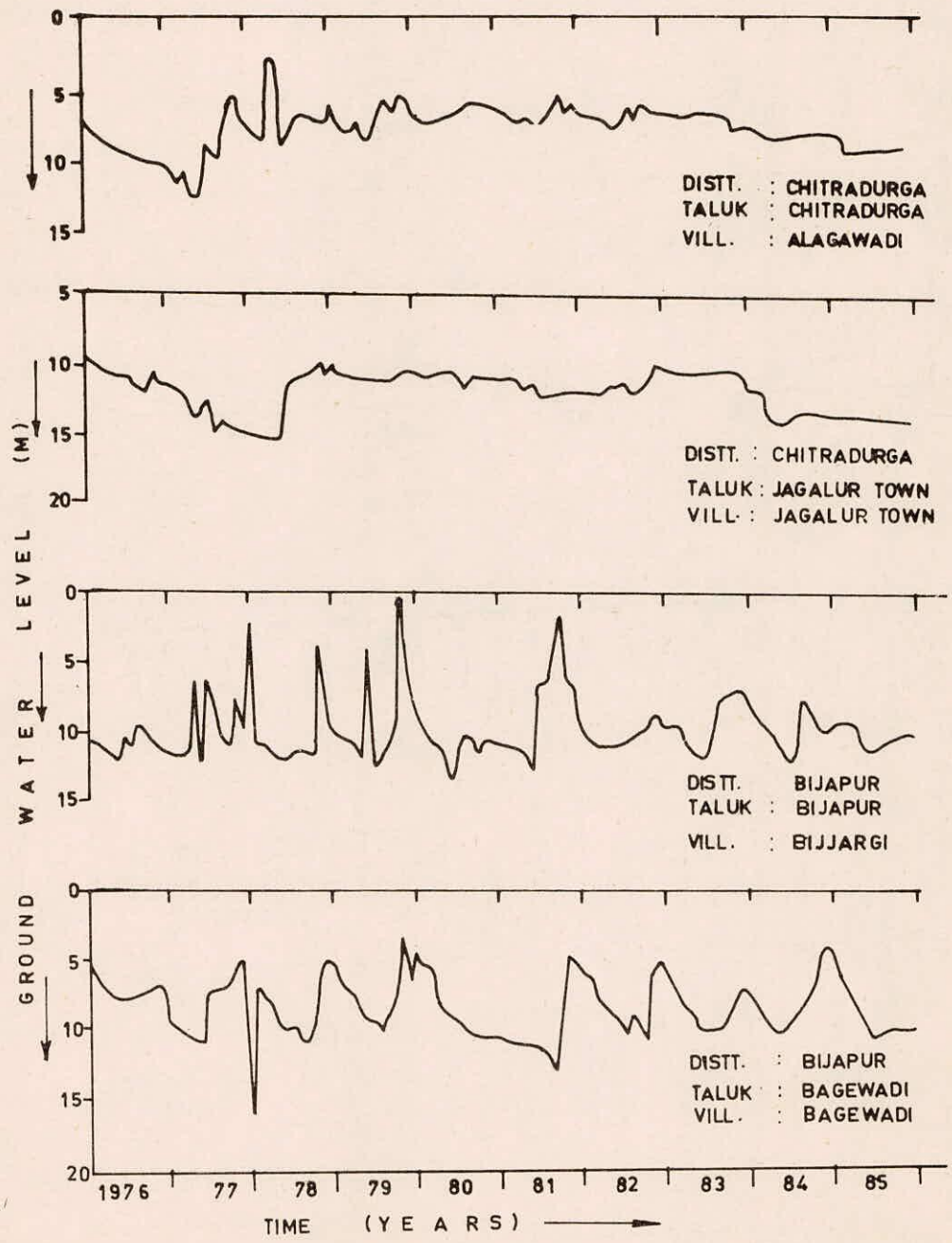
APP. V-3/12



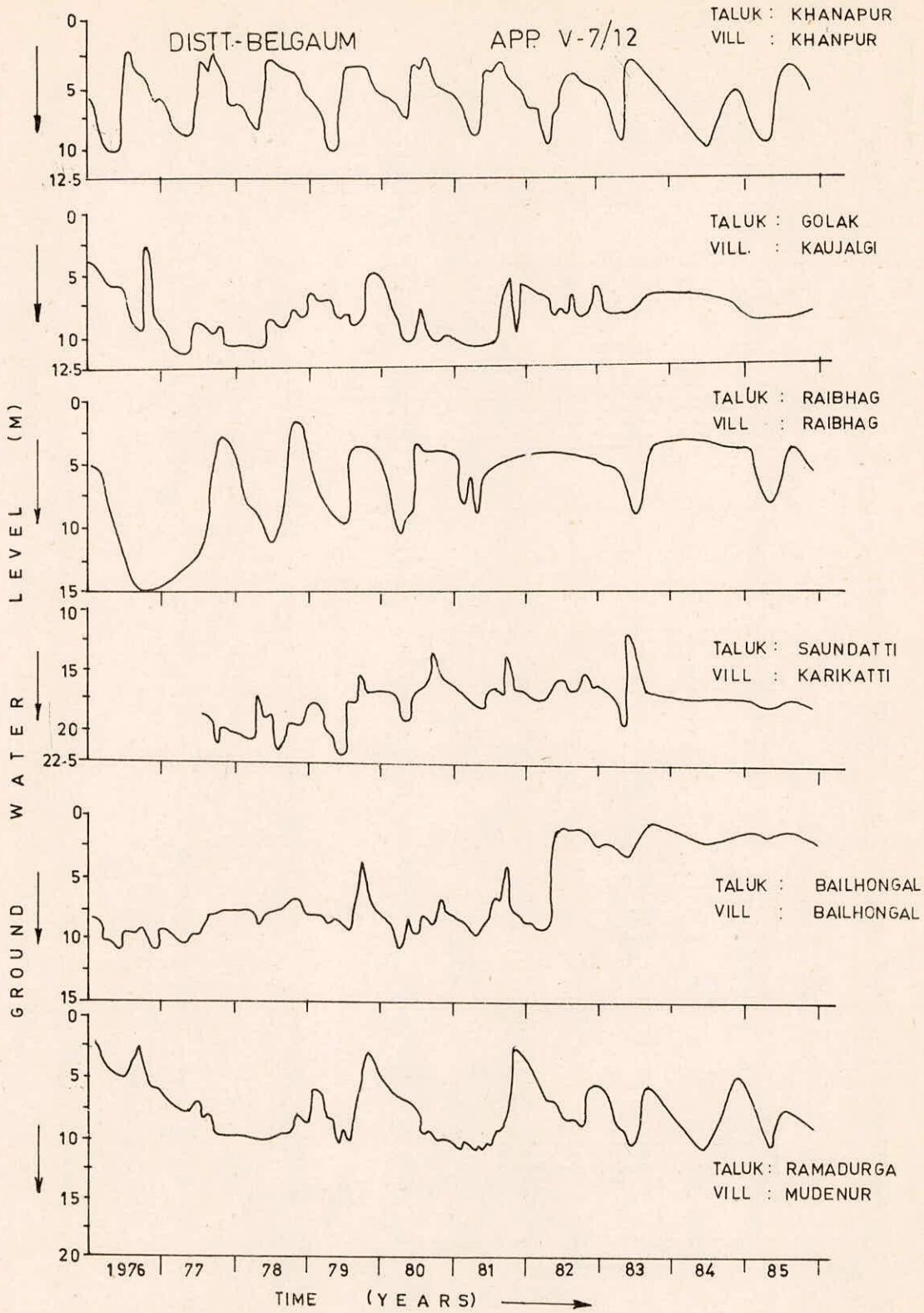
VARIATION OF GROUND WATER LEVELS (A.P.)
ALONG WITH RAINFALL



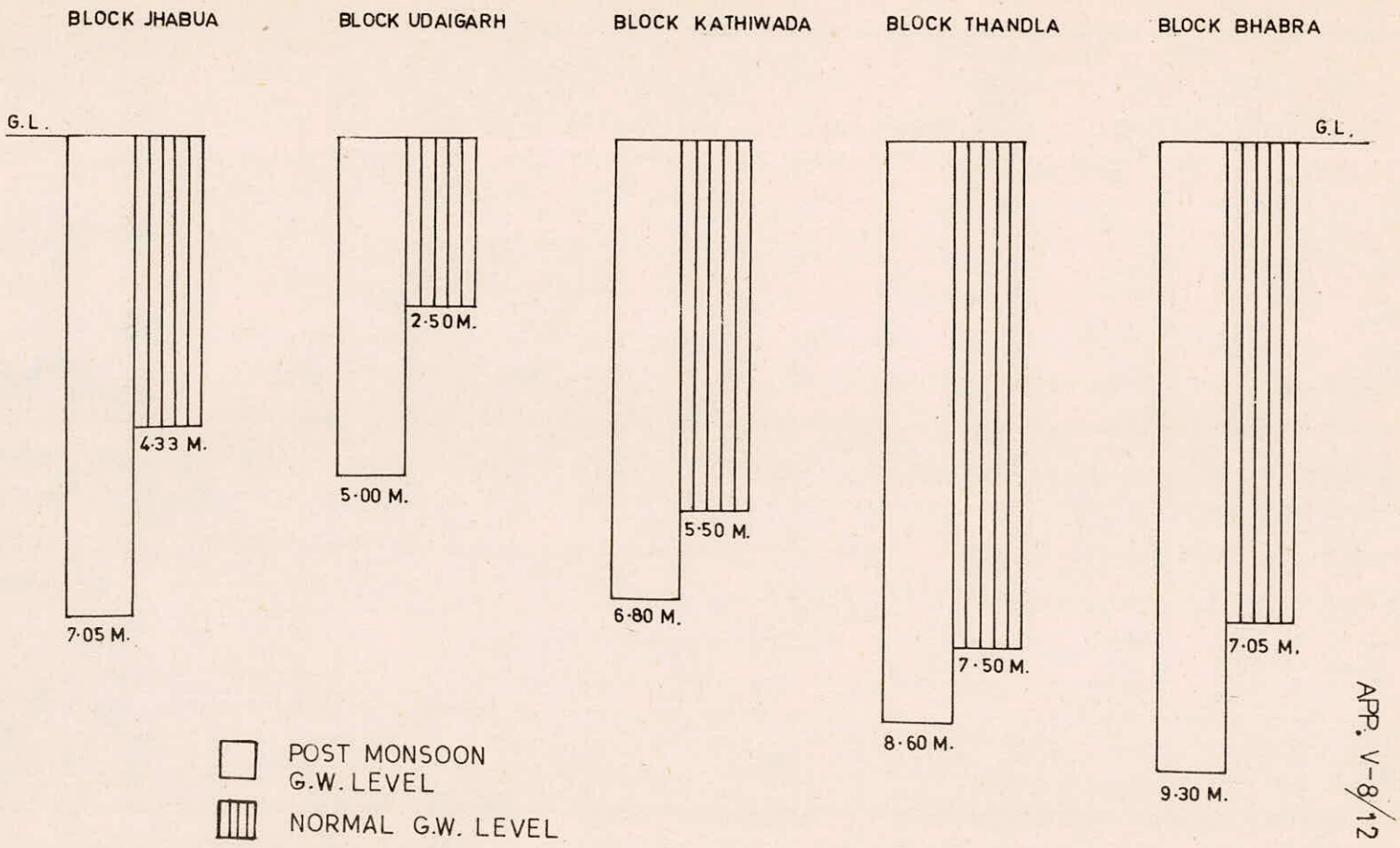
VARIATION OF GROUND WATER LEVEL (KARNATAKA) ALONG WITH RAINFALL



VARIATION OF GROUND WATER LEVELS
(KARNATAKA)

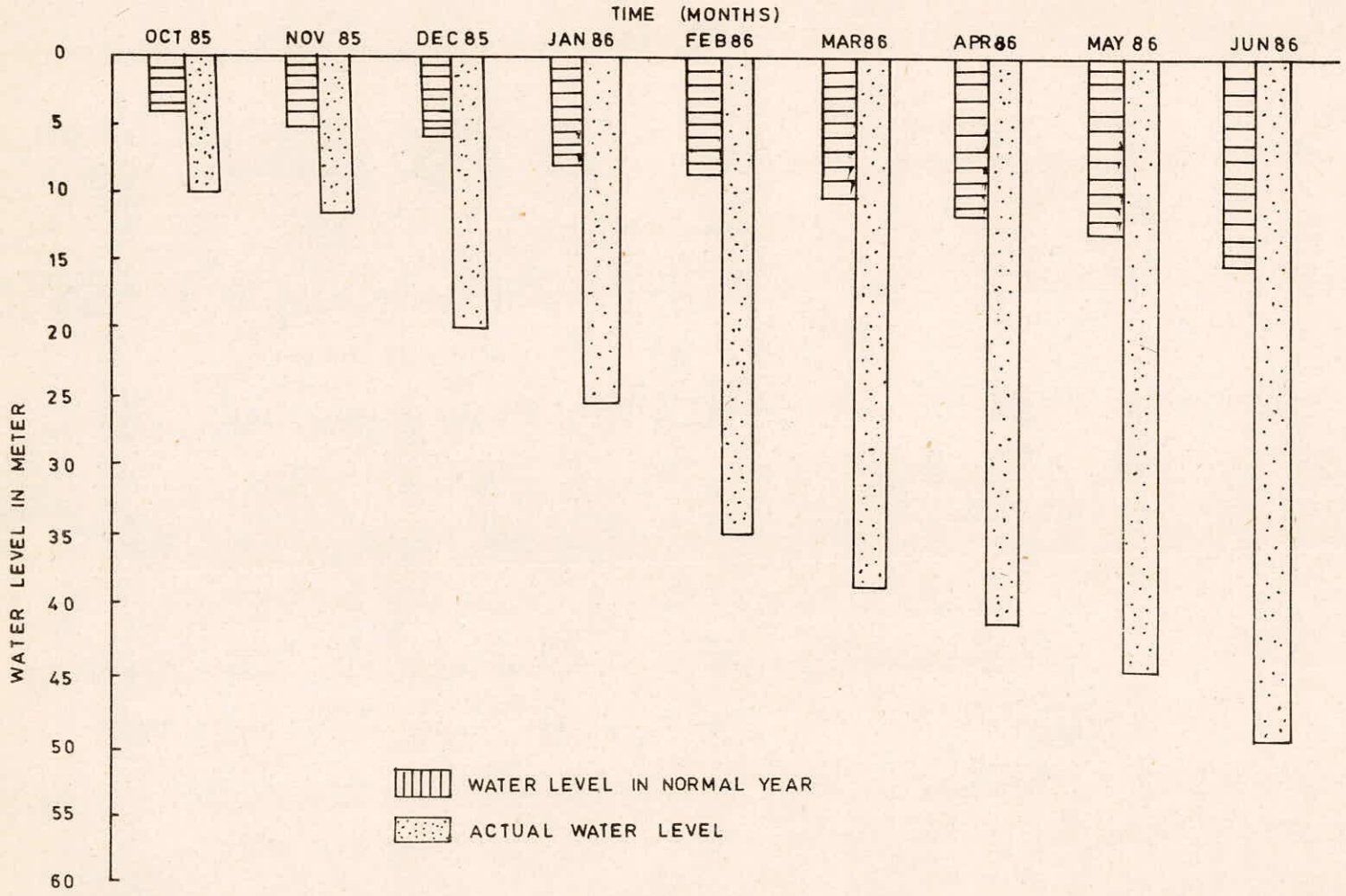


VARIATION OF GROUND WATER LEVELS
(KARNATAKA)



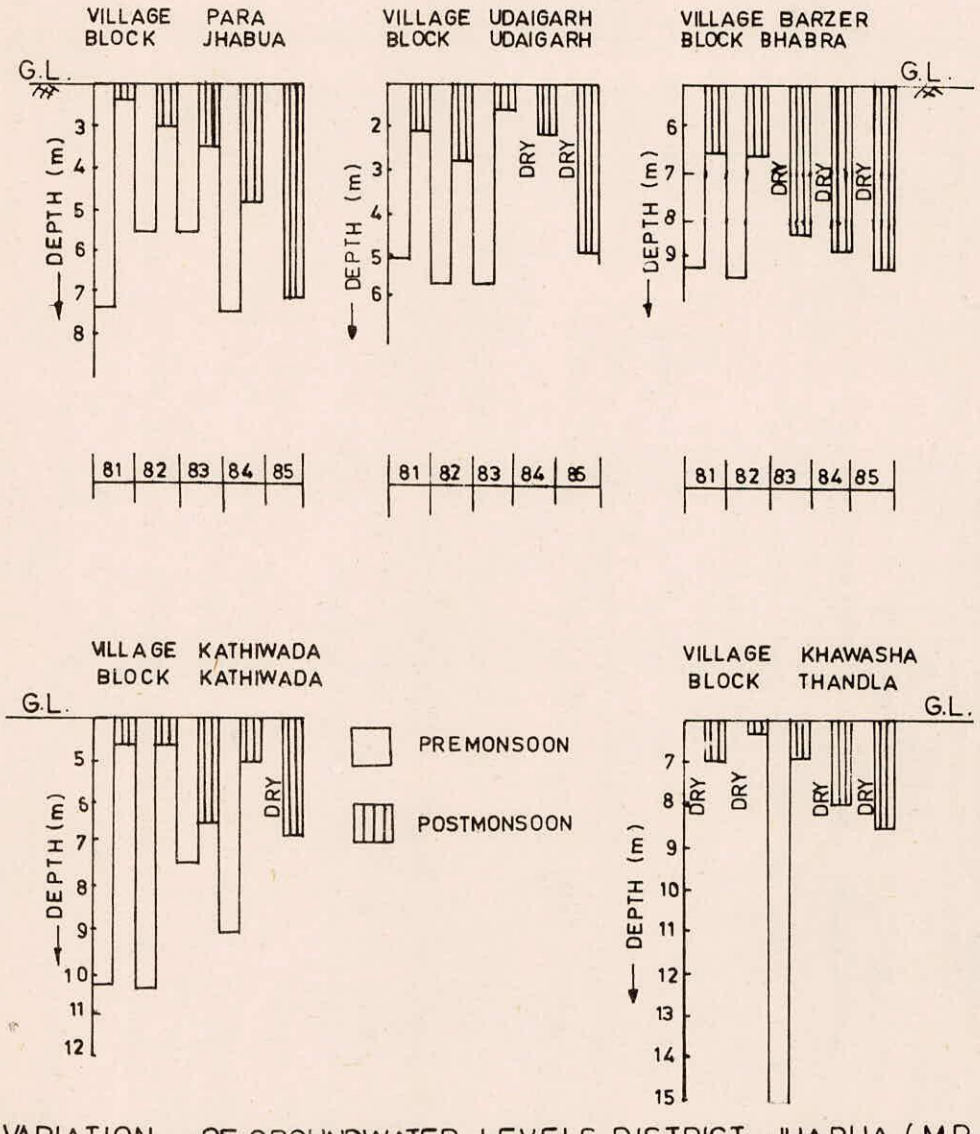
APP. V-8/12

GRAPH SHOWING DEPLETION OF GROUND WATER LEVELS FROM NORMAL (POST MONSOON) IN JHABUA (M. P.)

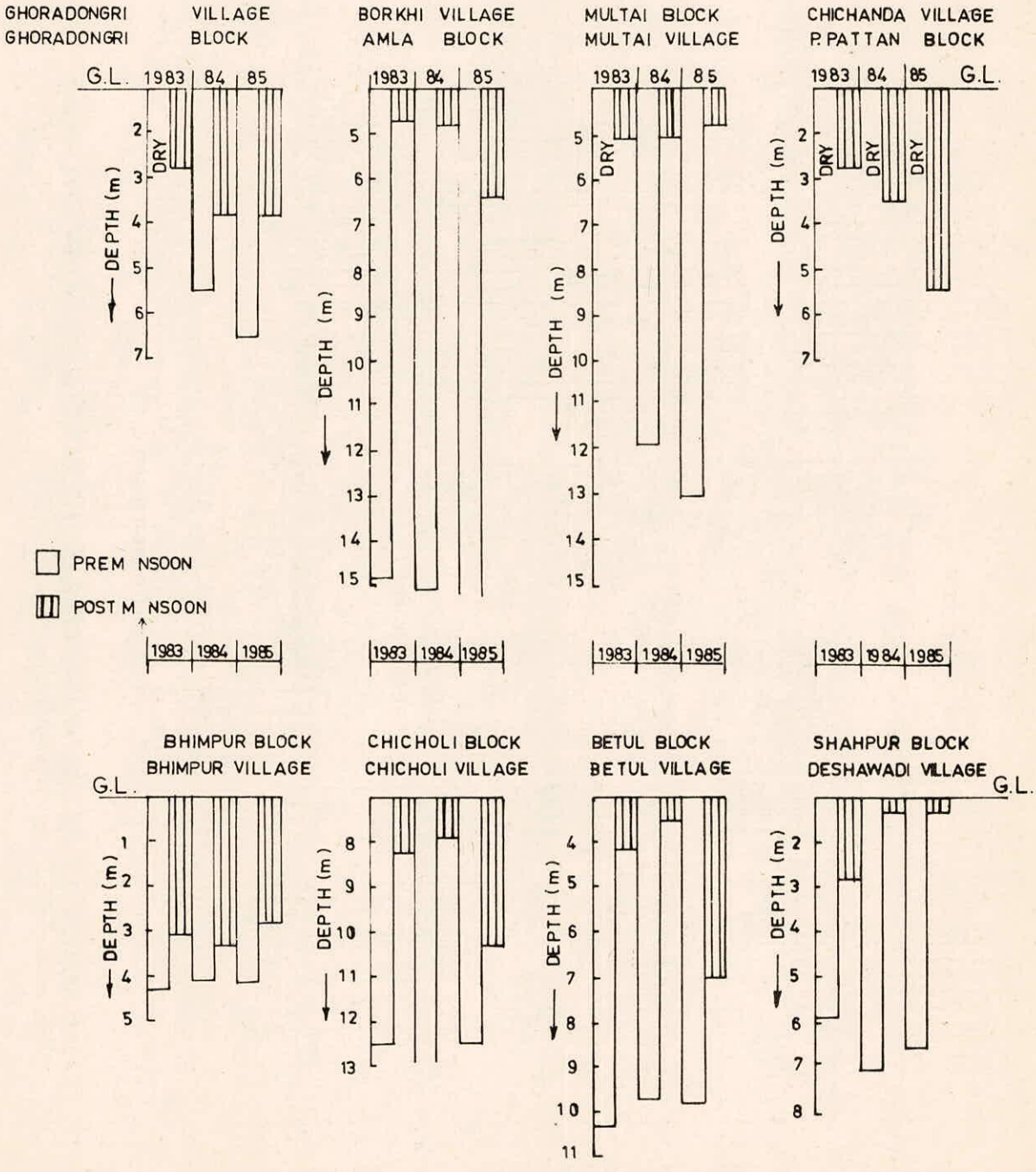


GRAPH SHOWING DEPLETION OF WATER LEVEL IN TUBE WELL, BLOCK: KUKSHI, DISTT: DHAR (M.P.)

APP. V-9/12

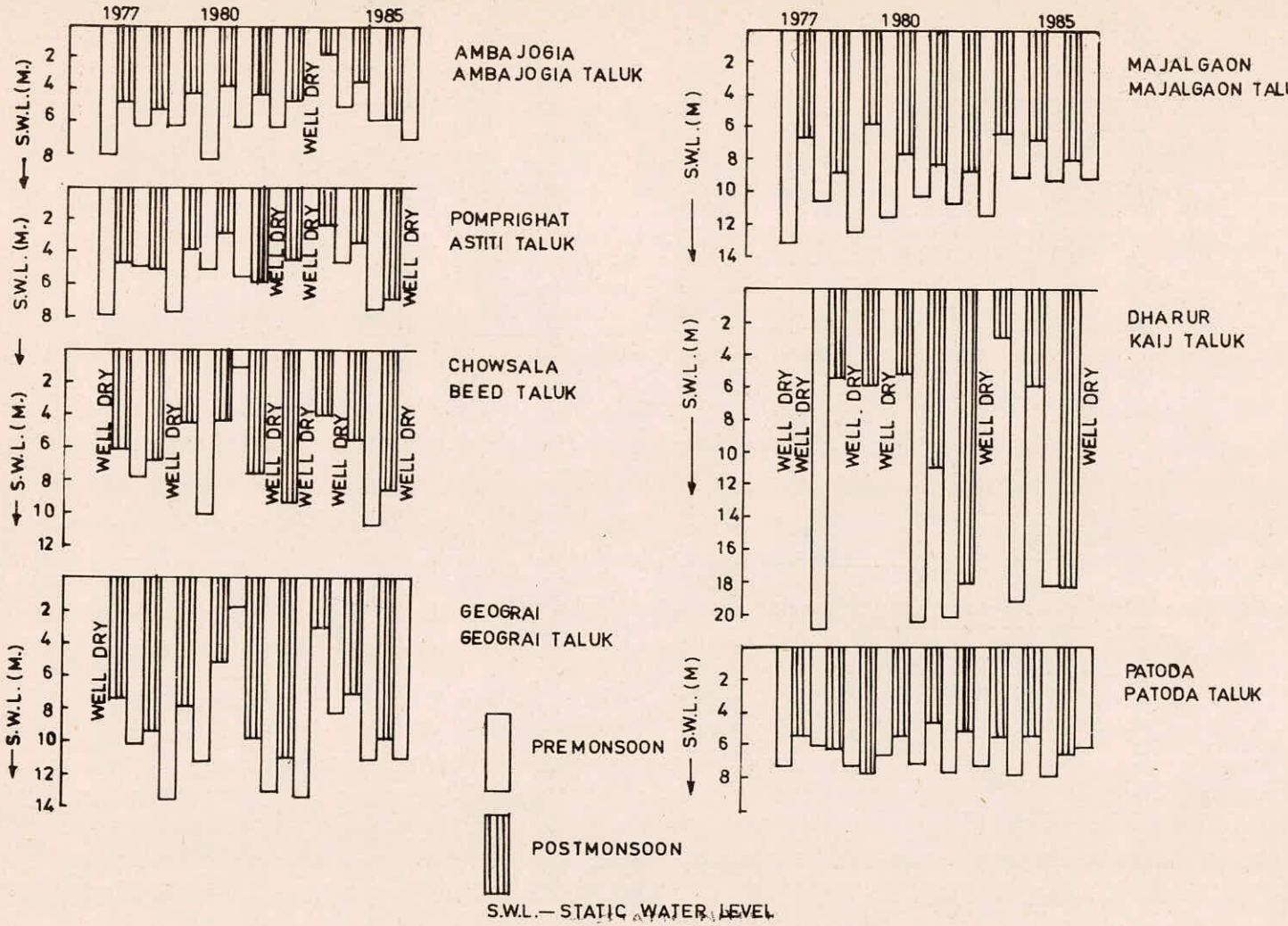


VARIATION OF GROUNDWATER LEVELS, DISTRICT JHABUA (M.P.)



VARIATION OF GROUND WATER LEVELS

DISTRICT BETUL (M.P.)



FLUCTUATION OF STATIC WATER LEVELS IN SELECTED OBSERVATION WELLS IN BEED DISTRICT. (MAHARASHTRA)

Area And Production of Principal Crops in Andhra Pradesh

Sl. No.	CROPS	AREA (LAKH HECTARES)				PRODUCTION (LAKH TONNES)			
		1981-82	1982-83	1983-84	1984-85	1981-82	1982-83	1983-84	1984-85
I.	Cereals and Millets					78			
1.	Rice	30.24	36.24	41.63	41.63	35.31	78.68	76.72	87.91
2.	Wheat	0.17	0.18	0.13	0.15	0.11	0.13	0.12	0.10
3.	Jowar	22.14	21.17	19.76	17.55	13.34	15.20	11.25	11.13
4.	Bajra	5.44	4.92	5.13	3.94	4.44	2.60	3.61	2.15
5.	Maize	3.32	3.33	3.41	3.03	6.32	7.44	5.22	4.45
6.	Ragi	2.59	2.42	2.55	2.21	2.87	2.34	2.63	2.09
7.	Minor Millets	6.03	4.73	4.74	4.11	3.71	1.47	2.40	1.26
II.	Pulses Total	77.93	73.13	77.35	66.30	109.47	105.90	113.14	91.02
8.	Bengalgram	0.52	0.60	0.59	0.40	0.24	0.26	0.23	0.14
9.	Redgram	2.48	2.41	2.65	2.43	0.61	0.45	0.74	0.57
10.	Blackgram	2.19	2.17	2.24	2.32	0.90	1.26	1.32	2.01
11.	Greengram	5.66	5.85	6.15	5.27	2.10	2.86	2.45	1.67
12.	Horsegram	2.95	3.07	2.82	2.33	0.78	0.96	0.82	0.65
13.	Other pulses	0.32	0.29	0.53	0.40	0.04	0.04	0.10	0.06
	Total	14.30	14.39	14.98	13.15	4.70	5.83	5.66	5.10
III.	Other Crops								
14.	Ground nuts	14.51	15.05	16.65	16.95	14.37	11.33	17.16	13.23
15.	Sesamum	1.72	1.64	1.74	1.35	0.29	0.26	0.27	0.19
16.	Cotton Lint	4.73	4.43	4.77	5.29	6.63*	624.0*	10.18*	9.85*
17.	Sugarcane(Gur)Harvested	1.80	1.70	1.42	1.39	16.43@	13.45@	10.38@	10.38@
18.	Tobacco	1.84	2.53	1.86	1.77	1.93	2.70	1.86	1.72
19.	Chillies	1.57	1.81	1.61	1.49	1.65	1.91	1.79	2.32

* Production of lint in bales of 170 Kgs.

@ Production in terms of Gur

APP VI - 1/6

Area and production of crops in Gujarat.

(AREA IN LAKH HEC.,PROD.IN LAKH TONNES.

Crops	1983-84 Area	1983-84 Prod.	1984-85 Area	1984-85 Prod.	1985-86 Area	1985-86 Prod.	Forecast No.
Rice	5.40	7.54	5.65	8.38	4.92	4.54	Final
Kh.Jowar	7.97	4.40	7.37	3.66	7.46	2.52	II
Bajri	13.09	13.73	12.43	12.53	11.86	4.40	Final
Maize	3.18	4.76	3.10	3.84	3.17	1.14	Final
Ragi	0.45	0.49	0.45	0.44	0.45	0.33	Final
Kodra	0.58	0.48	0.54	0.39	0.52	0.08	Final
Small millets	0.57	0.31	0.52	0.25	0.42	0.12	I(P)
Total Kh. Cereals:	31.24	31.76	30.06	29.49	28.80	13.13	
Kharif Pulses							
Tur	3.00	2.05	3.29	2.51	3.10	2.09	II
Mug	1.57	1.33	1.63	1.13	1.61	0.23	Final
Math	1.03	0.44	0.91	0.29	0.84	0.05	Final
Other kh.pulses	0.30	0.13	0.29	0.12	0.28	0.10	I(P)
Udid	0.65	0.30	0.76	0.34	0.81	0.22	Final
Total kh. pulses:	6.55	4.25	6.88	4.30	6.64	2.69	
Total food grains.	37.79	36.01	36.94	33.88	35.44	15.82	
Rabi Crops							
Wheat(iiri.)	5.68	15.25	4.91	12.50	3.27	7.93	
Wheat(unirri)	1.73	1.01	1.46	0.79	1.13	0.55	
Wheat(total)	7.41	16.26	6.37	13.29	4.40	8.48	II
Barley	0.07	0.10	0.07	0.06	0.05	0.05	I(P)
Rabi Jowar	1.50	1.41	1.38	1.33	1.30	1.00	I(P)
Small millets	0.01	0.01	0.02	0.01	0.01	0.01	I(P)
Total R.Cereals:	8.99	17.78	7.84	14.69	5.76	9.54	
Pulses(Rabi)							
Gram	1.22	1.18	1.16	1.01	0.78	0.45	II
Other R.Pulses	0.26	0.16	0.26	0.16	0.21	0.10	I(P)
Total R.Pulses:	1.48	1.34	1.42	1.17	0.99	0.55	
Total R.food grains	10.47	19.12	9.26	15.86	6.75	10.09	
Hot weather bajri	1.28	2.30	1.29	2.83			
Total foodgrains:	49.54	57.43	47.49	52.57	42.19	25.91*	
Groundnut	19.50	15.05	19.33	13.96	17.51	3.90	Final
Gr.nut(summer)	2.00	3.05	1.28	1.77	0.40	0.50	I(P)
Gr.nut-total	21.50	18.10	20.61	15.73	17.91	4.40	(P)
Sesamum	1.27	0.46	1.44	0.50	1.26	0.21	III
Rape amd Mustard	1.74	2.36	1.95	2.39	1.78	1.81	II
Castor	2.02	2.81	2.58	3.49			
Total Oilseeds	26.53	23.73	26.58	22.11			
Cotton	13.99	14.44	13.83	20.69	14.07	19.47	IV
Tobacco	1.08	1.87	1.08	1.74	0.89		I
Sugarcane	1.03	7.75 (Gul)	1.03	7.58 (Gul)	0.90	6.43 (Gul)	II
Potatoes	0.11	3.00	0.10	3.23	0.06		I

Production of Cotton bales each of 170 kgs/lint.
(P):Provisional. *Excluding summer bajra.

Sl. No.	Crops	Chitradurga						Bijapur						Dharwar					
		79-80	80-81	81-82	82-83	83-84	84-85	79-80	80-81	81-82	82-83	83-84	84-85	79-80	80-81	81-82	82-83	83-84	84-85
1.	Rice	3079	2668	2749	2838	2129	2359	1157	1297	1297	1187	1054	1180	1470	1687	1466	1398	1178	1611
2.	Jowar	2470	1591	1652	1038	1105	1276	549	362	589	452	'453	560	1222	1145	1229	1089	1154	1028
3.	Ragi	1713	1546	1492	1140	1621	1686	-	-	-	-	-	-	1485	877	853	780	1636	1290
4.	Maize	3209	3141	3774	3097	2641	1813	2490	2267	2348	1896	2255	2255	2549	2304	2281	2036	2302	2362
5.	Bajra	568	340	633	414	654	383	194	242	386	375	579	590	353	244	272	208	386	397
6.	Wheat	542	1222	1629	1140	1110	1087	542	700	651	683	622	525	601	390	490	429	491	494
7.	Minor Millets.	524	432	740	577	526	379	496	471	557	521	273	332	580	462	570	654	193	590
Total Cereals		1783	1954	1595	1319	1397	1420	809	443	596	513	569	629	1071	1921	1064	984	1013	1805
Total Pulses		623	489	815	463	627	458	360	308	411	335	290	286	358	328	358	374	384	354
Total Oilseeds		1052	921	923	1093	883	1154	403	325	462	336	433	402	576	564	515	525	770	768
Cotton		118	152	104	183	163	145	64	31	57	48	62	38	144	114	124	142	135	125
Sugarcane		71	86	91	83	78	92	65	65	61	80	65	73	65	65	61	80	65	67
Tobacco		619	492	630	916	424	346	742	860	591	1021	579	706	742	860	591	1021	457	721

Notes - 1. The data from 1979-80 to 1982-83 are based on fully revised Estimates and the data for 1983-84 and 1984-85 are based on final forecast of 1984-85.

2. Yield of Sugarcane in terms of tonnes.

Source - Directorate of Economics & Statistics

App.VI-3/6(Cont.)

Cropwise Agricultural Production in (KARNATAKA)

Yield/ha. in kgs.

Sl. No.	Crops	Belgaum						Kolar						Tumkur					
		79-80	80-81	81-82	82-83	83-84	84-85	79-80	80-81	81-82	82-83	83-84	84-85	79-80	80-81	81-82	82-83	83-84	84-85
1.	Rice	1284	1309	1493	1318	1371	1463	1529	965	1611	1219	1386	1314	2064	1834	2074	1702	1770	2102
2.	Jowar	792	722	912	679	980	1141	2504	533	661	391	693	633	1045	830	607	464	521	706
3.	Ragi	769	742	730	780	1181	1016	739	370	783	419	695	590	815	931	1187	1038	906	1055
4.	Maize	2568	2227	2566	2202	2772	2484	2788	2560	3381	2988	3184	1844	3530	3166	3407	2764	3052	2254
5.	Bajra	191	165	253	226	278	291	509	527	617	413	631	383	521	254	616	412	629	382
6.	Wheat	592	564	774	540	933	822	538	412	519	1230	463	410	1271	1427	1629	1230	1435	1460
7.	Minor Millets	505	423	514	563	572	620	479	391	479	382	401	165	594	428	465	393	269	232
Total Cereals		874	823	1609	821	1107	1140	943	548	989	630	902	703	1105	979	1200	1027	867	1074
Total Pulses		403	330	385	391	467	484	334	293	394	208	283	240	453	307	339	275	314	175
Total Oilseeds		731	562	660	565	594	793	853	445	863	621	949	1009	630	519	790	572	861	451
Cotton		148	155	182	261	247	237	116	152	104	183	251	155	116	152	104	183	208	168
Sugarcane		65	65	61	80	65	66	51	91	91	74	72	68	51	91	91	83	96	77
Tobacco		742	860	591	1021	596	721	1145	1086	630	916	536	540	1145	1086	630	916	406	416

....2....

Table 4.1

DISTRICTWISE ABSTRACT OF AREA IRRIGATED FROM SURFACE STORAGES IN LAST 10 YEAR IN SAURASHTRA(GUJRAT)

Sl. No.	Name of District	Design Irrigation Potential (Ha.)	Area Irrigated (Ha.)										
			1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
1.	RAJKOT	41252	22719 (55.07)	28909 (70.08)	35563 (86.21)	12867 (31.19)	24960 (60.51)	28754 (69.70)	33388 (80.94)	23060 (55.90)	27345 (66.29)	21410 (51.90)	-
2.	SURENDRANAGAR	9986	9915 (99.29)	8701 (87.13)	13397 (134.16)	10158 (101.72)	17066 (170.89)	15530 (155.52)	18391 (184.17)	17886 (179.11)	12692 (127.10)	10891 (109.06)	1728 (17.30)
3.	JAMNAGAR	11866	5692 (47.97)	6477 (54.58)	8578 (72.29)	5358 (45.15)	9138 (77.01)	5118 (43.13)	9201 (77.75)	5674 (47.82)	6462 (54.46)	6169 (51.99)	-
4.	AMRELI	12723	3262 (25.64)	3518 (27.65)	5100 (40.08)	5986 (47.05)	6901 (54.24)	8678 (68.21)	5909 (46.44)	5441 (42.77)	11048 (86.83)	2019 (15.87)	-
5.	JUNAGADH	30075	1016 (33.78)	2482 (8.25)	3512 (11.68)	2695 (8.96)	4015 (13.35)	3592 (11.94)	3770 (12.54)	5096 (16.94)	5650 (18.79)	5460 (18.15)	2474 (8.23)
6.	BHAVNAGAR	54599	8310 (15.22)	25959 (24.54)	34647 (63.46)	1687 (3.09)	41502 (76.01)	29466 (53.97)	19182 (35.13)	35645 (65.29)	44031 (80.64)	4907 (8.99)	1909 (3.50)
	TOTAL	160501	50914 (31.72)	76046 (47.38)	100797 (62.80)	38751 (24.14)	103582 (64.54)	91138 (56.78)	89841 (55.98)	92802 (57.82)	107229 (66.81)	50856 (31.69)	6111 (3.81)

Value in Brackets indicate %age of Design Irrigation Potential

Area, Production and Average yield under Principal Crops (Kg/ha) in (MAHARASHTRA)

District	Kharif Jowar			Bajra			Rabi Jowar		
	Area 100 ha	Prod. 100 ton	Yield Ka/ha	Area 100 ha	Prod. 100 ton	Yield Kg/ha	Area 100 ha	Prod. 100 ton	Yield Kg/ha
Nasik	315	385	1222	3582	877	245	670	234	349
Dhule	923	921	997	1422	802	564	879	567	645
Jalgaon	2209	2418	1095	1147	636	554	423	437	1033
Ahmednagar	163	174	1064	3326	1021	307	5706	3573	626
Pune	267	384	1438	1850	610	330	4888	2625	537
Solapur	85	96	1132	257	72	280	7664	3073	401
Satara	933	1471	1577	1124	271	243	1525	1091	715
Sangli	1281	1327	1037	932	144	154	1139	543	477
Aurangabad	566	325	575	1637	380	232	2766	523	189
Parbhain	1800	1651	917	99	30	303	1767	1128	638
Beed	1121	1048	935	1257	479	381	2708	1280	473
Nanded	2507	2938	1172	10	3	300	429	288	669
Osmanabad	1140	1173	1029	83	26	313	1855	1103	595
Latur	2112	2257	1069	142	45	317	457	329	720
Akola	2792	2558	916	40	13	345	2	1	340
Bhandan	24	9	356	-	-	-	267	95	356

APP. VI-5/6

: Area and Production Under Rabi Crops in Rajasthan
(RAJASTHAN)

Prod. in lac. tonnes:

Crops	Target		Likely Achievements		Likely Percentage Reduction	
	Area	Prod.	Area	Prod.	Area	Prod.
CEREALS:						
Wheat	19.50	36.00	15.68	29.41	20	19
Barlay	3.10	4.60	2.33	3.55	25	23
Total Cereals	22.60	40.60	18.01	32.96	20	19
PULSES:						
Gram	17.00	13.44	15.01	13.47	12	-
Rabi Pulses	0.40	0.20	0.26	0.16	35	20
Total Pulses	17.40	13.60	15.27	13.63	12	-
Total food-grains :	40.00	54.20	33.28	46.49	17	14
OILSEEDS:						
Rape & Must.	11.00	9.00	8.99	7.69	18	15
Linseed	0.80	0.50	0.79	0.29	1	46
Total:	11.80	9.50	0.78	7.96	17	16
Other Rabi Crops	5.65	-	2.04	-	64	
G.Total:-	57.45	-	45.10	-	22	