HYDROLOGICAL ASPECTS OF DROUGHT UPTO 1987-88 - A CASE STUDY OF ANDHRA PRADESH

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PREFACE

A most important factor in understanding droughts, often not included in definition, is that it is a supply and demand phenomenon. Though a no. of definitions of drought pertaining to various uses have been developed, however, a definition which does not include reference to water requirement or demand can be regarded as inadequate. To a hydrologist drought means below average availability of flow in streams and below average storages in reservoirs, lakes, tanks, ground water aquifers and soil moisture in soil column. The various hydrological variables which can be used to study hydrological aspects of drought include rainfall, groundwater levels, surface water storages and soil moisture.

The problem of drought in the country has been recurrent in nature. In late 80's the country has faced drought for three years in succession. Reliable estimates indicate that the drought of year 1987 is ranked second in the century, the first one being in year 1918. It has been estimated that about 1/3rd of the geographical area of the country (107 M ha) spread over 99 districts, are drought prone. The Central Water Commission (CWC) has carried out studies in these 99 districts for identifying drought proneness.

The National Institute of Hydrology initiated drought studies in the year 1986 with the major objectives to lay emphasis on hydrological aspects of drought and to develop suitable drought indices alongwith evolving short and long term drought management strategies. In this venture the institute has already carried out studies on various aspects of drought. In order to study the gravity of problem studies have been taken up using the field data to evaluate impacts of drought. In this pursuit the institute has

chosen six states namely, Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra & Rajasthan. The present report covers the study of six districts of Andhra Pradesh state. These districts are Anantpur, Cuddapah, Chittoor, Prakasam Mahboobnagar and Kurnool.

The scientific teams of the institute undertook visits to the state of Andhra Pradesh and contacted the relevant state / central govt. agencies for collecting the required data. The study includes various kinds of analysis of rainfall, and ground water level data for assessing drought impacts. Based on the analysis, inferences, highlighting hydrological aspects of the recent droughts, have been drawn

The study has been carried out by Shri V.K.Lohani, Scientist 'C', Shri Sudhir Kumar Goyal, Scientist 'B', Shri Yatveer Singh, R.A., Sri Mukesh Kumar Sharma, S.R.A.,Shri Tanveer Ahmed, R.A. under the guidance of Dr.G.C.Mishra, Scientist 'F'. The manuscript has been typed by Shri S P Modi, L.D.C..

(SATISH CHANDRA)

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ABSTRACT

The occurrence of drought in India is not a recent phenomenon. In recent years the country faced three drought years in succession namely 1985, 1986 and 1987. It has been reported intensitywise the drought of year 1987 ranks second in the 20th century,the first one being in the year 1918. Statistics on area coverage indicate that out of the country's total geographical area of 328 m.ha., 107 m.ha. or about one third of the area and 29 percent of the population are affected by drought.

In view of severity of drought problem and less understanding the hydrological aspects associated with the droughts, the National Institute of Hydrology started studies in the year 1986 to better understand the drought impacts from hydrology point of view. In this venture the institute started collection, from field organisations, of the data concerning rainfall, streamflow and ground water in selected areas, covering the period 1951 to 1988. Six states of Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Madhya Pradesh and Rajasthan were selected for the study. This report covers the analysis of rainfall, groundwater, and reservoir level data in respect of six selected districts of Anantpur, Cuddapah, Chittoor, Prakasam, Kurnool and Mahboobnagar of State Andhra Pradesh for the assessment of drought imoact.

1.0 INTRODUCTION

1.1 General

In spite of all the inconveniences that drought causes all around the world, many drought phenomena are still insufficiently understood in terms of the characterization and impact assessment. There have been difficulties encountered in finding a generally accepted drought definition. The definitions currently in use are derived either on professional standpoints (meteorology, hydrology, geography etc.), or on the economic activity affected (agriculture, power, production, water supply etc.). A most important factor in understanding drought, often not included in definitions, that it is a "supply and demand" phenomena. A definition of drought which does not include reference to water requirement or demand can be regarded as inadequate. In general terms, the chief characteristics of drought is associated with a decrease of water availability in a particular period and over a particular area for specified use(s).

In India, the problem of droughts is recurrent. Estimates indicate that about one-third of the geographical area of the country (107 m.ha.) spread over 99 districts are affected by drought. In recent times, the country faced three drought years in succession namely, 1985, 1986 and 1987. It has been reported that intensity wise the drought of 1987 ranks second in the century, the first one being in year 1918. During the drought of 1987 about 50% of country's area was affected by drought with about 18% negative departure in monsoon rainfall all over India and about 45% negative departure in monsoon rainfall over the drought affected region (Upadhyay & Gupta, 1989). Sampath (1989)

has reported that during 1987, 21 meteorological sub-divisions out of 35 recorded deficient/scanty rains leading to drought conditions.It has been further reported that these subdivisions account for about 53% of the total food grains production in the country. A quick glance of food grains production figures indicates that during year 1987-88 the production was 138.41 million tonnes while in 1988-89 it was estimated to be about 172.0 million tonnes. The years 1985-86 through 1987-88 saw declining trend of food grains production which fell from 150.4 million tonnes in 1985-86 to 138.41 million tonnes in 1987-88. The fluctuation of foodgrain production clearly show dependability of agricultural activities on the rainfall.

The incidents of drought lead to reduction in stream flows, depletion of soil moisture storages, decline of reservoir and tank levels and fall in groundwater table. This in turn lead to reduced agriculture and fodder production. The drought characteristics and the associated problems vary from area to area depending upon the amount of variability of available water supplies and the demand of water for specified users.

1.2 Objectives of the Study

Inspite of repeated occurrence of droughts in the country, the hydrological aspects of droughts have not been studied to the desired extent. Such studies have a direct bearing on evolving strategies for planning judicious use of scarce water resources. The Institute has initiated studies to lay emphasis or Hydrological Aspects of Droughts starting year 1985 as these aspects were by and large neglected in past studies whatever carried out. Keeping in view the successive three drought years since 1985-87, in major parts of the drought prone area of the country, study areas were chosen in six various states namely:

Andhra Pradesh, Maharashtra, Karnataka, Rajasthan, Gujarat and Madhya Pradesh. Studies laying focus on hydrological aspects of drought for 1985-86 with two districts in each of chosen states and for 1986-87 with four districts have been completed.The studies for the year 1987-88 were carried out in six districts each in six states, and in view of wider aerial coverage in each state it was decided to prepare separate study reports contrary to the earlier study reports which presented results of studies in all states in one volume.

The present report, therefore, presents results of studies carried out in six districts of Andhra Pradesh 1987-88 The districts included for studies are Cuddapah, Anantpur, Chittoor, Prakasam, Kurnool and Mahboobnagar. The report includes analysis of rainfall, & groundwater level data for finding deficit of rainfall and trend of groundwater tables as a result of drought incidents. The status of storages in Nagarjunasagar and Sri Sailam reservoirs during drought periods located in the state has been included in the report. Stream flow analysis for the sites of Krishna and Godavari basin, lying in the state of Andhra Pradesh has been done basinwise and has been presented in the report Hydrological Aspects of Drought 1987-88 - A case Study (CS-37). The report is an attempt towards developing a comprehensive hydrological drought index for characterising drought studies. List of offices and places from where data & information have been collected in the State of Andhra Pradesh are shown in Appendix -II.

2.0 DESCRIPTION OF STUDY AREA

2.1 General

There are 99 districts spread over 13 states which have been identified as drought prone districts in the country and are shown in Fig. 2.1 . This report covers the study of six drought prone districts of state Andhra Pradesh namely: Anantpur, Cuddapah, Chittoor, Prakasam, Kurnool and Mahboobnagar. The locations of the districts are shown on the state map in Fig. 2.2.

Geographically Andhra Pradesh is the fifth largest state of India, covers about one fourth of the Deccan Plateau. It covers an area of 2,766,754 sq.km which is nearly 8% of the total area of the country. It extends from $12^{o}37'$ -$19^{o}54'$ N Latitude and 76^{o} $46'$ - $84^{o}46'$ E longitude. The state is divided in three regions: i) Coastal Andhra Pradesh, ii) Rayalseema and iii) Telangana. Andhra Pradesh receives rainfall from both South-west as well as the North-east monsoons. The S-W monsoon generally sets in from early June and lasts till about the end of September. The N-E monsoon occurs from October to December.

Andhra Pradesh is popularly referred to as the 'River State' since it has the advantage of having most of the East flowing rives in the heart of the state bringing in copious supplies from the Western and Eastern Ghats and the Deccan Plateau. The 5 most important rivers which are perennial in nature are : i) Godavari, ii) Krishna, iii) Vansadhara, iv) Nagavalli, v) Pennar.

2.2 Population - Man and Cattle

Andhra Pradesh is fifth populous state in the country

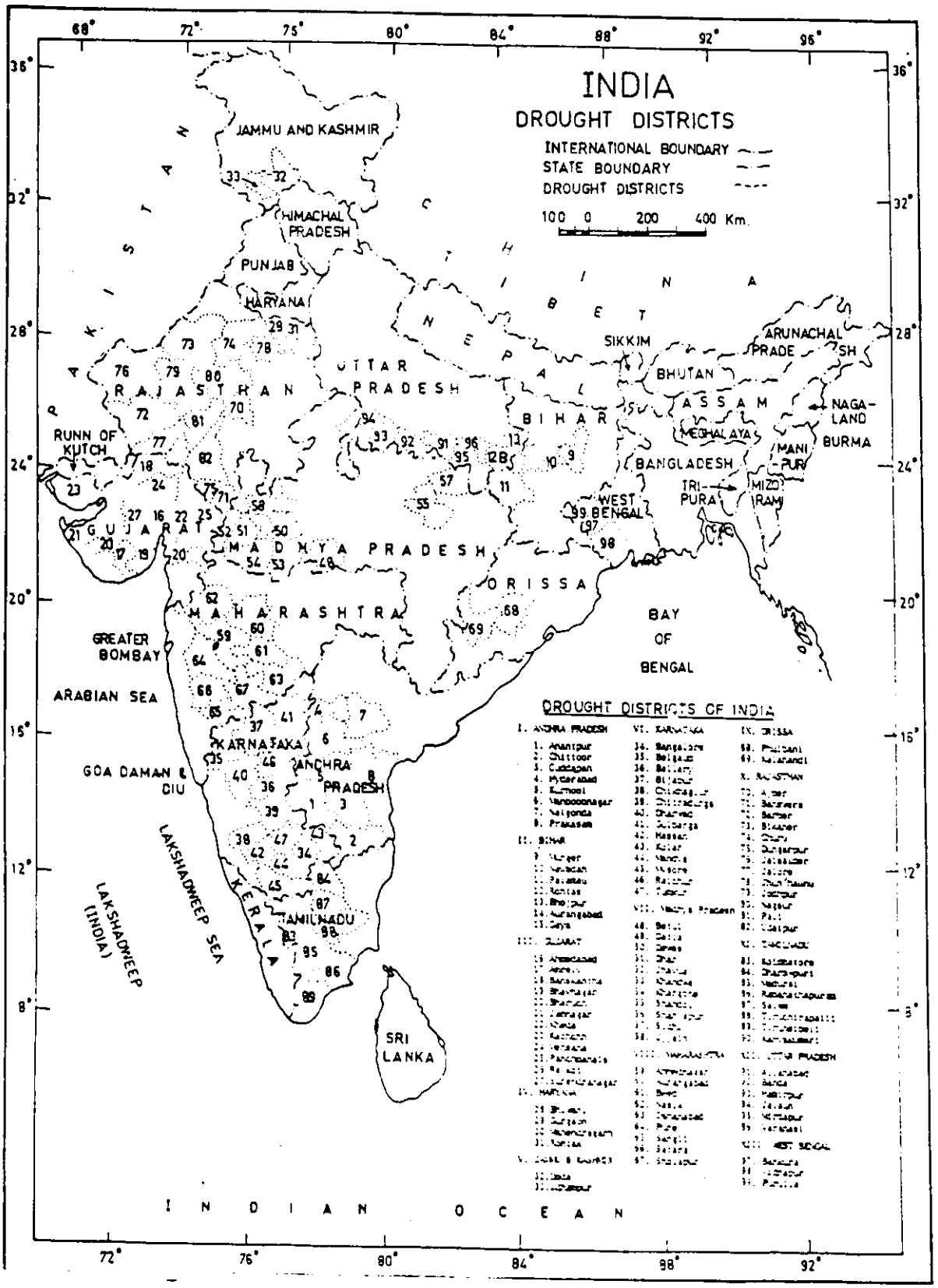


FIG. 2.1 : DROUGHT PRONE DISTRICTS IN INDIA

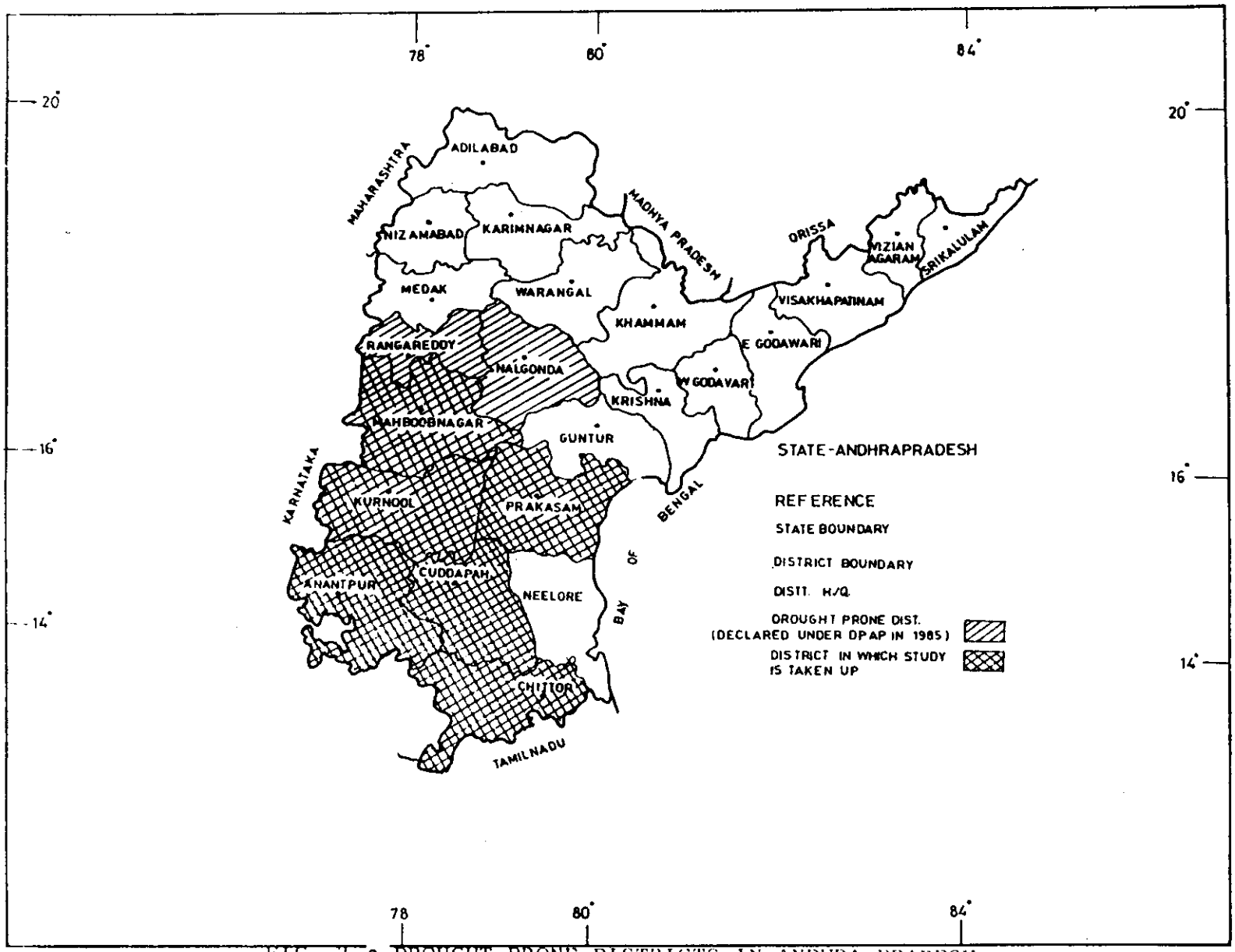


FIG. 2.2 DROUGHT PRONE DISTRICTS IN ANDHRA PRADESH

having a population of 535.5 lakhs. It accounts for 7.9% of the total population of the country. The population characteristics of the state are given in Table 2.1.

As per live-stock census of 1977 the total live stock of state Andhra Pradesh is about 3.15 crores. The details of the live stock of state Andhra Pradesh is given in Table 2.2.

2.3 Land use and Vegetal Cover

The details of land use from 1980-81 to 1984-85 are given in table 2.3. It can be noticed from the table that forest cover has been reduced considerably from about 62 lakhs ha. in 1980-81 to about 58 lakhs ha. in 1984-85. Fig. 2.3 shows the land utilization details in Andhra Pradesh.

2.4 Soils

There are six main types of soils viz. i) Alluvial , ii) Black cotton , iii) Red, iv) Lateritic , v) Arenacious, vi) Sandy loams. Fig. 2.4 shows the soil map of state Andhra Pradesh.

2.5 Surface Water Availability

The position of storages in the state of Andhra Pradesh for already completed, under completion and proposed projects are given in Table 2.4 (CWC, 1988).Table 2.5 gives the details of district wise area irrigated by surface irrigation as per figures of 1984-85.

TABLE 2.1

POPULATION CHARACTERSTICS - ANDHRA PRADESH

Sl. No.	Item	Unit	1961	1971	1981
(1)	(2)	(3)	(4)	(5)	(6)
1.	Total Population	...Lakhs	359.83	435.03	535.50
2.	Growth rate over the previous Census	.. Percentage	15.65	20.90	23.10
3.	Birth Rate (During the decade)	...Births per 1,000 Population	39.7	34.8	...
4.	Death Rate (during the decade)	...deaths per 1,000Population	25.2	14.6	...
5.	Density of Population	...Persons per Sq. Km.	131	157	195
6.	Male Population	...Lakhs	181.61	220.09	271.09
7.	Female Population	...Lakhs	178.22	214.94	264.41
8.	Sex Ratio	...Females per 1,000 Males	981	977	975
9.	Rural Population	...Lakhs	297.09	351.00	410.62
10.	Urban Population	.. Lakhs	62.74	84.03	124.88
11.	Urban Population as a percentage of total population	...Percentage	17.4	19.3	23.3
12.	(a) Scheduled Caste Population	...Lakhs	49.74	57.75	79.62
	(b) Scheduled Caste Population as a percentage to total population	...Percentage	13.8	13.3	14.9
13.	(a) Scheduled Tribes population	...Lakhs	13.24	16.58	31.76
	(b) Scheduled Tribes population as a percentage of total population	...Percentage	3.7	3.8	5.9
14.	(a) Literates — Males	...Lakhs	54.82	73.04	106.42
	(b) Literates — Females	...Lakhs	21.44	33.86	53.93
	(c) Literates — Total population	...Lakhs	76.26	106.90	160.35
15.	(a) Literacy rate — Males	...Percentage	30.2	33.2	39.3
	(b) Literacy rate — Females	...Percentage	12.0	15.8	20.4
	(c) Literacy rate — Total Population	Percentage	21.2	24.6	29.9
16.	(a) Workers — Total	...Lakhs	186.63	180.06	245.06
	(b) Workers — Agriculture	...Lakhs	128.23	126.23	157.33
	(c) Workers — Non-Agriculture	Lakhs	58.40	53.83	87.73

SOURCE : Census Publication of the relevant years

TABLE 2.2

COMPARISON OF ANDHRA PRADESH WITH ALL INDIA–LIVESTOCK CENSUS, 1977

(in '000)

Sl. No	Items	Andhra Pradesh	All India	Andhra Pradesh as Percentage to All India
(1)	(2)	(3)	(4)	(5)
1.	Cattle			
	a) Males (over 3 years)	5,401	74,907	7.2
	b) Females (over 3 years)	4,114	57,599	7.1
	c) Young stock	2,526	47,634	5.3
	Total	12,041	1,80,140	6.7
2.	Buffaloes:			
	a) Males (over 3 years)	1,275	8,378	15.2
	b) Females (over 3 years)	3,668	31,865	11.5
	c) Young stock	2,220	21,786	10.2
	Total	7,163	62,029	11.5
3.	Sheep	7,064	40,907	17.3
4.	Goats	4,364	75,620	5.8
5.	Horses and ponies	27	916	3.0
6.	Pigs	755	7,647	9.9
7.	Camels	(a)	1,068	(a)
8.	Mule.	(a)	89	(a)
9.	Donkeys	58	917	6.3
10.	Yaks	...	146	...
11.	Other livestock (Mithuns)	...	61	...
	Total livestock	31,472	3,69,540	8.5
12.	Poultry	21,609	1,60,670	13.4

(a) Below 500

SOURCE : Directorate of Economics and Statistics, Ministry of Agriculture and Co-operation (Department of Agriculture) Government of India, New Delhi.

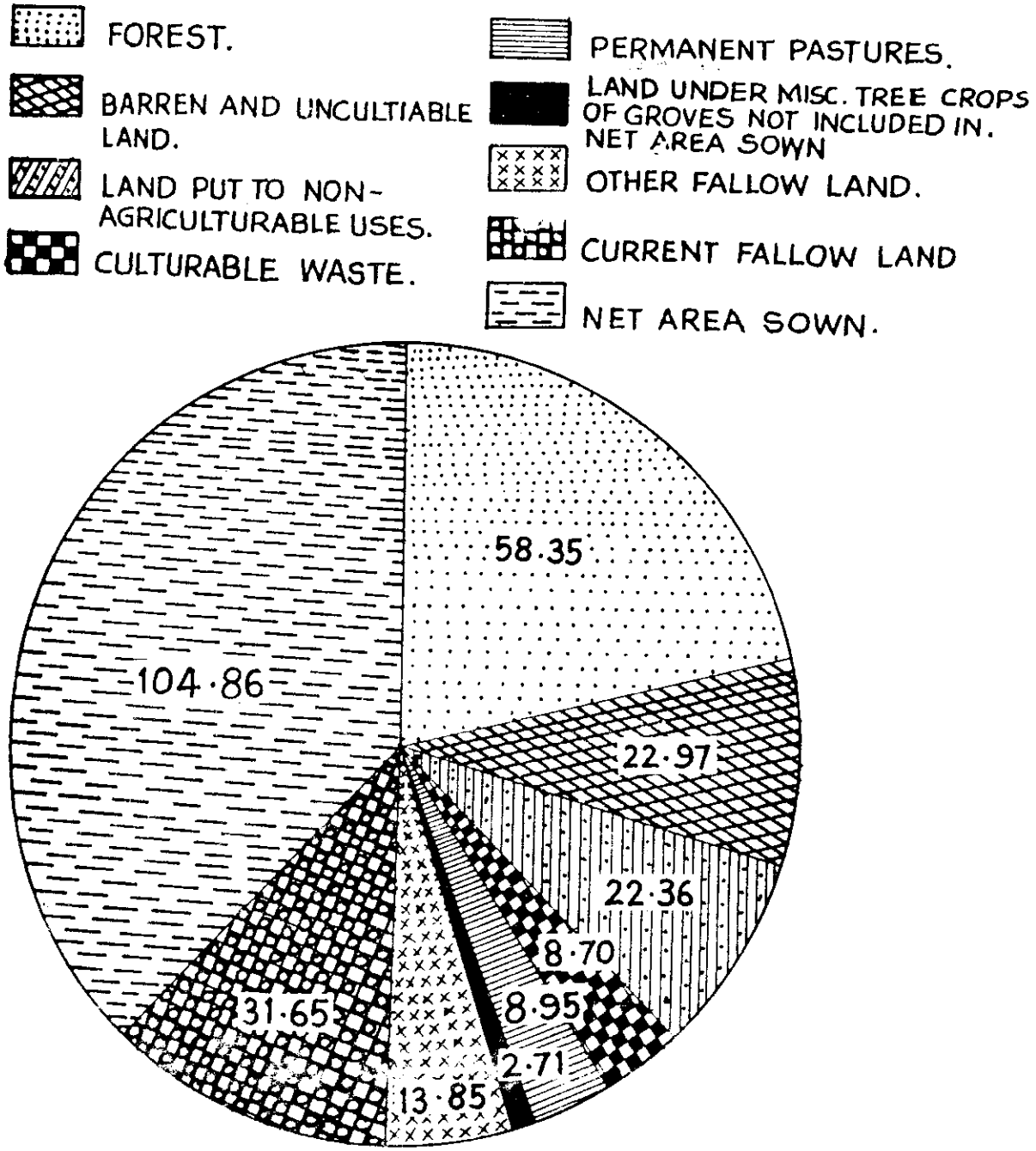
TABLE 2.3

LAND USE DETAILS OF A.P. AS PER 1984-85

Sl. No.	Category	1984-85		1983-84	
		Area in '000 hects.	Percentage to the total geographical area	Area in '000 hects.	Percentage to the total geographical area
(1)	(2)	(3)	(4)	(5)	(6)
1	Forest	58,35	21.3	62,00	22.6
2	Barren and unculturable land	22,97	8.4	22,98	8.4
3	Land put to Non-Agri. uses	22,36	8.1	22,17	8.1
4	Culturable waste	8,70	3.2	8,94	3.2
5	Permanent pastures and other grazing land	8,95	3.3	9,01	3.3
6	Land under Misc. tree crops and groves not included in net area sown	2,71	1.0	2,76	1.0
7	Current fallows	31,65	11.5	18,40	6.7
8	Other fallow lands	13,85	5.0	13,79	5.0
9	Net area sown	1,04,86	38.2	1,14,35	41.7
10	Total geographical area	2,74,40	100.0	2,74,40	100.0
11	Gross area sown	1,22,12	44.5	1,33,93	48.8
12	Area sown more than once	17,26	6.3	19,58	7.1

LAND UTILISATION IN ANDHRA PRADESH 1984-85

(AREA IN LAKH HECTARES)



TOTAL GEOGRAPHICAL AREA : 274·40

Fig. 2.3 : Land use details

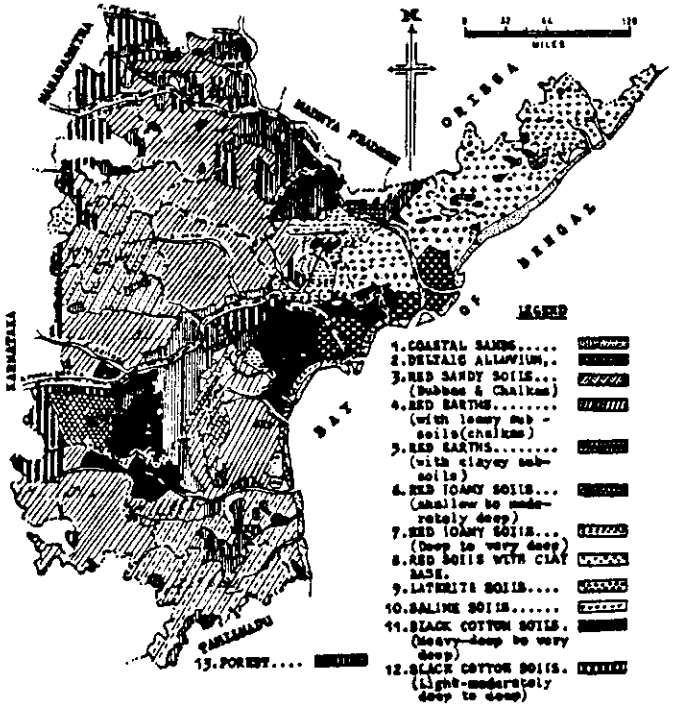


Fig. 2.4 Soil Map of Andhra Pradesh

Table 2.4 : Storages in the Projects of State Andhra Pradesh

Sl. No.	Type of Projects	Gross Storage in M.ha.m.	Live Storage in M.ha.m.
1.	Project completed	3.0888	2.24
2.	Projects under construction	0.5447	0.462
3.	Total	3.6335	2.702
4.	Proposed Projects	0.6038	0.1023

Source : CWC report on Water Resources of India, 1988.

2.6 Groundwater Availability

The groundwater resource potential in the state of Andhra Pradesh as in 1983-84 is given below:

1.	Utilisable resources	36.58 cubic km/year
2.	Net draft	7.41 -do-
3.	Potential available for future development	29.17 -do-
4.	Stage of groundwater development (%)	20 -do-

Source: Water Resources of India, CWC, 1988.

Table 2.6 gives the details of districtwise area irrigated by groundwater resource as per 1984-85 figures.

2.7 Water Use

The annual requirement of water in the state for domestic & live stock purposes during 1981 was of the order of 0.1154 M.ha.m. which has been estimated to increase to a level of 0.1987 M.ha.m. by the year 1991 (CWC, 1988). Table 2.7 gives the districtwise details of net area irrigated by different sources as per figures of the year 1984-85. The water availability and water requirement figures for drought prone districts of the state are given in Table 2.8.

Table 2.5 : Districtwise Area Irrigated by Surface Irrigation in A.P. as per 1984-85

Sl. No.	District	Private Surface Irrigation Works (Private Lift Irrigation Works)		
		Net Area Irrigated	Area Irrigated more than once	Gross area Irrigated
(1)	(2)	(3)	(4)	(5)
1.	Srikakulam ...	...	...	...
2.	Vizianagaram ...	97	..	97
3.	Visakhapatnam ...	...		...
4.	East Godavari ..	..		...
5.	West Godavari ...	...	...	...
6.	Krishna ...	69	34	103
7.	Guntur ...	222	75	297
8.	Prakasam ...	4,590	...	4,590
9.	Nellore ...	216	...	216
	Coastal Andhra region ...	5,194	109	5,303
10.	Kurnool	257	276	533
11.	Anant pur ...		...	...
12.	Cuddapah ...		...	...
13.	Chittoor ...	151		151
	Royalaseema region ...	408	276	684
	Andhra region ...	5,602	385	5,987
14.	Rangareddy ...	...	...	...
15.	Hyderabad ...		...	...
16.	Nizamabad	1,830	2,518	4,348
17.	Medak ...	1,006	289	1,295
18.	Mahabubnagar ...	39	76	115
19.	Nalgonda ...	...	...	...
20.	Warangal ...	...	...	...
21.	Khammam ...	..	...	
22.	Karimnagar ...	2,721	281	3,002
23.	Adilabad ...		73	73
	Telangana region ...	5,596	3,237	8,833
	Andhra region ...	11,198	3,622	14,820

Contd.

(Area in Hectare)

Private Surface Water Private Sources Total			Total Surface Irrigation		
Net Area Irrigated	Area Irrigated more than once	Gross area Irrigated	Net area Irrigated	Area Irrigated more than once	Gross area Irrigated
(6)	(7)	(8)	(9)	(10)	(11)
969	...	969	1,75,618	3,909	1,79,527
183		183	1,24,055	2,932	1,26,987
....	...	...	10,0022	5,596	1,05,618
...	..	..	2,07,408	1,39,965	3,47,373
...	.		2,55,309	1,70,923	4,26,232
1328	49	1,377	3,04,723	89,974	3,94,697
741	75	816	3,18,572	70,522	3,89,093
7683	...	7,683	1,29,953	7,767	1,37,720
2291	96	2,387	1,54,192	11,666	1,65,858
13,195	220	13,415	17,89,952	4,53,254	22,43,106
1,169	756	1,925	99,584	18,569	1,18,153
2,220	301	2,521	50,214	5,258	55,472
1,469	530	1,999	44,270	3,166	47,436
1,190	81	1,271	56,553	15,841	75,364
6,048	1,668	7,716	2,53,591	45,834	2,09,425
19,243	1,888	21,131	30,43,443	4,99,088	25,42,531
1,098	71	1,169	17,678	5,197	22,875
....	...	...	307	14	321
1,847	2,518	4,365	1,21,666	14,546	1,36,212
1,035	301	1,336	64,358	3,383	67,741
278	76	354	40,559	15,895	56,454
1,552	249	1,801	1,25,825	49,473	1,75,298
2,491	173	2,664	65,217	5,729	70,946
7,375	1,125	8,500	73,700	7,863	81,563
4,543	519	5,062	99,289	27,584	1,26,873
11	81	92	33,549	6,590	4,139
20,230	5,113	25,343	6,42,148	1,36,274	7,78,422
39,473	7,001	46,474	26,85,591	6,35,362	33,20,953

Table 2.6 : Districtwise Area Irrigated by Groundwater Sources in A.P. as per 1984-85

Sl. No.	District	Dug Wells-(Wells Without Pumpset)		
		Net area Irrigated	Area Irrigated more than once	Gross area Irrigated
(1)	(2)	(3)	(4)	(5)
1.	Srikakulam ...	3,698	...	3,698
2.	Vizianagaram ...	4,517	...	4,817
3.	Visakhapatnam ...	2,031	7,596	9,627
4.	East Godavari ...	15	122	137
5.	West Godavari ...	13	...	13
6.	Krishna ...	987	152	1,139
7.	Guntur ...	...	...	...
8.	Prakasam ...	5,568	2,040	7,608
9.	Nellore ...	501	...	501
	Coastal Andhra region ...	17,330	9,910	27,204
10.	Kurnool ...	964	340	1,340
11.	Ananthapur ...	2,995	...	2,995
12.	Cuddapah ...	784	373	1,157
13.	Chittoor ...	9,045	2,477	11,522
	Rayaleseema region ...	13,788	3,190	16,978
	Andhra region ...	31,118	13,100	44,218
14.	Rangareddy ...	89	81	170
15.	Hyderabad ...	..	4	4
16.	Nizamabad ...	2,627	1,159	3,786
17.	Medak ...	1,590	947	2,537
18.	Mahabubnagar ...	5,801	4,486	10,287
19.	Nalgonda ...	3,392	3,337	6,729
20.	Warangal ...	8,681	1,212	9,893
21.	Khammam ...	2,626	1,102	3,728
22.	Karimnagar ...	7,621	1,919	9,540
23.	Adilabad ...	771	658	1,379
	Telangana region ...	33,148	14,905	48,053
	Andhra Pradesh	64,266	28,005	92,277

Contd.

(Area in Hectares)

TOTAL DUG-WELLS (WITH & WITHOUT PUMPSET)			TOTAL GROUNDWATER IRRIGATION		
Net area Irrigated	Area Irrigated more than once	Gross area Irrigated	Net area Irrigated	Area Irrigated more than once	Gross area Irrigated
(6)	(7)	(8)	(9)	(10)	(11)
9,280	...	9,280	12,546	561	13,107
7,035	...	7,035	7,776	149	7,925
3,971	10,540	14,511	5,378	11,373	16,751
424	163	587	28,869	7,254	36,123
5,092	159	5,251	66,762	13,247	80,009
8,973	474	9,447	25,540	2,362	27,902
783	247	1,030	11,284	2,693	13,977
42,975	18,990	61,965	43,884	19,007	62,891
37,267	3,893	41,160	73,810	14,883	88,693
1,15,800	34,466	1,50,266	2,75,849	71,529	3,47,378
16,943	5,885	22,828	17,100	6,173	23,273
59,162	7,581	66,743	62,871	8,710	71,581
51,226	8,039	59,265	57,655	9,126	66,781
78,618	33,673	1,12,291	80,540	34,336	1,14,876
2,05,949	55,178	2,61,127	2,18,166	58,345	2,76,511
3,21,749	89,644	4,11,393	4,94,015	1,29,874	6,23,889
23,758	16,837	40,095	23,607	16,881	40,488
326	141	467	334	145	479
28,030	24,208	52,238	29,501	26,362	55,863
39,061	14,758	53,819	39,094	14,810	53,904
39,722	33,866	73,588	40,362	34,136	74,498
40,483	33,949	74,432	40,485	33,951	74,436
75,761	12,698	88,459	77,825	12,905	90,730
10,061	4,505	14,568	17,843	5,954	23,797
68,100	33,580	1,01,680	68,100	33,580	1,01,680
5,082	2,967	8,049	5,730	3,095	8,825
3,29,886	1,77,509	5,07,395	3,42,881	1,81,819	5,24,700
6,51,635	2,67,153	9,18,788	8,36,896	3,11,693	11,48,589

Table 2.7

Districtwise Net Area Irrigated by Different Sources as per 1984-85

District	NET AREA IRRIGATED BY						Area Irrigated more than once	Gross Area Irrigated
	Canals	Tanks	Tube Wells	Other Wells	Other sources	Total		
(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Srikakulam ...	81,812	90,768	3,266	9,280	3,038	1,88,164	4,470	1,92,634
Vizianagaram ...	24,372	97,110	741	7,035	2,573	1,31,831	3,081	1,34,912
Visakhapatnam ...	47,374	41,244	1,407	3,971	11,404	1,05,400	16,969	1,22,369
East Godavari ...	1,95,067	7,957	28,445	424	4,384	2,36,277	1,47,219	3,83,496
West Godavari ...	2,16,650	28,547	61,670	5,092	10,112	3,22,071	1,84,170	5,06,241
Krishna ...	2,76,527	16,956	16,567	8,973	11,240	3,30,263	92,336	4,22,599
Guntur ...	3,34,063	2,698	10,501	783	1,811	3,49,856	23,215	3,73,071
Prakasam ...	87,063	28,737	909	42,975	14,153	1,73,837	26,774	2,00,611
Nellore ...	74,963	76,213	36,543	37,267	3,016	2,28,002	26,549	2,54,551
COASTAL ANDHRA	13,37,891	3,90,230	1,60,049	1,15,800	61,731	20,65,701	5,24,783	25,90,484
Kurnool ...	82,795	12,172	157	16,943	4,617	1,16,684	24,742	1,41,426
Anantapur ...	37,571	9,513	3,709	59,162	3,130	1,13,085	16,968	1,30,053
Cuddapah ...	23,380	15,818	6,429	51,226	5,072	1,01,925	12,292	1,14,217
Chittoor ...	2,678	54,491	1,922	78,618	2,354	1,40,063	50,177	1,90,240
RAYALASEEMA ...	1,46,424	91,994	12,217	2,05,949	15,173	4,71,757	1,04,179	5,75,936
Rangareddy ...	3,184	11,266	349	23,258	3,228	41,285	22,078	63,363
Hyderabad ...	...	97	8	326	210	641	159	800
Nizamabad ...	80,006	34,233	1,471	28,030	7,427	1,51,167	40,908	1,92,075
Medak ...	10,567	51,343	33	39,061	2,448	1,03,452	18,193	1,21,645
Mahabubnagar ...	12,175	27,107	640	39,722	1,277	80,921	50,031	1,30,952
Nalgonda ...	97,051	23,031	2	40,483	5,743	1,66,310	83,424	2,49,734
Warangal ...	1,231	61,495	2,064	75,761	2,491	1,43,042	18,634	1,61,676
Khammam ...	42,439	23,886	7,780	10,063	7,375	91,543	13,817	1,05,360
Karimnagar ..	46,423	44,943	...	68,100	7,923	1,67,389	61,164	2,28,553
Adilabad ...	16,498	14,801	648	5,082	2,250	39,279	9,685	48,964
TELANGANA ...	3,09,574	2,92,202	12,995	3,29,886	40,372	9,85,029	3,18,093	13,03,122
ANDHRA PRADESH	17,93,889	7,74,426	1,85,261	6,51,635	1,17,276	35,22,487	9,47,055	44,69,542

SOURCE : Bureau of Economics and Statistics, Andhra Pradesh.

Table 2.8: Water Availability and Water Requirement for Drought Prone Districts of State Andhra Pradesh

Sl. No.	District	Water Availability		Total requirements
		50% Dependability	75% dependability	
1.	Anantpur	2.58	2.16	2.16
2.	Chittoor	4.12	2.93	1.96
3.	Cuddapah	2.77	2.49	2.03
4.	Hyderabad	2.10	1.89	1.27
5.	Kurnool	5.23	4.42	3.50
6.	Mahboobnagar	4.85	4.96	2.63
7.	Nalgonda	5.63	4.96	3.82
8.	Prakasam	5.61	4.30	3.34

Source : Water Resources of India, CWC,1988.

Also cropwise area irrigated in the state of A.P. from 1980 -81 to 1984-85 is given in table 2.9.

2.8 Crops and Fodder

Based on the distribution of soils and climate and cropping patterns, the state has been divided into 7 agroclimatic zones i.e. i) Krishna - Godavari zone, ii) North Coastal zone, iii) Southern zone, iv) Northern Telengana zone, v) Southern Telangana zone, vi)Scarce rainfall zones of Royalseema and vii)High altitude and tribal areas. Cropping pattern differ with the agroclimatic zones. Depending on the soil depth and texture, a variety of crops like Sorghum, maize,pearl millet, finger millet, red gram and other pulses, ground nut, tobacco etc. are grown in red soils during rainy season (Kharif). Normally ,only one crop is raised on these soils during rainy season. However, in the Maghi Sorghum tracts and in heavy rainfall areas two crops are taken. In

Table 2.9 : Cropwise Area Irrigated in A.P. 1980-81 to 1984-85

(in Hectares)

CROPS	1980-81	1981-82	1982-83	1983-84	1984-85
(1)	(2)	(3)	(4)	(5)	(6)
FOOD CROPS					
Rice ...	33,78,223	36,09,929	34,26,092	39,24,474	33,06,484
Wheat ...	9,931	12,260	12,601	12,844	10,110
MAJOR MILLETS					
Jowar ...	18,936	19,218	51,021	17,647	14,090
Bajra ...	55,650	61,210	54,093	54,430	47,510
Maize ...	76,248	67,632	75,720	84,187	63,963
Ragi ...	96,379	86,969	82,343	75,397	73,772
SMALL MILLETS					
Korra ...	4,221	5,149	3,419	2,734	1,667
Varagu ...	143	178	541	406	1,882
Samai ...	3	129	73	35	30
Other Small Millets ...	675	288	195	305	115
TOTAL SMALL MILLETS ...	5,042	5,744	4,228	3,482	3,694
TOTAL MILLETS ...	2,52,255	2,40,773	2,37,405	2,35,143	2,03,029
TOTAL CEREALS AND MILLETS	36,40,409	38,62,962	36,76,098	41,72,461	35,19,623
PULSES					
Bengalgram ...	499	565	370	255	114
Greengram ...	303	453	383	412	348
Redgram ...	119	327	576	419	205
Blackgram ...	411	780	912	690	1,338
Horsegram ...	100	183	235	11	11
Other pulses ...	57	203	108	81	80
TOTAL PULSES ...	1,519	2,517	2,584	1,826	2,096
TOTAL FOOD GRAINS ...	36,41,928	38,65,479	36,78,682	41,74,287	35,21,719

(Contd.)

CROPS	1980-81	1981-82	1982-83	1983-84	1984-85
(1)	(2)	(3)	(4)	(5)	(6)
FOOD CROPS					
CONDIMENTS AND SPICES					
Chillies ...	69,466	75,376	87,025	87,025	90,066
Turmeric ...	28,800	21,860	20,591	23,420	23,988
Ginger ...	394	328	514	526	567
OTHER CONDIMENTS AND SPICES	4,745	5,047	3,777	3,543	2,681
TOTAL CONDIMENTS AND SPICES ...	1,03,405	1,03,611	1,11,907	1,09,816	1,17,302
Sugarcane	1,70,809	2,17,427	2,01,651	1,68,167	1,67,789
Onions ...	14,777	13,202	14,239	16,236	15,284
Other Food Crops ...	98,340	89,908	96,236	1,05,669	1,09,038
TOTAL FOOD CROPS ...	40,19,259	42,89,627	41,02,715	45,74,175	39,13,132
NON-FOOD CROPS (OIL SEEDS)					
Groundnut ...	2,14,071	2,66,326	2,88,946	3,35,764	3,30,424
Gingelly (Sesamum) ...	26,769	28,506	27,097	27,854	31,485
Castor ...	68	179	200	65	29
Coconut ...	3,365	2,431	2,833	3,853	4,586
Other Oil Seeds ...	212	452	1,036	1,462	3,240
TOTAL OIL SEEDS ...	2,44,485	2,97,894	3,20,112	3,68,998	3,69,764
OTHERS					
Indigo ...	...	...	...	...	...
Tobacco ...	32,678	34,769	42,681	42,375	42,859
Cotton ...	22,068	27,999	24,344	38,246	96,003
Fodder Crops ...	7,394	11,786	7,933	13,292	11,970
Other Non-Food Crops ...	15,677	15,790	19,943	21,028	17,814
TOTAL NON-FOOD CROPS ...	3,22,302	3,88,238	4,15,136	4,83,939	5,38,410
TOTAL AREA OF CROPS IRRIGATED	43,41,561	46,77,865	45,17,851	50,58,114	44,69,542

SOURCE : Bureau of Economics and Statistics, Andhra Pradesh.

Table 2.10 : Districtwise Area Under Principal Crops During 1986-87 in A.P.

(Area in '000 Hects)

S.No.	District	Rice			Wheat	Jawar			Bajra	Ragi	Maize	Korra	Red gram	Green gram
		Kharif	Rabi	Total		Kharif	Rabi	Total						
1.	Srikakulam	210	N	210	—	1	3	4	9	21	N	N	2	14
2.	Vizianagaram	133	1	134	—	1	1	2	9	19	7	1	1	8
3.	Visakhapatnam	99	1	100	—	6	4	10	55	34	1	4	5	3
4.	East Godavari	253	149	402	—	1	2	3	14	1	1	N	8	7
5.	West Godavari	285	183	468	—	2	2	4	N	N	2	N	1	2
6.	Krishna	314	91	405	—	N	15	15	N	—	2	—	8	48
7.	Guntur	303	N	303	—	7	5	12	5	N	—	N	23	18
8.	Prakasam	93	23	116	N	52	37	89	47	18	1	25	22	7
9.	Nellore	31	171	202	—	N	30	30	5	5	N	N	N	7
10.	Kurnool	52	6	58	2	64	159	223	27	N	N	133	21	2
11.	Anantapur	28	11	39	N	42	39	81	27	14	1	41	23	2
12.	Cuddapah	12	5	17	N	58	3	61	12	4	N	13	3	1
13.	Chittoor	16	43	59	—	11	1	12	13	24	N	N	7	N
14.	Rangareddy	12	1	13	1	66	14	80	3	10	6	2	25	16
15.	Hyderabad	N	N	N	N	—	—	—	—	—	N	—	—	—
16.	Nizamabad	120	7	127	2	10	30	40	N	N	66	N	3	16
17.	Medak	63	17	80	2	70	67	137	3	4	75	2	13	25
18.	Mahaboobnagar	22	5	27	1	162	32	194	25	30	N	12	23	10
19.	Nalgonda	137	31	168	—	59	54	113	65	N	1	1	13	53
20.	Warangal	82	13	95	N	34	43	77	11	—	40	—	5	95
21.	Khammam	125	3	128	—	6	86	92	4	N	6	N	16	60
22.	Karimnagar	93	33	126	N	10	30	40	—	—	78	—	15	88
23.	Adilabad	62	3	65	3	96	108	204	N	—	24	N	34	35
	Andhra Pradesh	2546	796	3342	11	759	765	1524	332	159	311	235	271	514

Contd.

(Area in '000 Hctrs)

S.No.	District	Black gram	Horse gram	Bengal Pulses	Other	Sugar cane	Chillies	Ground Nut K	Ground Nut R	Ground Nut T	Sesamun	Castor	Cotton	Mesta	Tobacco
1	Srikakulam	19	13		N	5	4	43	6	49	7	-	-	15	N
2	Vizianagaram	3	27	N	N	7	2	79	4	83	16	-	-	56	1
3	Visaknapatnam	3	14	N	4	25	5	29	2	31	23	N	-	1	2
4	East Godavari	11	10	N	1	14	6	7	3	10	13	N	3	N	11
5	West Godavari	5	6	N	2	22	7	3	4	7	10	N	2	N	23
6	Krishna	10	3	N	N	11	12	14	12	26	1	N	10	N	8
7	Guntur	93	1	4		1	26	5	16	21	7	5	131	N	4
8	Prakasam	15	6	3	N	N	19	12	16	28	14	19	29	N	47
9	Nellore	N	2		N	1	7	5	30	35	2	N	2	-	9
10	Kurnool	1	6	12	N	1	7	135	32	167	1	1	37	N	2
11	Anantapur	N	20	4	2	N	3	421	12	433	1	6	4	N	N
12	Cuddapah	N	1	2	N	N	2	86	8	94	3	N	2	-	N
13	Chittoor	N	10		2	22	3	199	22	221	1	N	-	N	N
14	Rangareddy	4	4	4	1	1	1	3	1	4	2	25	2	N	N
15	Hyderabad	-		-		-	-	-	-	-	-	-	-	-	-
16	Nizamabad	9	N	4	2	11	2	4	1	5	1	N	5	N	N
17	Medak	8	1	11	3	12	6	2	1	3	3	3	1	N	7
18	Mahaboobnagar	1	33	3	3		2	39	25	114	2	65	6	1	1
19	Nalgonda	4	7	N	N	1	7	39	10	49	1	135	5	N	1
20	Warangal		N	1	N		14	26	27	55	21	8	34	-	10
21	Khammam		N	-	N	1	24	9	19	28	6	N	9	N	10
22	Karimnagar	N	1	1	6	1	12	17	13	30	4	2	6	-	2
23	Adilabad	74	6	-	6	1	6	2	N	2	23	1	121	-	N
	Andhra Pradesh	295	190	51	34	136	177	1232	265	1497	162	270	411	73	143

Table 2.11 District wise production during 1986-87 in A.P.

(production in '000 tonns)

Sl.No.	District	RICE			Wheat	JOWAR			Bajra	Maize	Ragi	Korra	Redgram	Greengram	Blackgram
		Kharif	Rabi	Total		Kharif	Rabi	Total							
1.	Srikakulam	305	1	306	.	1	2	3	6	N	28	N	1	8	9
2.	Vizianagaram	237	1	238	.	1	1	2	9	N	19	N	N	4	3
3.	Visakhapatnam	121	3	124	.	3	3	6	35	9	27	1	2	1	2
4.	E. Godavari	267	420	687	.	1	2	3	12	2	1	N	3	4	5
5.	W. Godavari	218	590	808	1	1	2	N	2	N	N	N	N	1	4
6.	Krishna	624	240	864	.	N	14	14	N	3	.	.	5	18	98
7.	Guntur	864	N	864	.	6	4	10	3	3	N	N	8	7	72
8.	Prakasam	239	35	274	.	31	33	64	40	.	26	9	7	3	12
9.	Nellore	70	366	436	.	N	20	20	6	1	8	N	N	2	1
10.	Kurnool	107	11	118	2	23	48	71	8	1	N	45	2	1	1
11.	Anantapur	51	17	68	N	29	13	42	16	N	24	20	4	1	N
12.	Cuddapah	30	9	39	N	42	3	45	13	1	7	5	1	N	.
13.	Chittoor	30	66	96	.	13	N	13	10	N	23	N	1	N	.
14.	Rangareddy	18	1	19	1	63	15	78	1	4	6	1	13	4	1
15.	Hyderabad	N	N	N	.	.		.	.	.	.		.	.	.
16.	Nizamabad	181	11	192	1	4	17	21	N	122	N	N	1	4	1
17.	Medak	55	28	83	1	37	34	71	1	60	1	1	3	8	3
18.	Mahaboobnagar	27	7	34	N	71	26	97	9	N	19	4	12	12	N
19.	Nalgonda	407	63	470	.	23	23	46	24	2	N	N	3	11	1
20.	Warangal	84	26	110	N	13	15	28	5	546	.	.	1	15	.
21.	Karimnagar	211	66	277	N	5	28	33	.	158	.	.	1	30	N
22.	Khammam	202	5	207	.	3	58	61	1	9	N	N	9	19	N
23.	Adilabad	75	6	81	1	57	51	108	N	21		N	6	5	1
	Andhra Pradesh	4425	1971	6396		429	413	842	199	443	190	86	80	150	212

Contd.

Sl No	District	Ben galgra	Horse-gram	Other pulses	Sugar	Chillies	Groundnut			Sesamun	Castor	Mesta in 1000 Bales of 180kg.	Cotton in Bales of 170kg	Tobacco
							Kanf	Rabi	Total					
1.	Srikakulam	—	9	N	314	7	41	10	51	2	—	138	—	N
2.	Vizianagaram	N	9	N	395	5	65	6	71	4	—	378	—	2
3.	Visakhapatnam	N	5	1	1326	6	28	3	31	4	N	2	—	4
4.	East Godavari	N	4	N	1173	11	5	4	9	1	N	N	7	15
5.	West Godavari	N	2	N	1456	13	2	6	8	2	N	N	1	35
6.	Krishna	N	1	N	883	34	10	18	28	N	N	N	11	14
7.	Guntur	2	N	N	88	69	4	25	29	2	1	3	377	43
8.	Prakasam	2	1	N	3	20	9	25	34	6	4	3	47	43
9.	Nellore	—	1	N	37	4	4	51	55	N	N	—	4	26
10.	Kurnool	6	1	—	66	3	55	44	99	N	N	N	42	12
11.	Anantapur	1	2	N	18	1	398	11	409	N	1	N	2	N
12.	Cuddapah	1	N	N	5	1	58	15	73	N	1	N	1	N
13.	Chittoor	—	3	—	1398	1	149	46	195	N	N	N	—	—
14.	Rangareddy	2	1	N	41	2	1	1	2	N	2	2	1	N
15.	Hyderabad	—	—	1	—	—	—	—	—	—	—	—	—	—
16.	Nizamabad	2	N	N	760	6	2	3	5	N	N	1	2	N
17.	Medak	3	N	N	698	10	1	1	2	N	1	N	N	N
18.	Mahaboobnagar	1	14	N	—	4	27	25	52	N	13	5	8	5
19.	Nalgonda	N	1	2	31	17	32	18	50	N	31	N	4	1
20.	Warangal	N	N	1	—	9	12	21	33	2	1	—	86	6
21.	Khammam	N	6	1	34	66	7	28	35	1	N	2	7	11
22.	Karimnagar	N	1	1	71	7	8	6	14	1	N	—	5	2
23.	Adilabad	N	2	1	29	1	1	N	1	2	N	—	33	N
	Andhra Pradesh	20	66	6	8627	293	919	368	1287	28	53	534	637	154

Maghi tract a pulse, generally green in Kharif, precedes early Rabi or Maghi Sorghum. With improved technology, farmers are adopting inter cropping, cropping systems and growing two crops even in black soils. Similarly, a variety of rainfed crops like Sorghum,maize, pearl millet, finger millet, pulses, sesamum, ground nut, tobacco, chilies, coriander,safflower, and gram are grown in black soils mostly during the Rabi season.

Table 2.10 and 2.11 gives districtwise area and production of principal crops during 1986-87 in the state of Andhra Pradesh.

2.9 Districts Chosen for Study

The following section include description of individual districts taken up for study in the state of Andhra Pradesh.

2.9.1 Anantpur

The district of Anantpur forms part of Rayalaseema region of Andhra Pradesh and this district is a drought affected district. The district having an area of 19130 Sq.km.as per 1981 census, is located between $13^{o}41'$ to $15^{o}41'$ north latitudes and $76^{o}47'$ to $78^{o}26'$ east longitudes. It has got eleven tehsils namely- Anantapur, Dharmavaram, Gooty, Hindupur, Kadiri, Kalyandurg, Madakasira ,Panugonda, Rayadurg, Tadpatri, Urava Konda.The district has 930 inhabited villages, 28 uninhabited villages and 11 towns. The population of the district accordingly to the 1981 census is 2618239 and the density of population of the district is 137 persons per sq.km. as per 1981 analysis.

It has been reported that generally three types of soils are found in the district namely red soil, black soil and other types. As per data from 1970-71 to 1979-80 the land use details in the district include forests 194008 ha. land put to non

agricultural use 149900 ha, barren and uncultivatable land 192007 ha, and 1,351,580 ha with cultivable area.

The total irrigated area of the district is 162,693 ha, and the source wise distribution of irrigated areas are 76,962 ha by ground water and 76145 ha by surface water and 9586 ha by other sources.

The four main rivers Pennar, Chitravati, Hagari, and Papaghri are flowing through the district.The catchment area within the district of Panner basin is 8,869 sq.km.,Chitravati 6,026 sq.km., Hagari 2,354 sq.km. Papoghri 1,187.

As per CWC analysis of 1982, the normal rainfall of the district is 564.16 mm and there are normally 35.60 rainy days in a year. The south west monsoon gives about 56.03% of the normal rainfall and the co-efficient of variation for annual rainfall is 22.1%. Thirty three number of raingauge stations are located in the district and the density of raingauge stations are 580 sq.km per station.

According to CGWB data the ground water potential data estimate recharge to ground water of the order of 1109.85 m cu m and the draft 373.82 m cu m and the surplus is 736.03 m cu m as per 1982 census. The analysis of CWC (1982) the district faced 14 years of hydrological drought during the period 1951 to 1980. The map of the district showing locations of rain gauges and ground water observation wells which have been chosen for analysis is shown in fig.2.5.

2.9.2 Cuddapah

Cuddapah district is the third in area in Rayalaseema region of Andhra Pradesh. This district is as a drought affected district of A.P. The Cuddapah district having an area of 15378.41 sq.km. is located between $13^{o}43'$ to $15^{o}14'$ north latitudes and

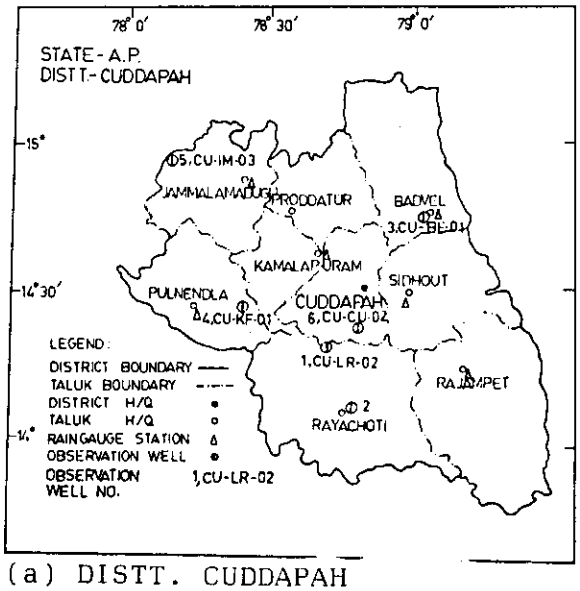
$77^{o}55'$ to $79^{o}29'$ east longitudes It has nine taluks namely Badvel, Cuddapah, Jammalanadugu, Kamalapuram, Proddatur, Pulivendla, Rajampet, Rayachoti and Sidhout. The district had 896 inhabited and 78 uninhabited villages as per 1971 census. The population of the district as per 1981 census is 1,917,736 and the density of population of the district is 125 person per sq.km.

It has been reported that generally six types of soils are found in the district namely black clay, black loam, black sandy, red loam, red clay, and red sandy. The land use details as per data available from 1970-71 to 1978-80 the forests is 497,191 ha, land put to non agricultural uses 138486 ha,barren and uncultivatable land 259243 ha and 616140 ha with the cultivable area.

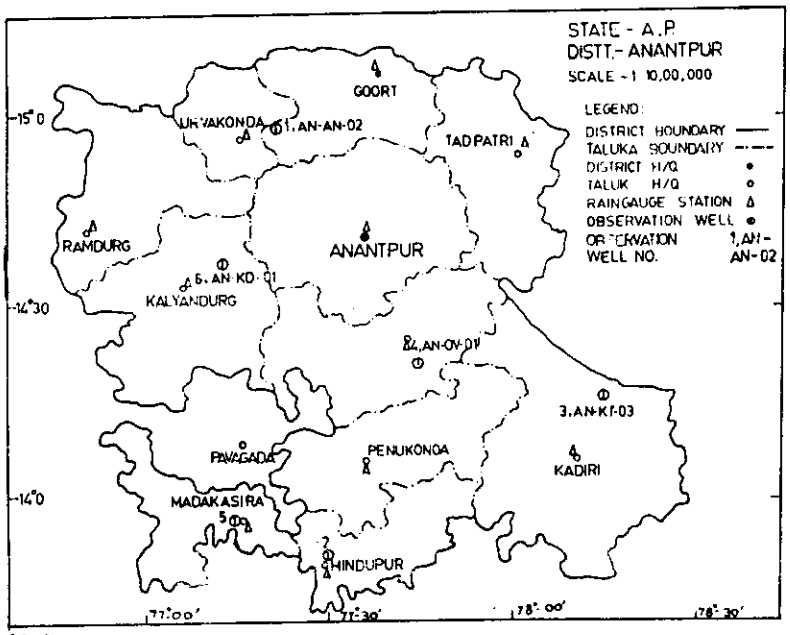
The total irrigated area in the district is 139676 ha and the source wise distribution of irrigated area are 56062 ha by surface water, 70656 ha by ground water and 12958 ha by other sources. Pennar is the main river flowing through the district and the catchment area of Pennar basin in the district is 15299.1 sq.km

As per CWC analysis of 1982 the normal annual rainfall in the district is 696.6 mm. About 86.0 per cent of annual rainfall is received during the monsoon season.The south west monsoon gives about 55.4 % of normal rainfall and the coefficient of variation for annual rainfall is 21.6%. The twenty number of raingauge stations are located in the district and the density of raingauge stations is one station per 768.6 sq.kms.

According to CGWB the ground water potential data estimates recharge to ground water of the order of 747.41 m cu m and the draft 433.36 m cu m and surplus is 314.05 m cu m . The analysis of CWC (1982) the district faced 40 years of hydrological drought during the period 1901 to 1980. The location of raingauge



(a) DISTT. CUDDAPAH



(b) DISTT. ANANTPUR

FIG. 2.5 : LOCATION OF RAINGAUGE STATION & GROUNDWATER WELL.

stations and ground water observation wells is shown in the district map given as in fig.2.5.

2.9.3 Chittoor

Chittoor district is situated in the south eastern fringe of Andhra Pradesh state. This district is a drought affected district of A.P. The district has a geographical area of 15152 sq.km as per 1981 census. It is located between the northern latitude of $12^{o}37'$ to $14^{o}08'$ and eastern longitudes of $78^{o}03'$ to $79^{o}55'$. The district Chittoor consists of 11 taluks namely Bangarupalem, Chandragiri, Punganur, Chittoor, Kuppam, Madanapalle, Palmanar Puttur, Sri-Kalahasti, Satyavedu and Vayalpad. The district has 1277 inhabited and 39 uninhabited villages and 13 towns. The population of the district is 2746847 as per 1981 census and the density of population of the district is 181 person per sq.km.

The soils of the district are generally red and black soils with good order retaining capacity. The land use details of the district includes forests 453784 ha, land put to non agricultural uses 138440 ha, barren and uncultivable land 172216 ha and 704954 ha with the cultivable area.

The total irrigated area is 219716 ha in the district and the source wise distribution of irrigated area are 5440 ha by canal, 94356 ha by tanks (by surface water) and 109591 ha by ground water and 10329 ha by other sources.

There are no perennial rivers flowing in the district. Some of the minor rivers flowing in the district are Papaghni, Polar, Swarnamukhi, Pincha, Ponnia, Arani, Bahuda, Kalyani, Kusasthali, Nagari, Kondinas.

As per CWC study 1982 the normal annual rainfall in the district is 864.62 mm. There are normally 49.74 rainy days in one

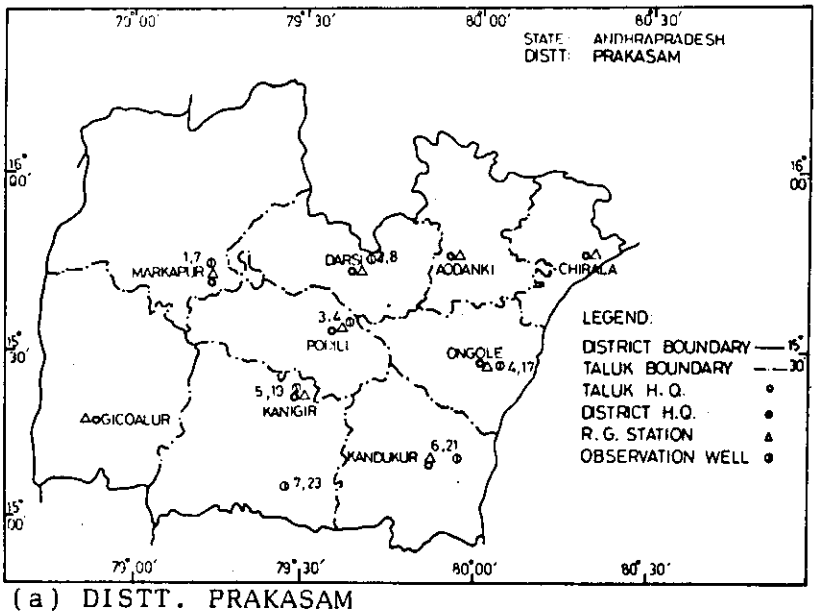
year. The district had 35 numbers of raingauge stations and the density of raingauge stations is 432.91 sq.km.per station. 43.38 per cent rainfall receiving by south west monsoon and the coefficient of variation for annual rainfall is 22.18 %.

According to CGWB the ground water potential data estimate recharge to ground water of the order of 1468.04 m cu m ,draft 828.18 m cu m and surplus is 639.86 m cu m. The analysis of CWC (1982) the district faced 12 years of hydrological drought during the period 1951 to 1980. The location of raingauge stations and ground water observation wells is shown in the district map given as in fig.2.6.

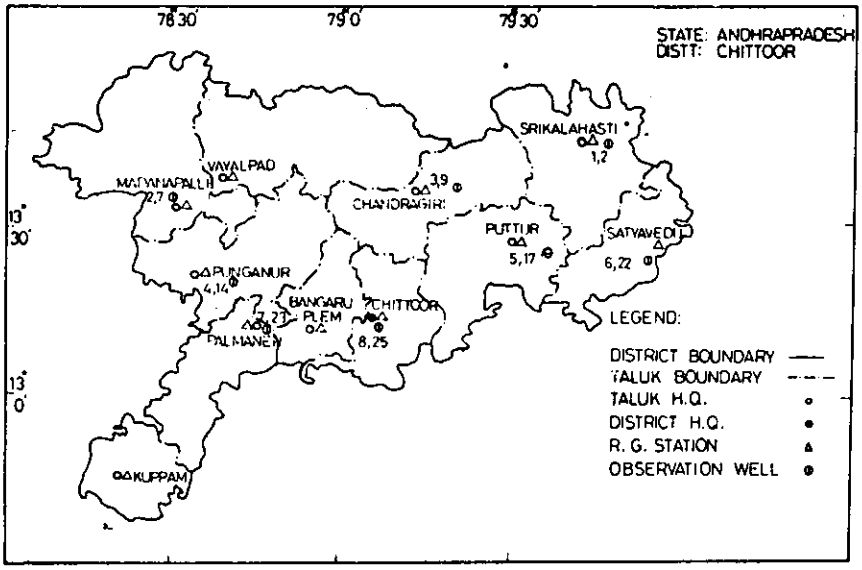
2.9.4 Prakasam

The district Prakasam forms a part of coastal Andhra region of Andhra Pradesh. This district is a drought affected district of A.P. Prakasam district having a geographical area 17404.4 sq.km and is located between $14^{o}57'$ to $16^{o}15'$ N latitudes and $78^{o}4'$ to $80^{o}50'$ E longitudes. The district has nine taluks namely- Addanki, Chirala, Darsi, Giddalur, Kandukur,Kanigiri, Markapur, Ongole and Podili. It has 1003 inhabited and 92 uninhabited villages and nine towns. The population of the district as per 1981 census is 2456543 and the density of population of the district is 141 person per sq.km.

As per the information available the soils in the district may be classified as black cotton, red loam and sandy loam. The land use details of the district as per data 1970-71 to 1979-80 include the forests 447228 ha,land put to non agricultural uses 122216 ha,barren and uncultivable land 134388 ha and the cultivable area is 935273 ha.The total irrigated areas of the district are 160957 ha and the source wise distribution of irrigated areas are 60770 ha by ground water, 94990 ha by surface



(a) DISTT. PRAKASAM



(b) DISTT. CHITTOOR

FIG.2.6 : LOCATION OF RAINGAUGE STATION & GROUNDWATER WELL

water and 5197 ha by other sources.The five main rivers Gundlakamma, Musi, Paleru, Manneru, and Saigileru are flowing through the district. The catchment area with in the district 9483 sq.km of Gundlakamma basin

As per CWC study of 1982 the normal rainfall of the district is 757.08 mm.There are normally 42.41 rainy days in a year. Thirteen numbers of raingauge stations are situated in the district and the density of raingauge stations is 1338.8 sq.km per station. The south west monsoon gives about 46.88% of the normal rainfall and the coefficient of variation of annual; rainfall is 23.65%.As per CGWB data the ground water potential is that annual recharge to ground water of the order of 1361.70 m cu m and the draft 251.60 m cu m and the surplus is 1110.10 m cu m. As per CWC (1982) study the district faced 11 years of hydrological drought during the period 1951 to 1980. the location of rain gauges and ground water observation wells is shown in district map given as in fig.2.6.

2.9.5 Kurnool

Kurnool is one of the drought affected districts of Andhra Pradesh. The geographical location of the district is between $14^{o}54'$ to $16^{o}7'$ north latitudes and $76^{o}58'$ to $78^{o}56'$ east longitudes. The geographical area of the district is 17600.4 sq.km as per 1981 census. The district consists of eleven taluks and has 898 inhabited villages, 18 uninhabited villages and 10 towns. The population of the district is 2404358 and density of population is 128 per sq.km. as per 1981 census.

The soil in the district are generally into three groups viz.red black soils, and other types. The land use description in the district as per data from 1970-71 to 1979-80 is forest in 334754 ha, land put to nonagricultural uses 82213 ha, barren and

uncultivable land 110258 ha and with 1228731 ha cultivable area.

As per data information from 1970-71 to 1979-80 the total irrigated area is 137355 ha and the source wise distribution of 119100 ha by surface water, 1342 ha by ground water and 4112 ha by other sources.

The five main rivers flowing through the Kurnool district. The catchment area of river basins Tungabhadra 2988.5 sq.km, Krishna 1513.2 sq.km., Handri 4700.2 sq.km., Hagari 1181.2 sq.km. and Kunderu 7215.9 sq.km. in the district.

As per CWC studies of 1982 the normal rainfall of the district (1901-1980) is 658.65mm and there are normally 42.64 rainy days in one year in the district. The district has 19 no. of raingauge stations and the density of raingauge stations 926.3 sq.km. per raingauge station. The maximum annual rain fall of 1321.26 mm was experienced in the district in year 1916. The south west monsoon gives about 69.13% of annual rainfall in the district. The coefficient of variation for annual rainfall has been reported as 23.19 % for the district.

The ground water potential of the district as per CGWB data is that the annual recharge to ground water is 1370 m cu m while the draft is 116 m cu m and the surplus is 1254 m cu m. As per CWC (1982) observations the district faced 12 hydrological drought years during the period 1951 to 1980 The locations of rain gauges and ground water observation wells is shown in the district map given as in fig.2.7.

2.9.6 Mahbubnagar

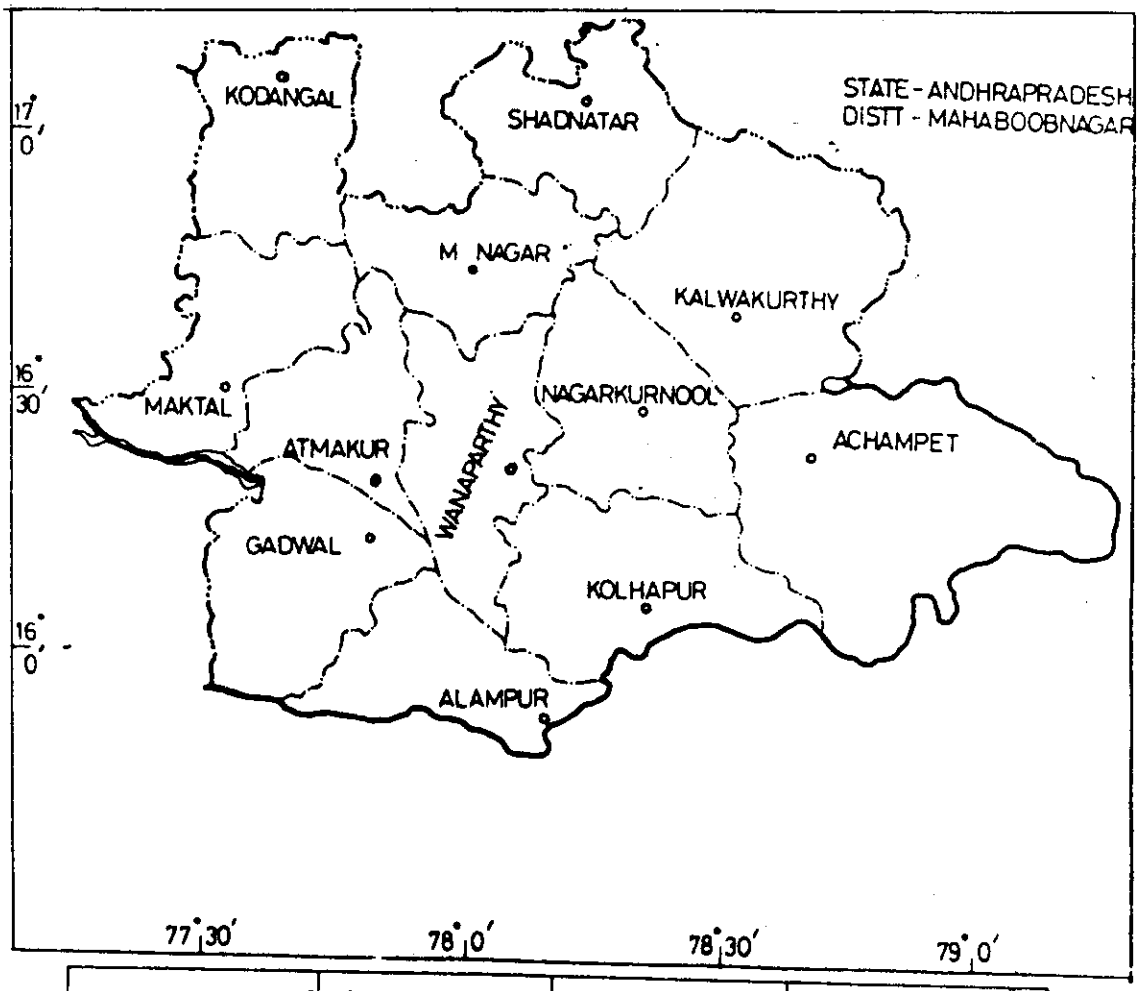
The district of Mahbubnagar forms part of Telangana region of Andhra Pradesh. The district is a drought affected district. Mahbubnagar is the third largest district of the state. This district has an area of 18472 sq.km. is located between 16^{O}

and 17 north latitudes and 77° and 79 east longitudes. The district consists of 12 taluks namely Achampet, Alampur, Atmakur Gadwal, Kalwakurthi, Kodangal, Kolhapur, Mahboobnagar, Makthal, Nagarkurnool, Shadnagar and Wanaparthy. The population of the district of 2456111 according to the 1981 census. The density of population in the district is 133 person per sq.km. The district has 1459 inhabited and 70 uninhabited villages and 11 towns.

The soils of the district is mostly three types, namely red soil or chalka soil, black cotton soil, mixed soils or dubba soil. The land use details of the district as per data 1970-71 to 1979-80 include the forests is 303092 ha, land put to non-agricultural uses 93031 ha, barren and uncultivable land 112652 ha.

The total irrigated area or the district is 184602 ha and the source wise distribution of irrigated areas are 71350 ha by ground water, 107058 ha by surface and 6,194 ha by other sources. The Krishna and Tungabhadra are two main rivers that flow through the district The catch are of the Krishna basin is 4458 sq.km and Tungabhadra 1373 sq.km.

As per CWC study 1982 the normal annual rainfall of the district is 746.9 mm. The district is receiving rainfall from both south west and north east monsoon. About 80% of the annual rainfall is received during the monsoon season. The location of rain gauges and ground water observation wells are shown in the district map given as in fig.2.7.



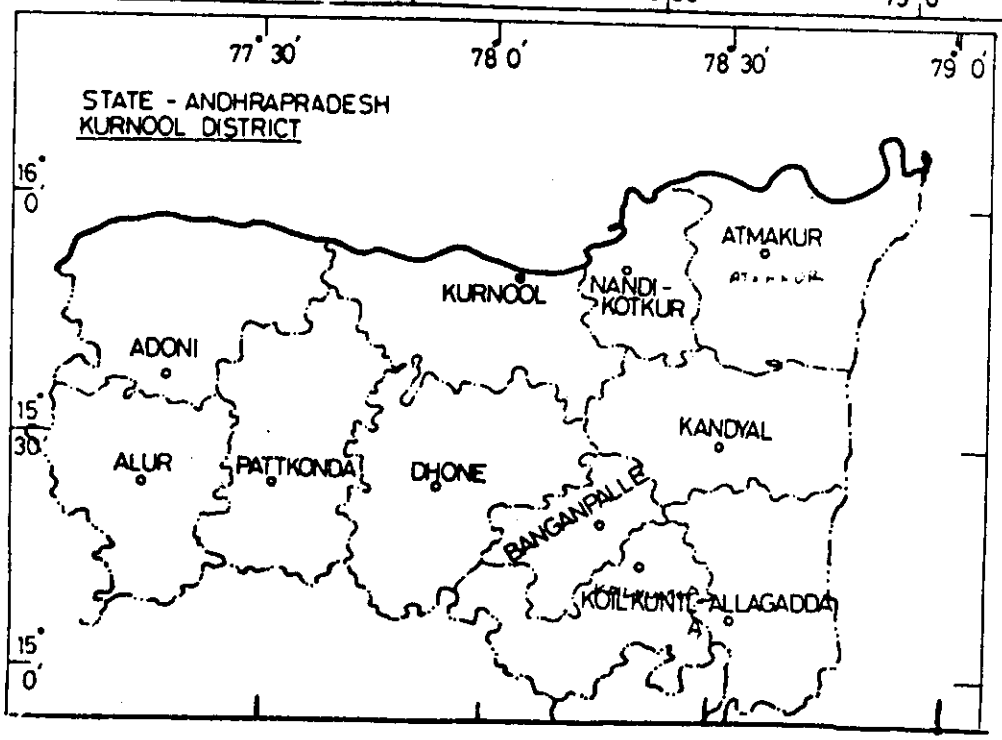


Fig. 2.7 : LOCATION OF RAINGAUGE STATION & GROUNDWATER WELL

3.0 Rainfall Analysis

3.1 General

As has already ben described in chapter 2.0,six districts,namely Anantpur,Cuddapah, Chittoor, Prakasam,Kurnool and Mahboobnagar from the state of Andhra Pradesh have been taken up for rainfall analysis in the present report.One representative raingauge station from each taluk in each of the six district has been selected for the study. The locations of rain gauges on the district maps have been shown in figures presented in chapter 2.0. The raingauge stations selected for the study are the ones which were selected by Central Water Commission for carrying out studies for identification of drought prone areas in 1982. The analysis of rainfall data has been carried out with the data from year 1901-1988. The data from 1901 to 1980 have been extracted from CWC reports (CWC 1982). The remaining data from 1981 to 1988 have been collected during visits of scientific teams to various central/state Govt. offices in the state Andhra Pradesh.

3.2 Rainfall Departure Analysis

3.2.1 Seasonal rainfall departure

In order to compute the deficiency of rainfall on seasonal basis seasonal rainfall Departure analysis has been carried out. The data from period 1970-87 have been used for this analysis. Seasonal normals for the chosen six districts of Andhra Pradesh have been calculated as the summation of normals for the months (June to September) as provided in the CWC reports. Only four months i.e. June, July, August and September are taken in account while estimating seasonal normals The results of analysis are given in table 3.1. The graphical representation of seasonal deficiencies are shown in Fig.3.1. The major inferences that could be drawn from the seasonal analysis are:

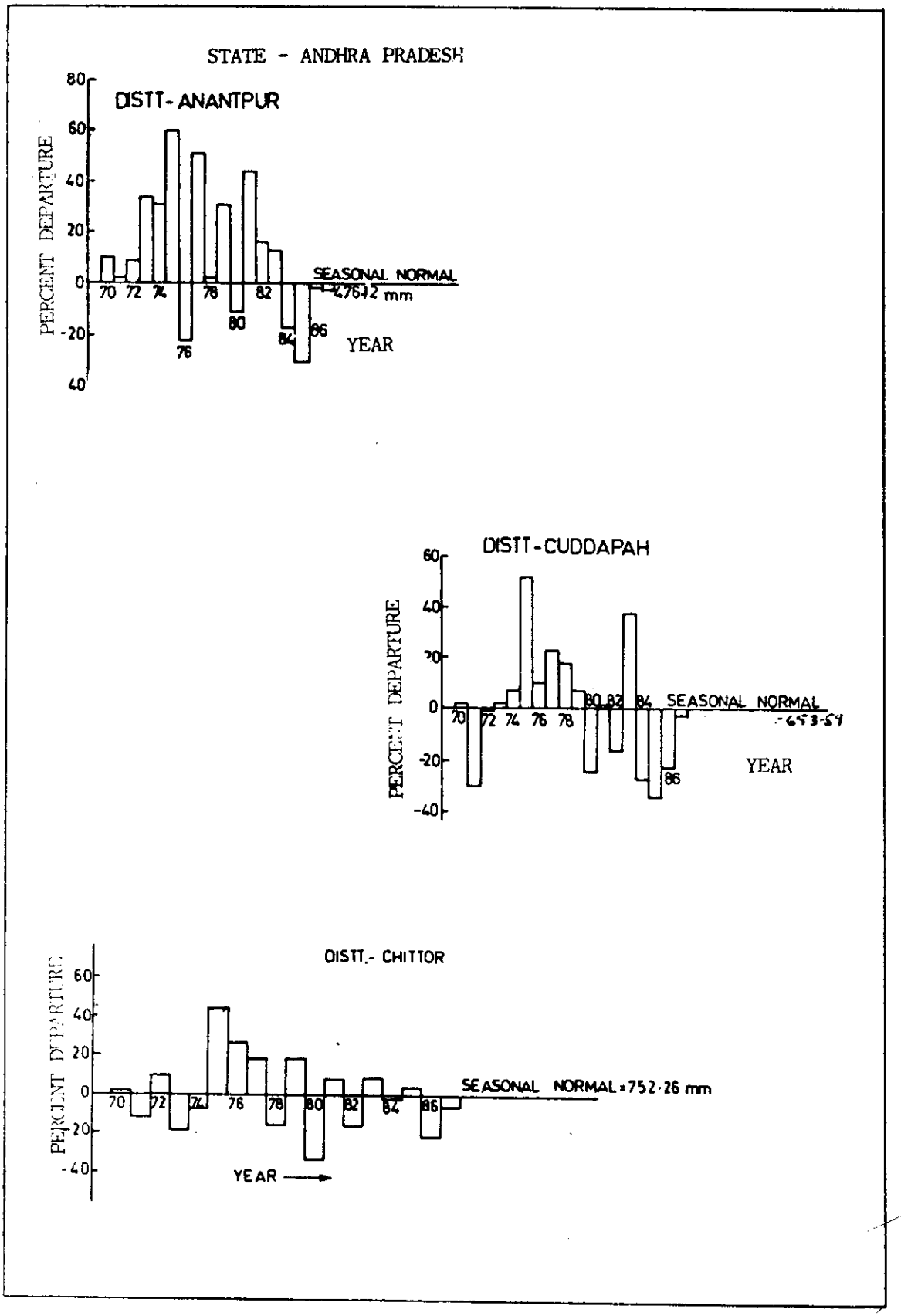


Fig. 3.1 : Districtwise Seasonal Rainfall Departures

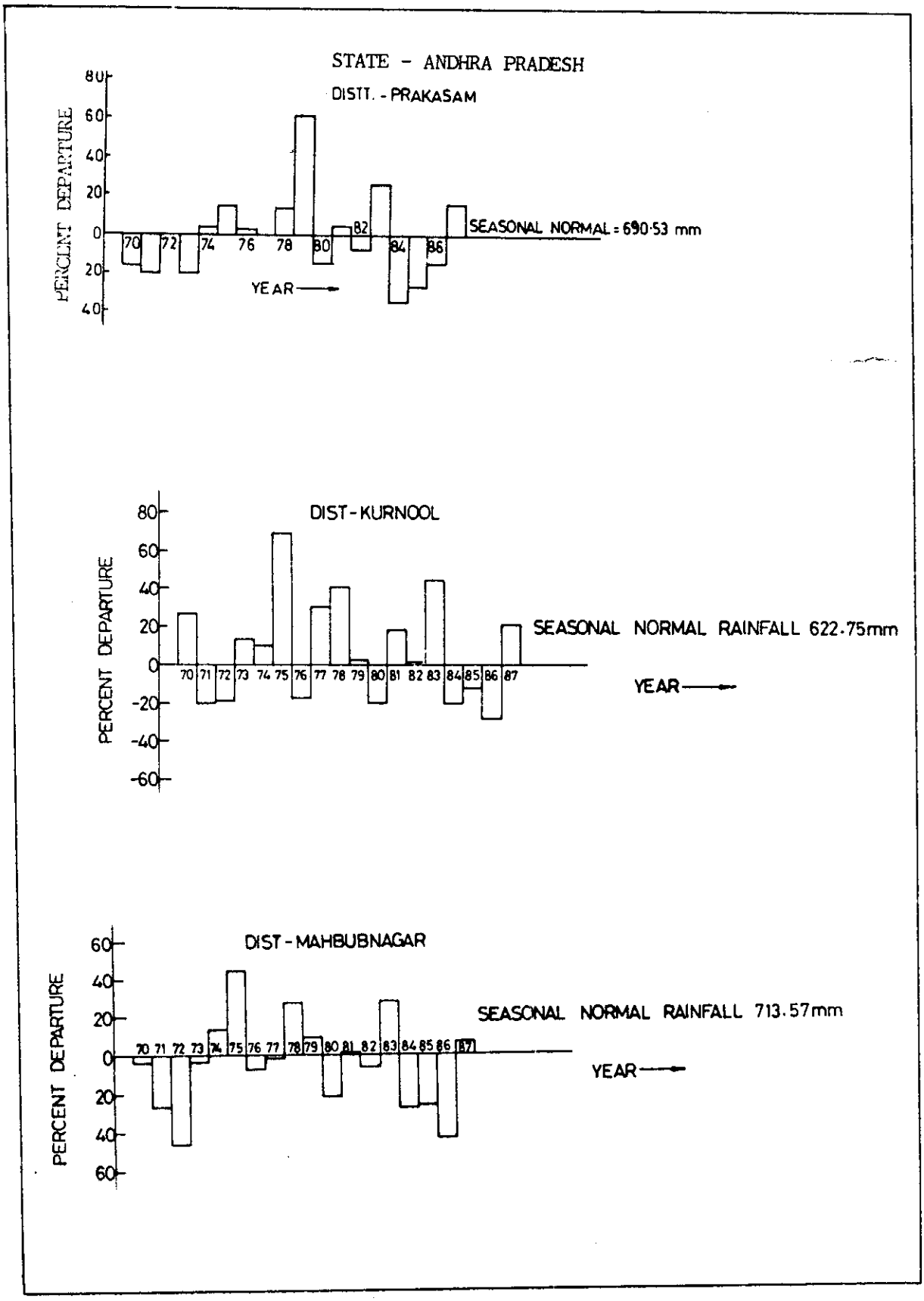


Fig. 3.1 : Districtwise Seasonal Rainfall Departures

Table 3.1 : Seasonal Rainfall Departure for Districts of Anantpur, Cuddapah, Chittoor, Prakasam, Kurnool and Mahboobnagar of state Andhra Pradesh.

District CUDDAPAH (Andhra Pradesh)

Year	Seasonal rainfall	Seasonal normal rainfall	Percent departure
1970	665.9	653.59	+ 1.88
1971	455.8	653.59	-30.26
1972	647.6	653.59	- 0.92
1973	667.6	653.59	+ 2.14
1974	698.6	653.59	+ 6.89
1975	998.7	653.59	+52.8
1976	717.4	653.59	+ 9.76
1977	806.7	653.59	+23.43
1978	774.9	653.59	+18.56
1979	699.7	653.59	+ 7.05
1980	424.3	653.59	-24.37
1981	655.3	653.59	+ 0.26
1982	546.0	653.59	-16.46
1983	904.7	653.59	+38.42
1984	474.6	653.59	-27.39
1985	429.1	653.59	-34.55
1986	514.94	653.59	-21.21
1987	649.94	653.59	- 0.55

District ANANTPUR (Andhra Pradesh)

1970	524.87	476.12	+10.20
1971	486.81	476.12	+ 2.25
1972	520.63	476.12	+ 9.35
1973	640.85	476.12	+34.60
1974	627.94	476.12	+31.89
1975	757.7	476.12	+59.14
1976	334.71	476.12	-29.70
1977	722.29	476.12	+51.70
1978	485.6	476.12	+ 1.99
1979	626.58	476.12	+31.60
1980	422.86	476.12	-11.19
1981	689.58	476.12	+44.83
1982	552.25	476.12	+15.99
1983	542.19	576.12	+13.88
1984	396.1	476.12	-16.81
1985	330.6	476.12	-30.5
1986	474.84	476.12	- 0.26
1987	465.66	476.12	- 2.19

District CHITTOOR(Andhra Pradesh)

1970	751.24	752.26	- 0.14
1971	671.13	752.26	-10.78
1972	827.67	752.26	10.02
1973	609.18	752.26	-19.02
1974	705.62	752.26	- 6.20
1975	1085.38	752.26	44.28
1976	953.62	752.26	26.77
1977	901.49	752.26	19.84
1978	631.48	752.26	-16.06
1979	896.85	752.26	19.22
1980	500.42	752.26	-33.48
1981	818.37	752.26	8.79
1982	620.60	752.26	-17.50
1983	820.06	752.26	9.01
1984	751.23	752.26	- 0.14
1985	796.29	752.26	5.85
1986	582.08	752.26	-22.62
1987	723.27	752.26	- 3.85

District PRAKASAM (Andhra Pradesh)

1970	579.37	690.53	-16.10
1971	545.82	690.53	-20.96
1972	700.04	690.53	1.38
1973	614.67	690.53	-10.99
1974	724.15	690.53	4.87
1975	796.15	690.53	15.30
1976	720.63	690.53	4.36
1977	650.16	690.53	- 5.85
1978	792.14	690.53	14.72
1979	1122.93	690.53	62.62
1980	587.13	690.53	-14.97
1981	727.00	690.53	5.28
1982	640.51	690.53	- 7.24
1983	883.16	690.53	27.90
1984	452.07	690.53	-34.53
1985	517.74	690.53	-25.02
1986	581.48	690.53	-15.79
1987	808.68	690.53	17.11

District MAHBOOBNAGAR (Andhra Pradesh)

1970	693.02	713.57	-2.88
1971	521.29		-26.95
1972	385.43		-45.99
1973	691.40		- 3.11
1974	809.00		13.37
1975	1026.06		43.79
1976	659.78		-7.54
1977	703.69		- 1.39
1978	900.99		26.26
1979	773.94		8.46
1980	562.48		-21.17
1981	717.49		0.55
1982	665.60		- 6.72
1983	911.32		27.74
1984	510.31		-28.48
1985	525.47		-26.36
1986	404.98		-43.25
1987	758.09		6.24

1970	794.90	622.75	27.64
1971	493.97		-20.68
1972	504.12		-19.05
1973	702.70		12.84
1974	685.51		10.08
1975	1052.29		68.97
1976	516.67		-17.03
1977	809.99		30.07
1978	877.22		40.86
1979	639.87		2.75
1980	498.41		-19.97
1981	727.15		16.76
1982	635.55		2.06
1983	895.28		43.76
1984	498.25		-19.99
1985	550.94		-11.53
1986	446.52		-28.30
1987	756.43		21.47

All the six selected districts namely Anantpur, Cuddapah,Chittoor, Prakasam, Kurnool,and Mahbubnagar did not experience much deficiency in the seasonal rainfall during year 1987-88.as per this analysis. It was alsc observed that all the districts in the state have been experiencing seasonal rainfall deficits of more than 20% since water year 1984-85 indicating continued occurrence of water shortages in these districts which is adversely affecting the economy of the region in these districts.

3.2.2 Monthly rainfall departure for the year 1987-88

In order to observe deficiency in monthly rainfall durirg the year 1987-88, monthly departures have been worked out for the six districts. This analysis has been done for all the taluks and district as a whole. Monthly rainfall values from June'87 to May'88 alongwith monthly normals of representative

rain gauges of various taluks have been considered for the purpose Monthly rainfall values for a district from June'87 to May'88 have been computed as weighted average rainfall of all the taluks considered for analysis in the district. Monthly normals of districts have been directly taken from reports of CWC (CWC,1982). It may be mentioned that in case of some districts/taluks monthly departure analysis has been limited to some months only due to data availability constraints.

The variations in rainfall month wise (monthly rainfall & corresponding normals) have been plotted for all the six districts for water year June'87 to May'88, and are shown in figures 3.2. The departure figures for all the six districts are shown in appendix III-I. The results of monthly departure analysis for the districts as a whole are presented in table 3.2.Based on monthly departure values, two categories of monthly departures i.e. 20-50% and more than 50% have been established for deriving monthly deficiency inferences. Table 3.2 gives details of six districts of state Andhra Pradesh which experienced rainfall deficits during months of June 87 to May 88 in these two ranges viz.20 to 50% and 50% and above. The following inferences can be drawn from the results shown/presented in figrues 3.2,Appendix III-I and table 3.2.

In the state of A.P. most of the districts lie in the monthly rainfall deficiency range 20-50% during June 87 to May 88. However during the monsoon months, 4 districts experienced more than 50% deficiency in the monthly rainfall is September months. The monthly deficiency pattern has been found similar from the districts of Kurnool and Cuddapah.

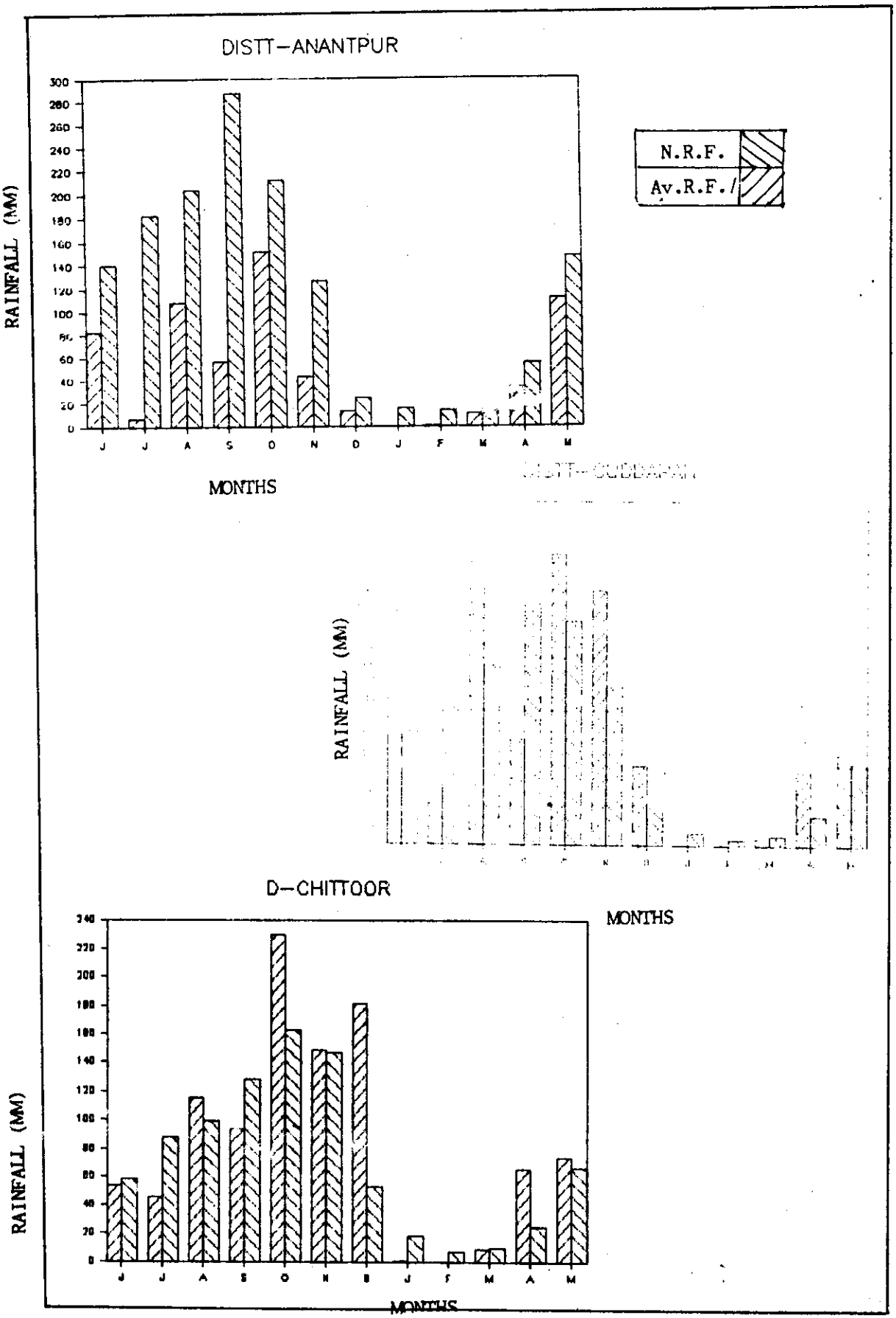


Fig.3.2 : Districtwise monthly Rainfall Departure for year 1987-88

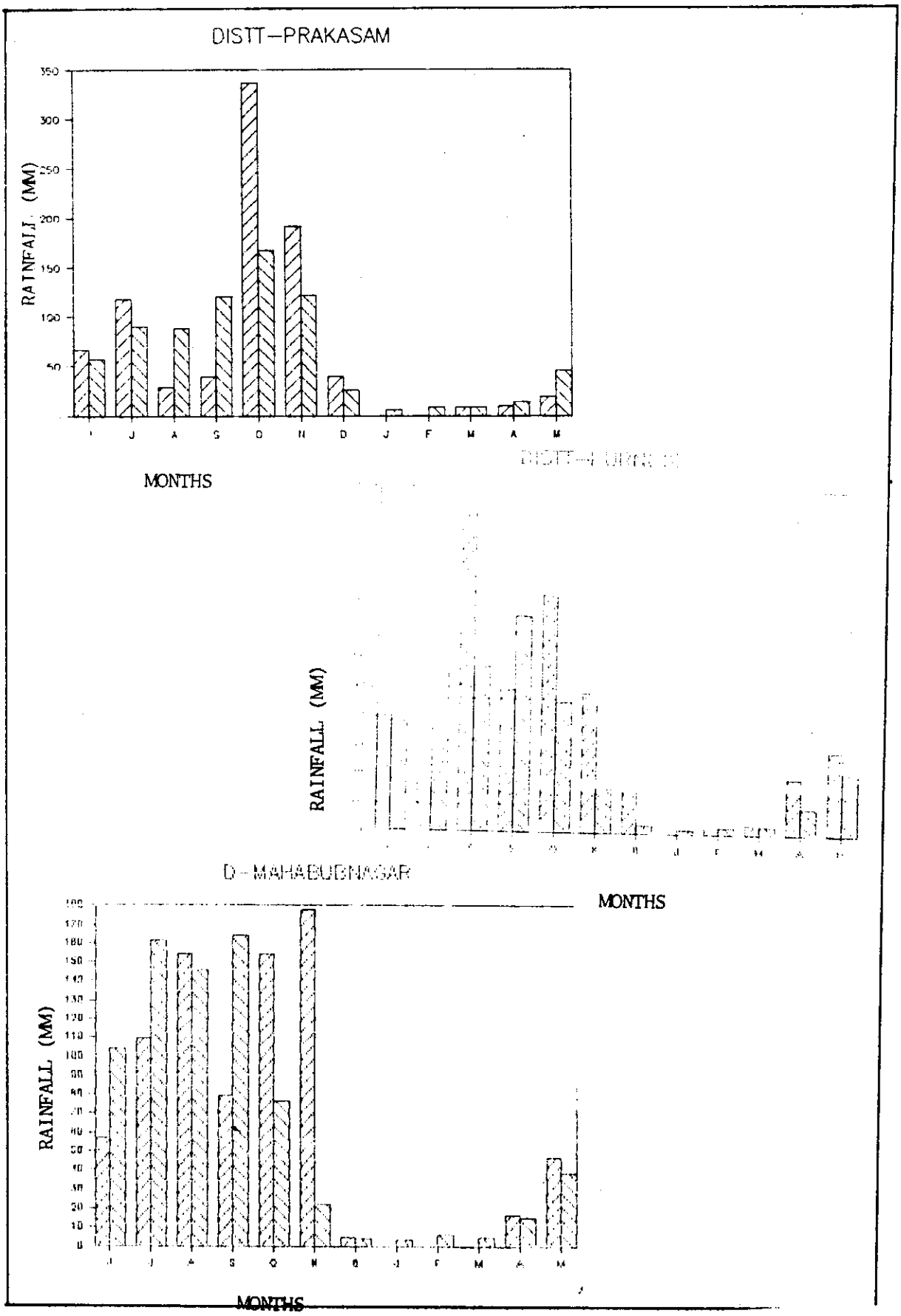


Fig. 3.2 : Districtwise Monthly Rainfall Departure for year 1987-88

Table 3.2 : Monthly Rainfall Deficits in District as a Whole During 1987-88

State	Months	Group Range of Deficiency in rainfall (expressed percentage of normals)	
		20 to 50%	50% and above
Andhra Pradesh (Distt taken 6)	June 87	Mahboobnagar Anantpur	
	July	Chittoor	Cuddapah, Anantpur
		Mahboobnagar	Kurnool
	August	Anantpur	Prakasam
	September	Chittoor	Mahboobnagar
		Kurnool	Cuddapah, Anantpur Prakasam
	October	Anantpur	
	November		Anantpur
	December	Anantpur	
	January'88		Chittoor, Mahboob- nagar, Cuddapah, Anantpur, Prakasam Kurnool
	February	Kurnool	Chittoor, Mahboob- nagar, Cuddapah, Anantpur, Prakasam
	March	Cuddapah Anantpur	Mahboobnagar
	April	Anantpur Prakasam	
	May	Anantpur	Prakasam

3.3 Frequency of Rainfall

3.3.1 Probability analysis of annual rainfall

Probability is a constant characterising given set of objects or incidents in a particular period. The probability analysis of annual rainfall is useful to predict with reasonable accuracy the relative frequency of occurrence in different group intervals of annual rainfall. It is also possible to work out the percentage probability of occurrence of 75% of annual rainfall or more for identification of drought proneness of district/taluk/tehsil.

Two taluks from each district and district as a whole have been selected for probability analysis of annual rainfall. The analysis has been carried out based on the data available from 1901 to 1987 and probability expressed both in number of years of occurrence and the percentage of years for each group interval. Group interval of 100 mm has been considered for the analysis.

The probability distribution curves have been drawn by plotting the values of percentage of cumulative probability in respect of various groups at their corresponding midpoint. The cumulative percentage have been worked out starting from the maximum rainfall group downwards adding the successive percentage.

Probability groups for all the six districts and also for two selected taluks in each districts of the state have been shown in figure 3.3 and appendix III-2 respectively. The range of annual rainfall at 75% probability level can be established using these graphs and such values for all districts and two taluks in each district are given in Table 3.3.

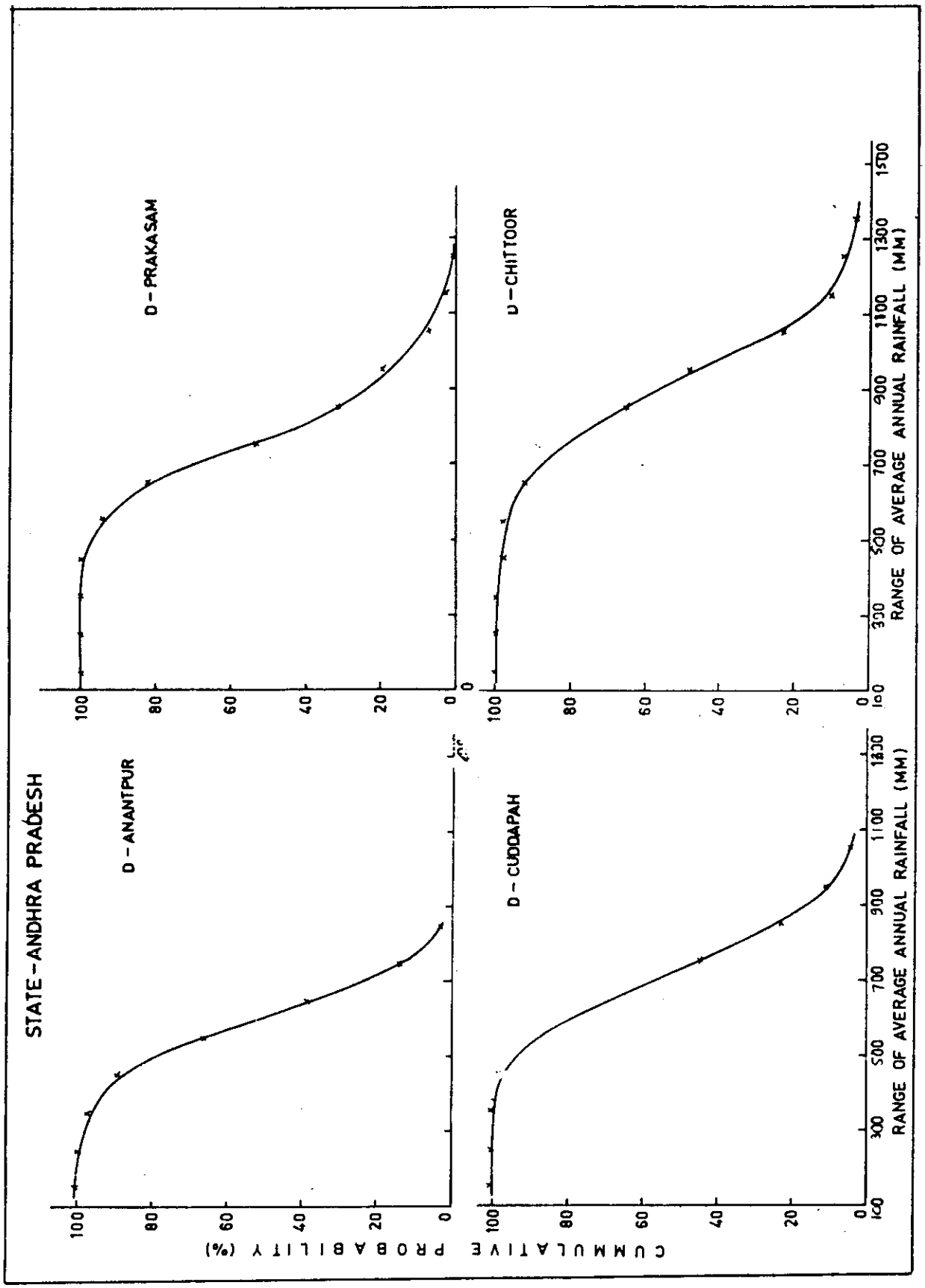


Fig.3.3 : Districtwise Probability of Annual Rainfall

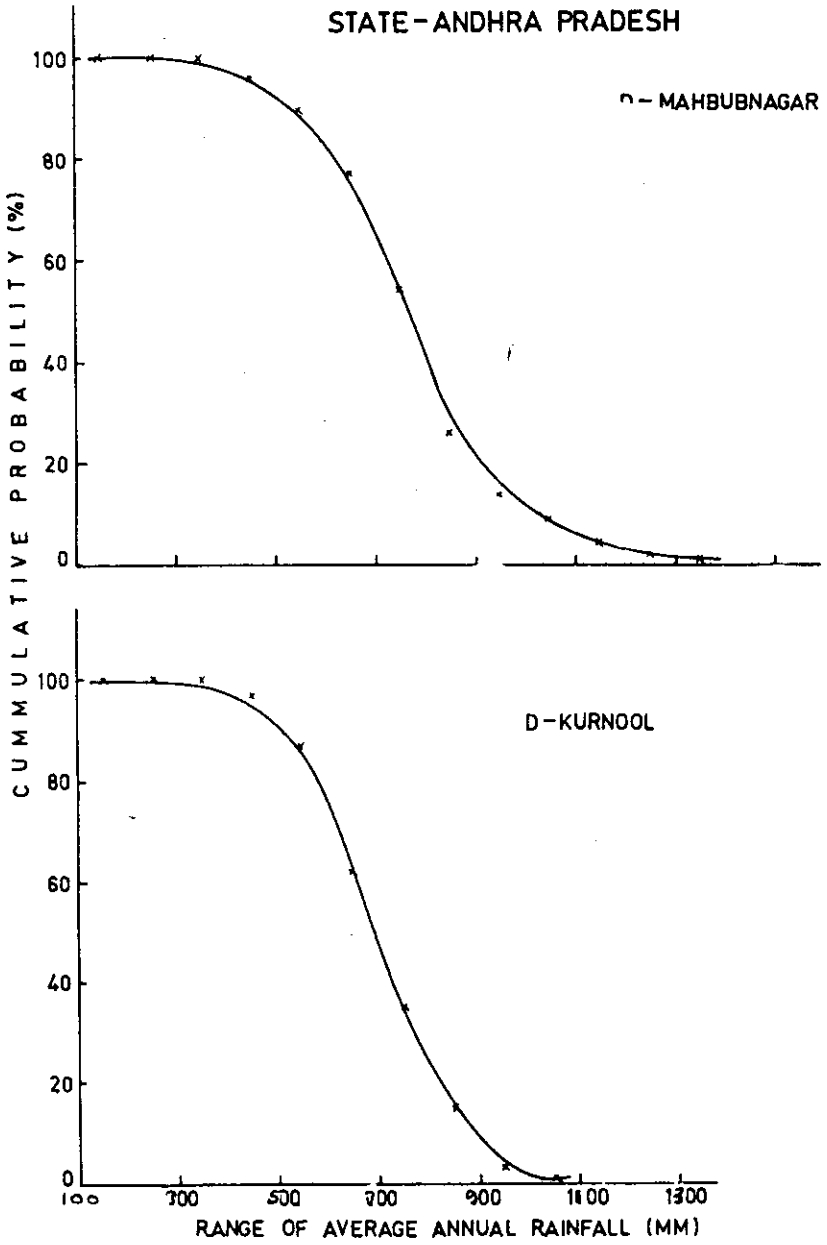


Fig. 3.3 : Districtwise Probability of Annual Rainfall

Table 3.3 : Probability Distribution of Annual Rainfall

Sl.	District State	Name of Taluks	75% probability & above (Range in mm)	Probability of occurrence of rai fall equivalent t 75 percent normal (in %age)
1.	Anantpur (A.P.)	1.Anantpur	400-500	74
		2.Madakasiva	500-600	84
		3.District as a whole	500-600	82
2.	Cuddapah (A.P.)	1.Cuddapah	600-700	86
		2.Jamalanadugu	500-600	83
		3.District as a whole	600-700	84
3.	Chittoor (A.P.)	1.Chittoor	700-800	81
		2.Kuppam	600-700	83
		3.District as a whole	800-900	87
4.	Prakasam (A.P.)	1.Ongole	600-700	81
		2.Adanki	600-700	82
		3.District as a whole	600-700	85
5.	Kurnool (A.P.)	1.Kurnool	500-600	84
		2.Adoni	500-600	83
		3.District as a whole	600-700	87
6.	Mahboob-nagar (A.P.)	1.Mahboobnagar	700-800	85
		2.Nagarkurnool	600-700	83
		3.District as a whole	600-700	83

3.3.2 Probability of occurrence of rainfall equivalent to 75% of the normal rainfall

For identification of drought proneness of the district/taluk, the percentage probability of occurrence of rainfall equivalent to the 75% of normal rainfall or more has also been worked out from the Figures 3.3 and Appendix III-2 and the values are presented in Table 3.3. As per IMD criteria, an area would be classified as drought prone if probability of rainfall equivalent to 75% of normal is below 80% indicating that more than 20% of years, the area experienced scarcity of rain. Central Water Commission has carried out analysis and identified drought prone areas on this ground (CWC, 1982). Using this criteria, inferences drawn from values in table 3.3 are as below:

The group range of 75% range of probability was worked out for all the districts and it has been found that for the districts of Mahbubnagar, Kurnool, Prakasam & Cuddapah, the group range of rainfall is 600-700.The probability values of occurrence of 75% normal rainfall in the districts Anantpur, Cuddapah, Chittoor, Prakasam, Kurnool, and Mahboobnagar are 82, 84, 87, 85, 87 & 83 respectively which are all above 80%, indicating that all the six districts can not be classified as drought prone districts based on the frequency analysis of rainfall as per IMD criteria. This can also beinfered that the districts of Anantpur, Cuddapah, Chittoor, Prakasam, Kurnool and Mahboobnagar experienced rainfall less than 75% of normal in 18, 16, 13, 15, 13 and 17 percent of the years respectively. The taluks of all the six districts showed similar results indicating that these taluks as well as districts as a whole can not be classified drought prone as per IMD criteria.

3.4 Excess/Deficit Rainfall Using Herbst Approach

3.4.1 Model Description

Herbst et al (1966) evolved a new method of drought analysis using monthly rainfall data, whereby it was possible to determine the duration and intensity of droughts and their months of onset and termination.

The model uses the following steps to calculate indices to evaluate onset and termination of droughts.

A. Calculation of mean monthly rainfall, MMR

From the long record of monthly rainfall, the mean rainfall for all the months (i.e. mean monthly rainfall, MMR) is calculated:

$$MMR(J) = \sum_{I=1}^{NYR} \frac{RF(I,J)}{NYR} \qquad \ldots(1)$$

Here MMR = Mean monthly rainfall

RF = Rainfall

NYR = Number of years of record

Suffix I and J denote years and months respectively.

B. Calculation of mean annual precipitation (MAP)

Mean annual precipitation (MAP) is calculated for entire period of record.

$$MAP = \sum_{J=1}^{NMN} MMR(J) \qquad \ldots(2)$$

where NMN = Number of months in a year

C. Calculation of Effective Rainfall

For calculation of drought criteria, the carry over effects from month to month is considered. For this purpose, the mean monthly rainfall for a month, say (J) is substracted from the actual rainfall for that month (J) so that deficit or excess for that month is obtained. This deficit or excess is multiplied by a 'weighting factor' for the next month (J+1) and the product whether negative or positive, is added algebraically to the rainfall figure of that month (J+1). This sum becomes the 'Effective rainfall' (ER) for that month (J+1).

The 'weighting factor' for a month used to calculate carryover effects is derived from an empirical formula as suggested by Herbst et al (1966).

$$W(J) = 0.1^{*} \left[1 + \frac{MMR(J)}{1/12^{*}MAP} \right] \qquad \ldots(3)$$

W(J) = weighting factor for j^{th} month

The carry over for j^{th} month and corresponding effective rainfall is calculated as under:

$$CO(I,J) = ER(I,J-1) - MMR(J-1) \qquad \ldots(4)$$

$$ER(I,J) = RF(I,J) + CO(I,J)*W(J) \qquad \ldots(5)$$

Here CO = Carry over factor

For the first month of first year of record, the effective rainfall has been assumed as equal to monthly rainfall. Thus for I = 1 and J = 1,

$$ER(1,1) = RF(1,1) \qquad \ldots(6)$$

There upon the effective rainfall for each month of every year was calculated by allowing for the carry over effect of a surplus or deficit of rainfall in the preceding month. The process is continued to obtain the effective monthly rainfall for the full period of record.

D. Calculation of mean annual deficit

The difference of effective rainfall for a month and 'Mean Monthly Rainfall' for that month is obtained for full period of record and termed as 'Difference'.

$$DIFF(I,J) = ER(J,J) - MMR(J) \qquad ...(7)$$

These 'differences' for various months of the record, if greater than or equal to zero, were reported as zero. Thus the 'Mean Monthly Deficits (MMD)' were based not only on those months in which a negative difference occurred, for positive differences (i.e., negative deficits) were taken as zero and thus also included in the computation.

$$MD(I,J) = 0.0; \text{ for } DIFF(I,J) > 0.0 \qquad ...(8)$$

$$MD(I,J) = DIFF(I,J); \text{ for } DIFF(I,J) < 0.0 \qquad ..(9)$$

In this way 'Mean Monthly Deficit' for each month of every year was calculated:

$$MMD(J) = \left[\sum_{J=1}^{NYR} MD\ (I,J) \right] * \frac{1}{NYR} \qquad ....(10)$$

The summation of Mean Monthly Deficits yields Mean annual deficit (MAD) or,

$$MAD = \sum_{J}^{NMN} MMD(J) \qquad ...(11)$$

Here MD = Monthly deficits or monthly differences

MMD = Mean monthly deficit

MAD = Mean annual deficit

Mean annual deficit is used in testing for onset and termination of drought.

The analysis includes establishment of another set of termination drought. This includes maximum parameters used for test of start and termination drought. This includes maximum of Mean Monthly Rainfall (MMMR), the sum of two highest values of mean monthly rainfall, the sum of three highest values of mean monthly rainfall and so on up to the sum of mean monthly rainfall of all the months yielding a value equal to mean annual rainfall.

E Test to Determine onset of drought

From the given record, a month with a negative difference is found, while inspecting delete negative difference, the following two cases may arise.

Case (A) Delete negative difference < MMMR

Case (B) Delete negative difference > MMMR

Case (A) Delete negative difference < MMMR

If delete negative difference is less than MMMR, the difference of the next month is inspected and if negative is added to the negative difference of the previous month and compared with the second values on the sliding scale, (MMMR + x). If sum of these two delete negative difference exceeds (MMMR + x), the drought is deemed to have started from the previous month In this manner the absolute value of sum of all negative differences occurring from the first month over a period of a year is tested sequentially against the twelve values of the sliding scale. If at any time the summed value of delete negative difference from

the first to the J^{th} month exceeds the value MMMR+(J-1)x, drought is deemed to have started from the first month.

Case (B) Delete negative difference ≥ MMMR

In this case when the delete negative difference is greater than or equal to MMMR, the drought is deemed to have stated from this month.

F Tests to determine the termination of drought

Once the start of the drought is found, the program begins to search for a month with a positive difference.

A precondition to be satisfied is that at least one of the two months following the initial month with a positive difference should also have a positive difference. Once this condition is met. then only the initial month is qualified for further testing for termination of drought. Thus for further testing for termination of drought a precondition to be satisfied is that two consecutive months should have positive difference.

Once this condition is met, the following two tests are carried out for testing for termination of drought:

i) In this test the differences are algebrically summed up from the month, the drought started to the month of the termination test. If the sum became positive, the drought is deemed to have terminated otherwise second test is carried out for testing of termination.

ii) The second tests comprises of ten sequential tests. Firstly the actual rainfall values from the first to the third month of testing are mmed up and compared with the sum of three highest values of mean monthly rainfall. If the sum of actual rainfall is higher the

drought is considered to have been terminated. If the sum of actual rainfall is not exceeded, then the sum of actual rainfall of first four month is compared with the sum of the four highest values of mean monthly rainfall, and so on should the drought not yet have been terminated, upto a comparison of the sum of the rainfall of the rainfall of the twelve months following and including the month from which the test commenced, with the mean annual rainfall. By this stage either the drought had been terminated, in which case it was deemed to have ended in the month from which the multiple test had been initiated or the drought conditions prevailed over this period and test for the termination recommenced at the first month with a positive difference following that from which the previous unsuccessful test had proceeded.

Once a termination had occurred testing for the start of the next drought began at the first month with a negative difference following the month in which the drought ended.

(G) Evaluation of drought index

Drought intensity is evaluated by dividing the total deficits beyond the monthly mean deficit for the period of drought (D) by the sum of the mean monthly deficits for the same period.

$$\text{Drought Intensity (I)} = \frac{\sum_{J=IDST}^{IDEND} [MMD(J)]}{\sum_{J=IDST}^{IDEND} [MMD(J)]} \quad \ldots(12)$$

WHERE IDST = Month of start of drought

IDEND = Month of termination of drought

In above equation if nominator is less than 0.0 (i.e., negative), than nominator is equaled to zero for calculation of drought intensity.

Severity Index: Severity Index is defined as product of drought (SI) intensity and drought duration SI = I x D..(13)

This analysis has been performed for all the six selected districts.Monthly rainfall data for the period 1951 to 1987 of selected raingauge stations located at taluk headquarters of each district have been used for analysis. A computer program using the above approach has been developed for the analysis. The district spells of drought alongwith monthly and overall intensity of drought for all the spells were obtained. The results of analysis in tabular form for all districts are given in Appendix III-3. The graphical representations of the drought spells with intensity for all districts are shown in figures 3.4.

The following inferences can be drawn from the analysis (Reference Fig.3.4 and Appendix III-3) It can be observed from figures given in Appendix III-3, that all districts except Chittoor fell under drought spells during year 1985-87. The districts of Cuddapah, Kurnool and Anantpur recorded similar spells of drought in intensity and duration during 1984-87. The district of Prakasam had a spell of drought in year 1987 while in the previous year the spell was not extensive. In general, all districts recorded about 12 spells of drought since 1951 till 1987. The duration of drought spells was largest in the last spell of 1984-87 in most districts. The approach has yielded comparable results of drought analysis and has further scope for improvement

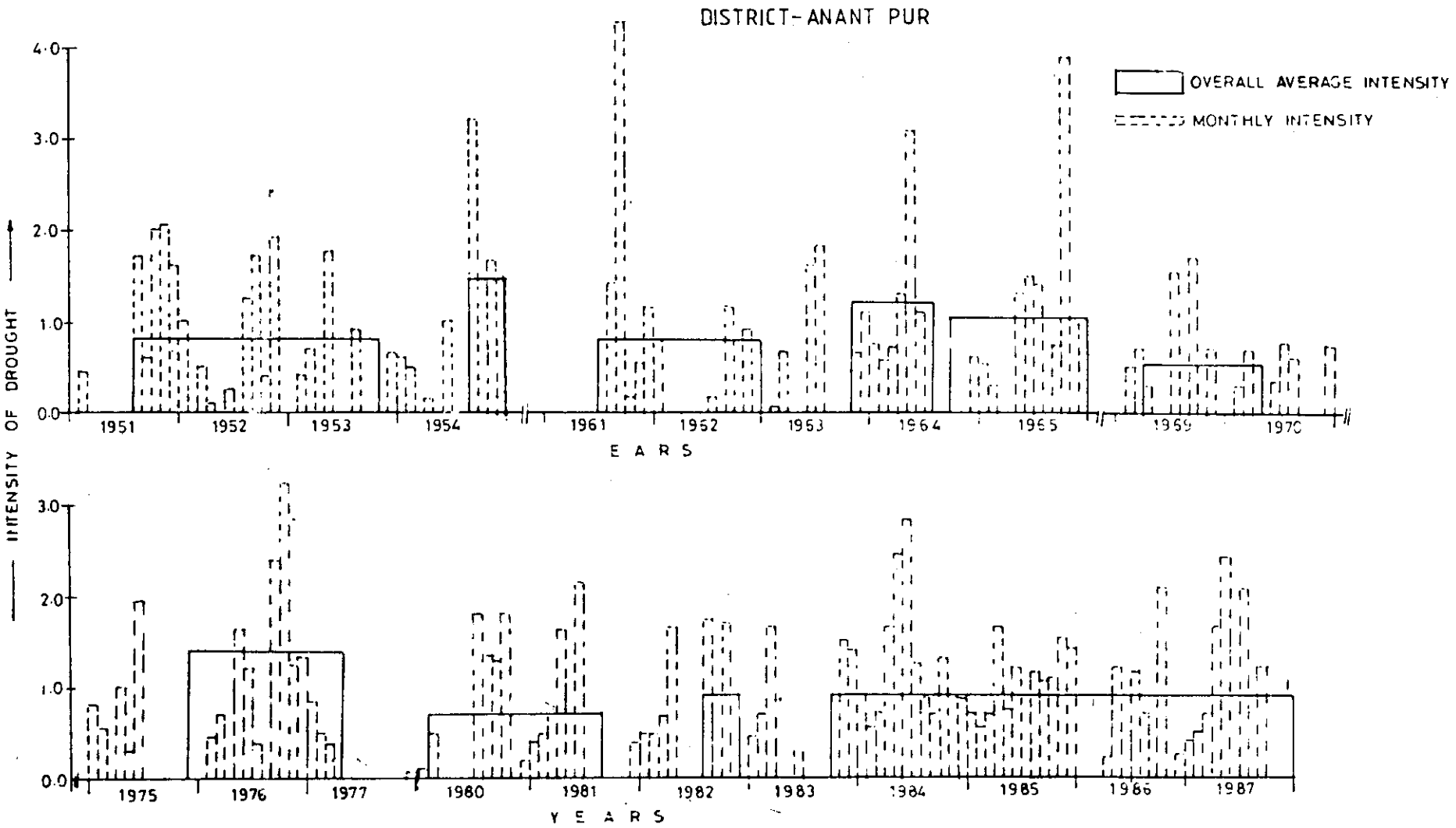


FIG. 3.4 - OVERALL AVERAGE AND MONTHLY INTENSITY OF DROUGHT

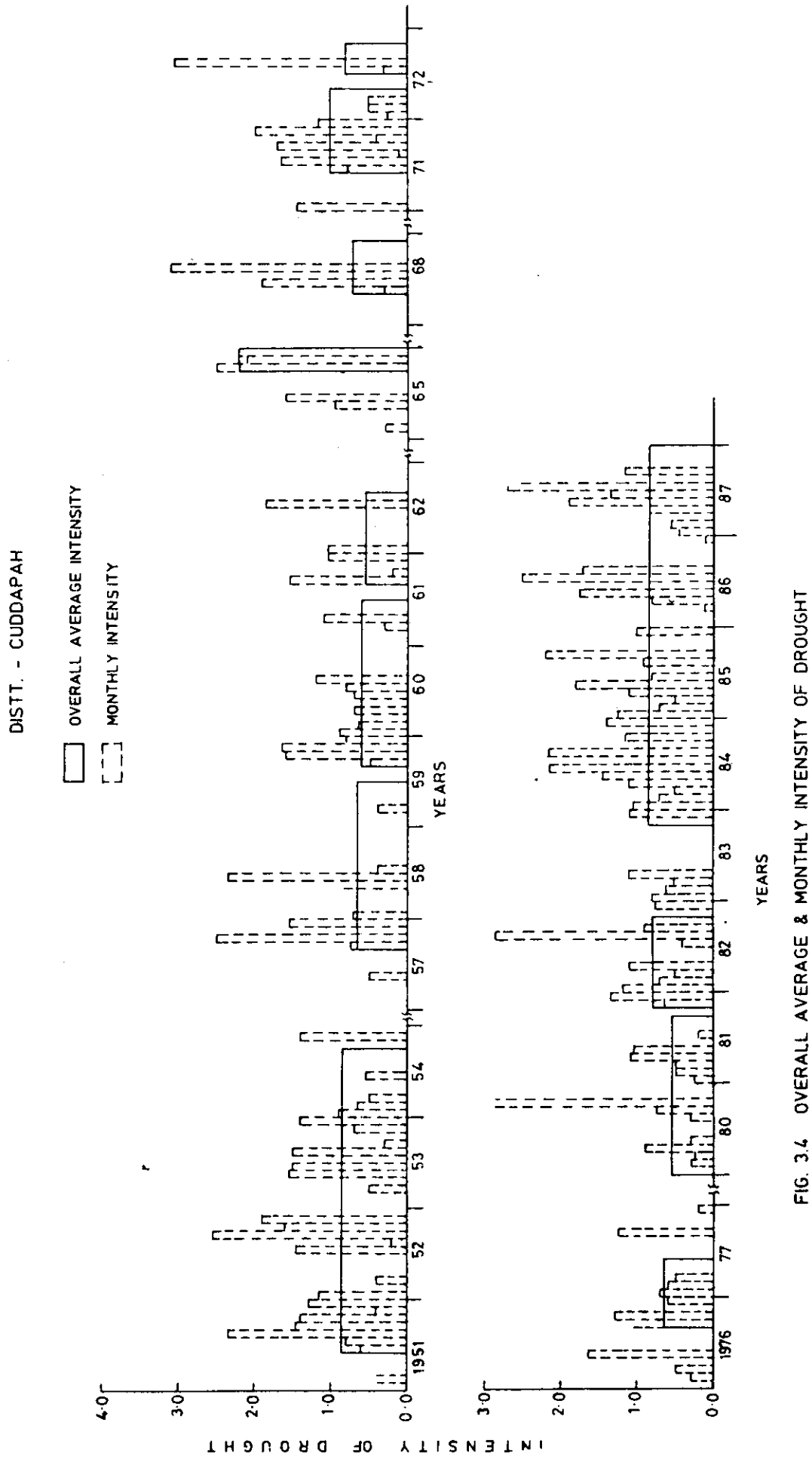


FIG. 3.4 OVERALL AVERAGE & MONTHLY INTENSITY OF DROUGHT

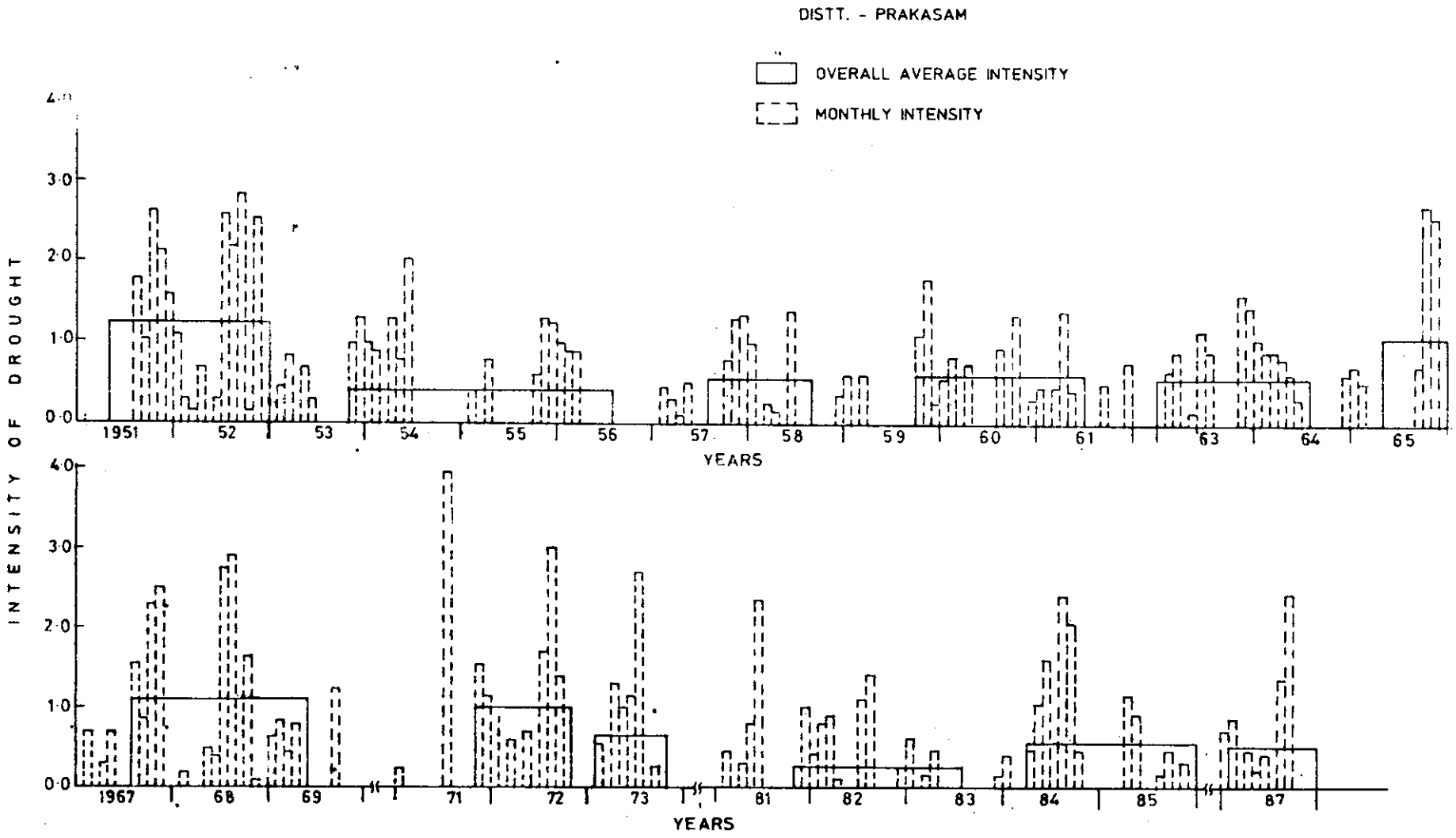


FIG. 3.4 OVERALL AVERAGE & MONTHLY INTENSITY OF DROUGHT

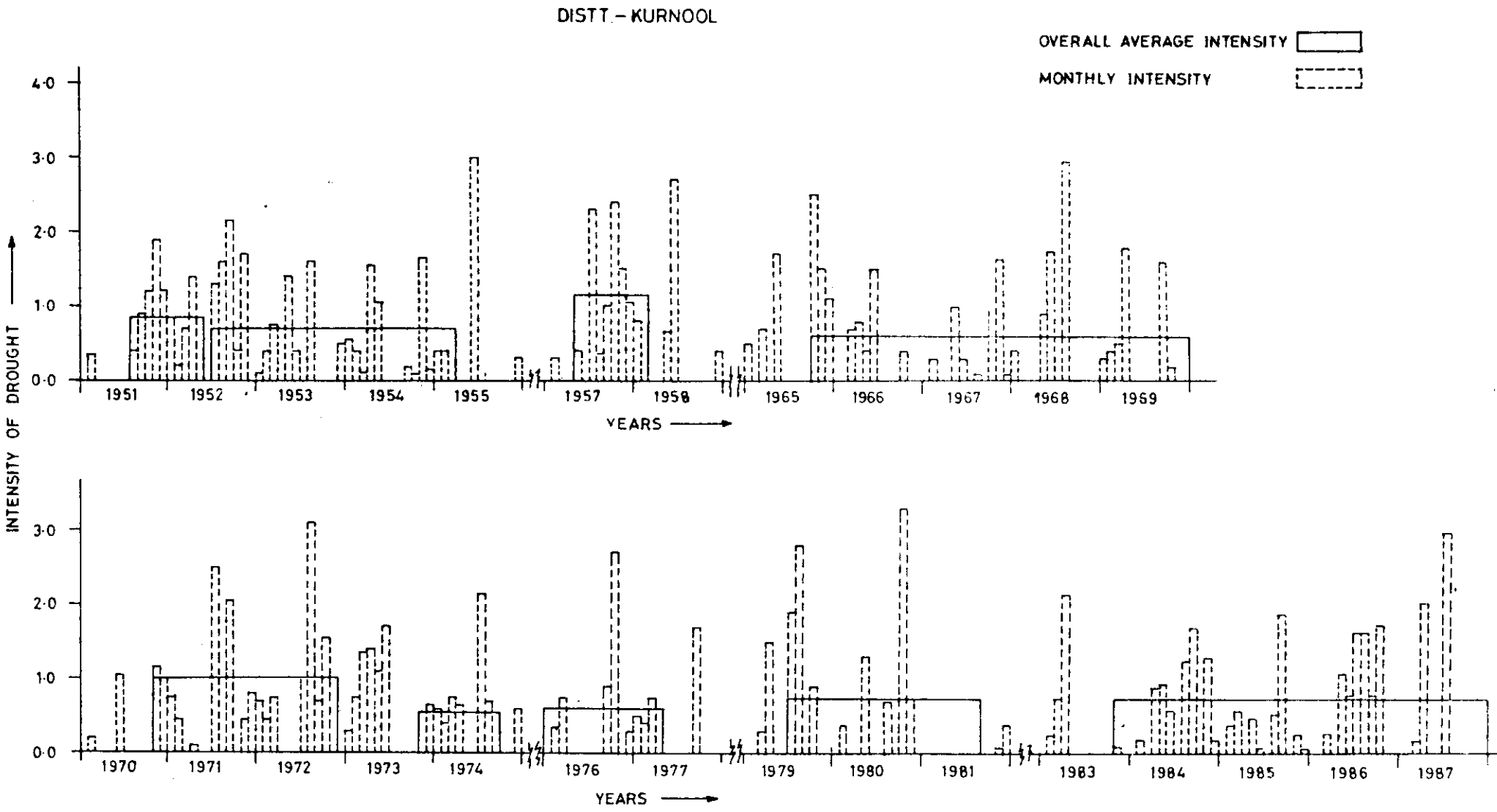


FIG. 3·4 – OVERALL AVERAGE AND MONTHLY INTENSITY OF DROUGHT

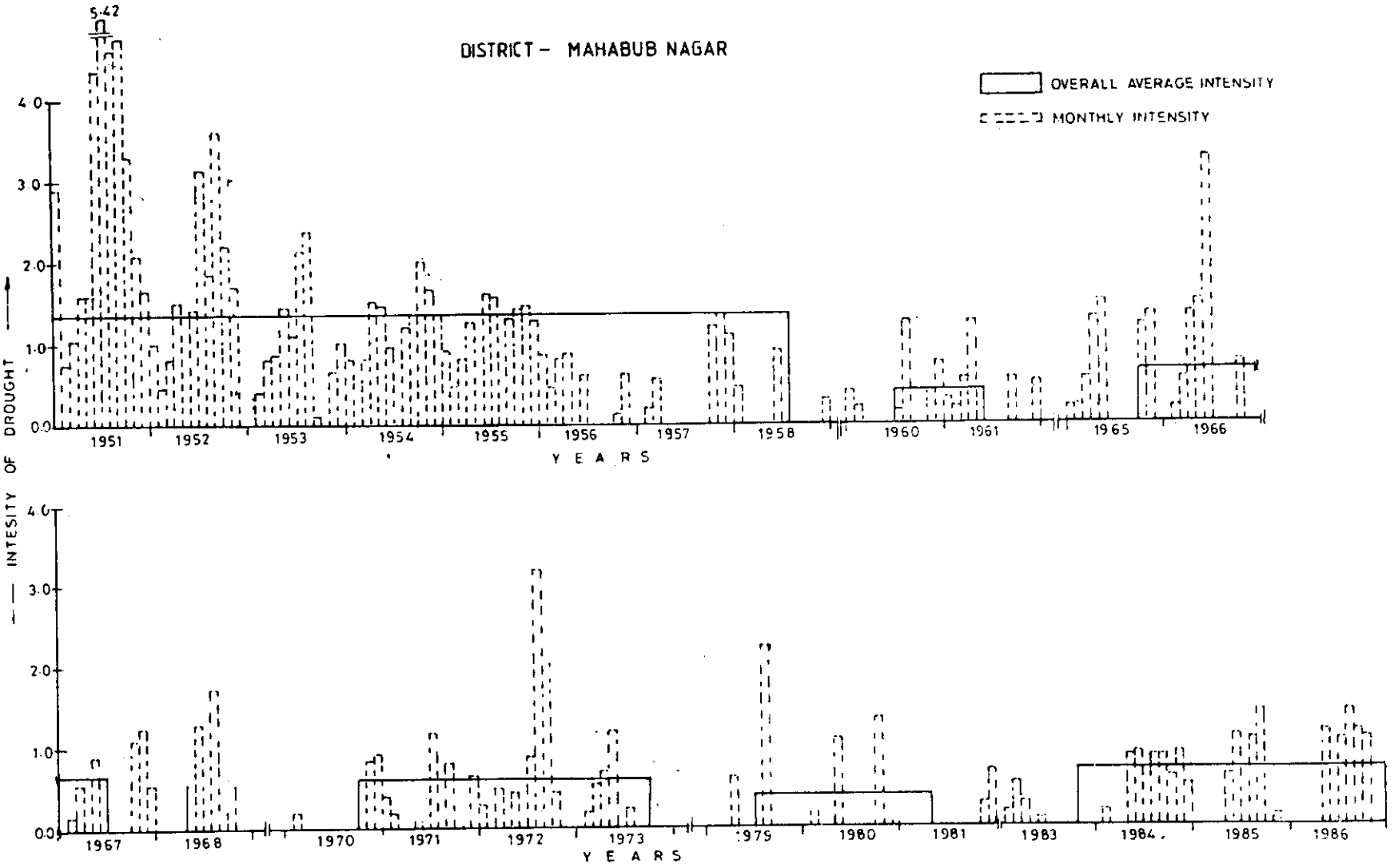


FIG. 3.4 – OVERALL AVERAGE AND MONTHLY INTENSITY OF DROUGHT

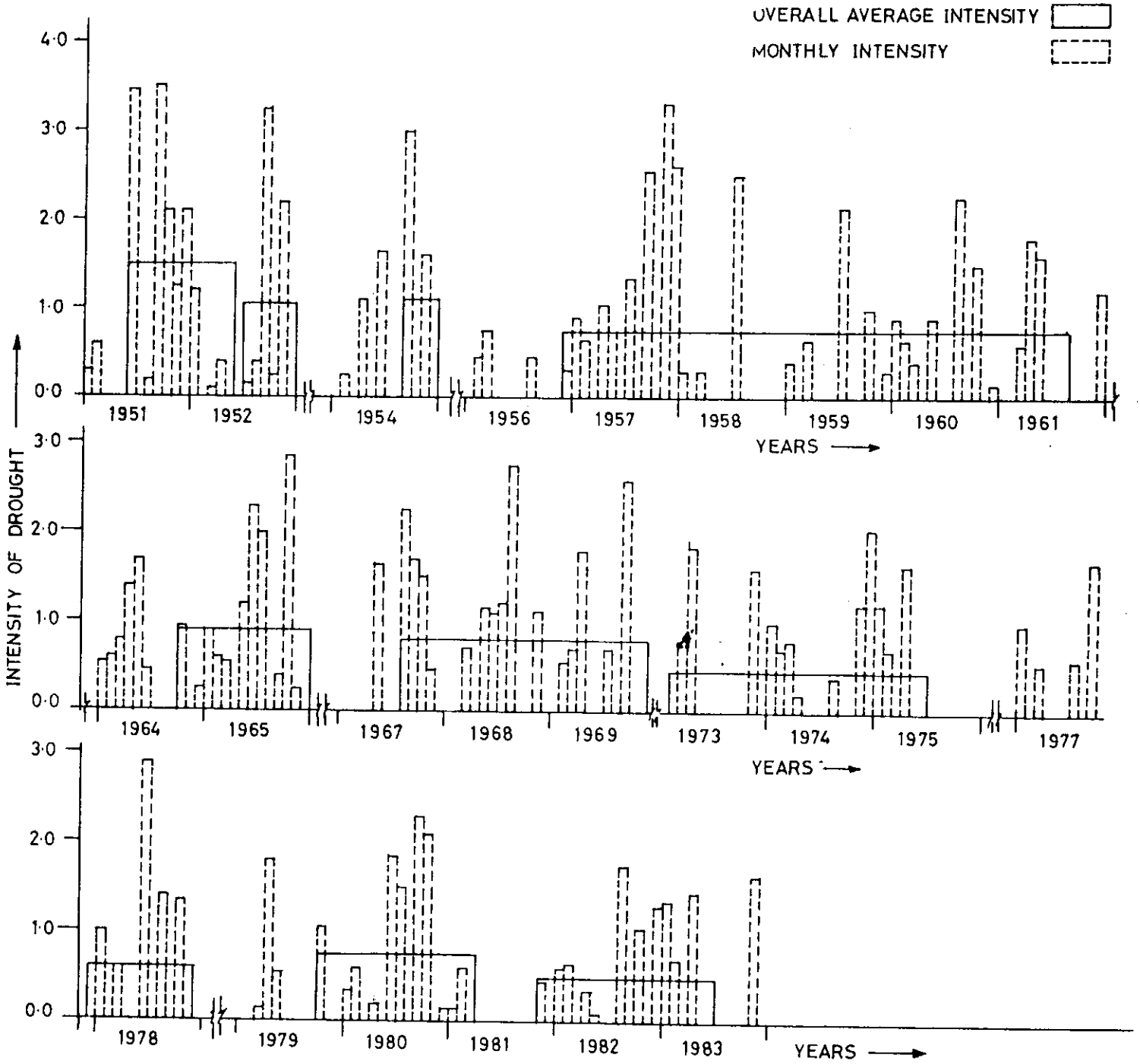


FIG. 3·4– OVERALL AVERAGE AND MONTHLY INTENSITY OF DROUGHT

taking into account the revision of monthly weightage factors keeping in view the agriculturally important months in the state.

3.5 Dry Spell Analysis:

Agriculture is the worst sufferer of droughts as the ultimate effects of drought results in partial or total crop failure. Out of the various growing stages of crops, some are sensitive to moisture stress known as critical growing stage. Agricultural droughts are the result of occurrence of dry spells specially during critical growth stages of crops. Therefore the analysis of dry spells ($\geq$ 2 weeks) within monsoon season has importance specially for rainfed agriculture in the country. Therefore,an attempt has been made to identify the dry spells of two or more than two weeks duration during monsoon period (4th June to 15th September) by selecting one taluk from each of the 6 districts of state Andhra Pradesh.

The criteria for selection of dry spell is that the daily rainfall should be less than or equal to 5 mm (as a day is assumed as rainy day if daily rainfall exceeds 5 mm) occurring continuously for at least two weeks (i.e. 14 days) or more. For counting number of spells the start of monsoon season has been assumed from fourth June of (beginning of 23rd standard week) every year. The duration and time of occurrence and number of such dry spells for all the 6 districts of state Andhra Pradesh have been presented in Appendix III-4 (A). The number of dry spells have been counted starting from the monsoon season of 1981 to 1987. The study has been carried out for one taluk in each district.

For statistical analysis, the duration of dry spells were represented as range (in days) and no. of spells falling in that range were counted. The number of spells falling in various

ranges of duration of spells were represented as percentage of total no. of spells occurring from 1981-1987 and cumulative percentage was obtained starting from the maximum duration of dry spell group downwards adding successive percentage (Appendix III-4(B). The probability curves have been drawn showing range of duration of dry spells on the abscissa and cumulative percentage of no. of spells as ordinates. The plots are shown in figure 3.5. Probability distribution graphs as shown in figure have been used to read the values of duration of dry spells (in days) at 75% probability level and have been given in table 3.4. It can be observed from the table that at 75% probability, the duration of dry spell ranges from 21-28 days for all the six taluks selected for all the six districts respectively except taluk Mahbubnagar of district Mahbubnagar.

This analysis is specially important from the view point of agriculture as it can give some idea about likelihood of dry spells during monsoon period based on which alternate arrangements can be made for providing water during critical growth stages to avoid hazardous effects on crop yields, especially in rainfed agriculture.

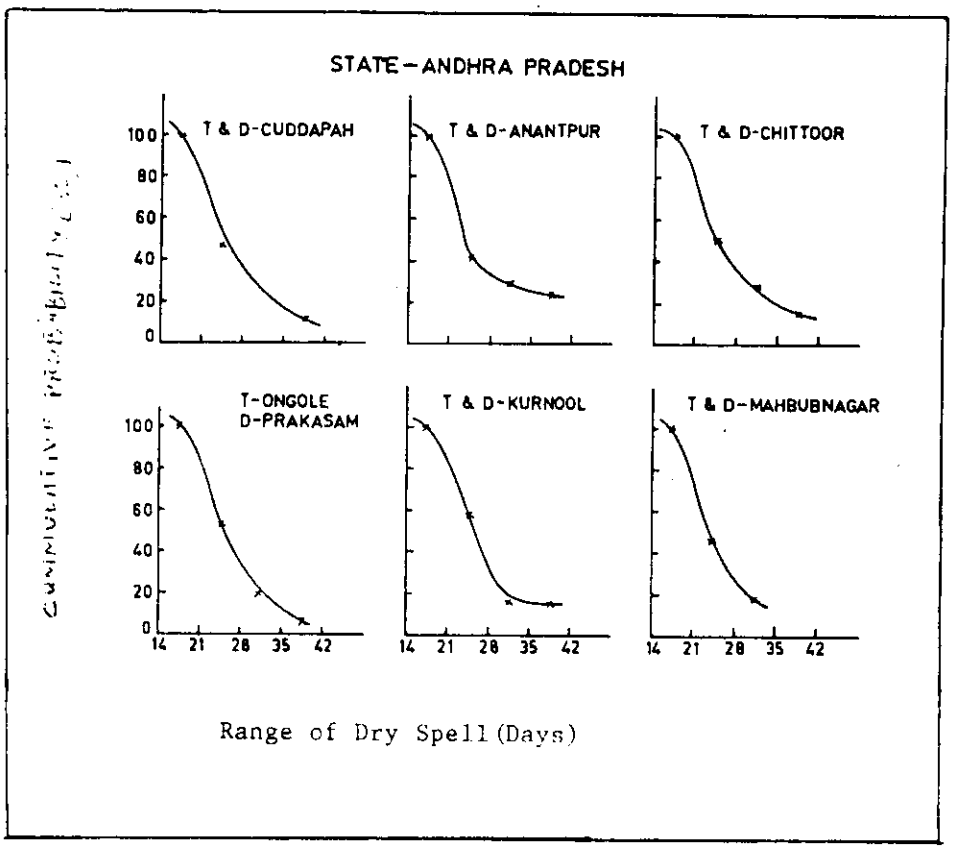


Fig.3.5 : Probability of Distribution of Dry Spells

Table 3.4 : RANGE OF DURATION OF DRY SPELLS FOR 75% PROBABILITY

S.No.	Taluk (Distt.)	State	At 75% Probability, duration of dry spells (in days)
1.	Cuddapah Cuddapah)	A.P.	21-28
2.	Anantpur (Anantpur)	A.P.	21-28
3.	Chittoor (Chittoor)	A.P.	21-28
4.	Ongole (Prakasam)	A.P.	21-28
5.	Kurnool (Kurnool)	A.P.	21-28
6.	Mahboobnagar (Mahboobnagar)	A.P.	14-21

4.0 GROUND WATER DEFICIT

4.1 General

The main objective of groundwater management is to ensure that groundwater will be available at an appropriate time and in an appropriate quantity and quality to meet the most important demands of society. The measurement of groundwater levels and their evaluation can play an important role in management of this underground resource of water. The fluctuations of water table reflect the effects of infiltration precipitation and discharge of groundwater to streams and lakes or withdrawal of water from wells. Usually the change in ground water storage is a seasonal phenomenon. However, during the period of scarcity of rains or droughts, more dependence comes on ground water storages and steep decline in groundwater levels are experienced. 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 ground water and surface water show that in a number of states ground water is being over exploited in certain pockets resulting in a fall in the water table. During droughts, due to deficiency of rainfall and higher rate of evapotranspiration the demand for irrigation gets enhanced, thereby the water level goes down. This results in increased use of energy for pumping water from greater depths involving higher expenditure. As a policy, the withdrawal of groundwater should be restricted to average annual recharge. This will conserve water from over exploitation during drought periods.

Therefore, there is a long standing need to better understand the relationship between precipitation and groundwater levels. The relationship can be developed by carrying out

statistical analysis of precipitation data and well level observations. Besides, information regarding well, abstractions should be available for evaluating effects on water table only due to reduced precipitation.

In order to see the effects of scarce rainfall as experienced during three successive drought years (1985-1987) on groundwater regime, statistical analysis of groundwater level data vis a vis precipitation has been carried out .In the present analysis of State Andhra Pradesh, four districts namely Chittoor, Prakasam, Mehboobnagar and Kurnool were chosen for the study of premonsoon and post monsoon ground water levels and seasonal rainfall fluctuations. Due to non-availability of Data, the study is restricted to four districts only. Due to non availability of abstraction data, the effects of withdrawal could not be introduced in the analysis.

4.2 Ground Water Level Analysis

The data concerning groundwater level fluctuations were collected in respect of observation wells in all the four districts, namely Chittoor, Prakasam, Kurnool and Mahboobnagar of state Andhra Pradesh. The information regarding period of data used, no. of observation wells and the source of data is given in table 4.1.

Table 4.1 : Status of Groundwater Data of State Andhra Pradesh

Sl. No.	Name of districts	Data available (four time in taken a year)	No. of wells	Source of data availability
1.	Chittoor	1977-88	6	C.G.W.B.
2.	Prakasam	1977-88	7	-do-
3.	Kurnool	1977-88	4	-do-
4.	Mehboobnagar	1977-88	10	-do-

As is evident from table 4.1, about 4-10 wells were chosen in each district for evaluating impacts on groundwater regime. Assuming that these wells are evenly distributed within the district. The locations of the wells on the district map have already been shown in the figures presented in chapter 2.

The groundwater level analysis was attempted with the help of quarterly/seasonal data depending upon the frequency of the data collected from the central & state Govt. agencies of the state. Appendix IV-1 gives the details of various observation wells spread over 4 selected district prone districts of Ardhra Pradesh state with their latitude and longitude. The analysis has been carried out for ground water level data from 1978-88.

The water levels in the wells have been calculated with respect to mean sea level and for each district average ground water level has been calculated using Thiessen Polygen method. The Thiessen weight of all wells considered in each district was established and groundwater level calculated with respect to mean sea level, multiplied by Thiessen weight, gave average ground water level for the district. The values so obtained were plotted against each year to drive trend in ground water fluctuations. The trend was established for two period namely, pre monsoon and post monsoon. In order to see the trend in the rainfall, the seasonal rainfall was also plotted on the same graph showing the ground water level fluctuations. For this purpose, the seasonal rainfall from June to September was used for all four districts selected for study in the state of Andhra Pradesh. A simple regression line as fitted to show the trend of rainfall in order to see the effects of deficit in water level. As has already been mentioned that due to non availability of data the effects caused due to over exploitation of ground water during drought period could not

be introduced in the study and it is presumed that decline in ground water level is caused solely due to failure of rainfall. Also a district has been taken as a unit for analysing ground water levels. Ideally, a hydrogeological boundary will need to be established for such an analysis. However, it has been presumed that the district has no inflow or outflow of ground water into from its aquifer. Based on the analysis,following inferences can be drawn.

The pre-monsoon and post-monsoon ground water levels along with seasonal rainfall fluctuations for these districts are shown in Fig.4.1 to Fig.4.6 for the year 1987-88. In case of Anantpur and Cuddapah only rainfall trend for the year 1986-87 has been established due to non-availability of ground water data. However, based on the rainfall trend it can be inferred that for both of these districts the ground water regime might have improved due to better rainfall conditions as compared to previous two years. However, this can be verified only after receipt of data. In case of Chittoor and Prakasam districts declining trends in seasonal rainfall have been observed. This has led to decline in ground water levels, in case of Chittoor district. However, for Prakasam district positive departure in seasonal rainfall value has ben observed and relatively the ground water trend have shown rising trend as compared with the last year. In Mehboobnagar and Kurnool district the rainfall shown declining trend with both positive departure in Kurnool and negative departure in Mehboobnagar. The pre and post water level trends show decline for Mehboobnagar district while for Kurnool these trends show rising behaviour.The analysis of ground water levels based on the water table fluctuations data of post 10-12 years has yielded in knowing the ground water level trends (Pre & Post) as a result of seasonal rainfall departure. In most cases the water table has been recorded falling and the rate of recharge was found lesser in 1987-88 as compared to previous years. The continuous decline in

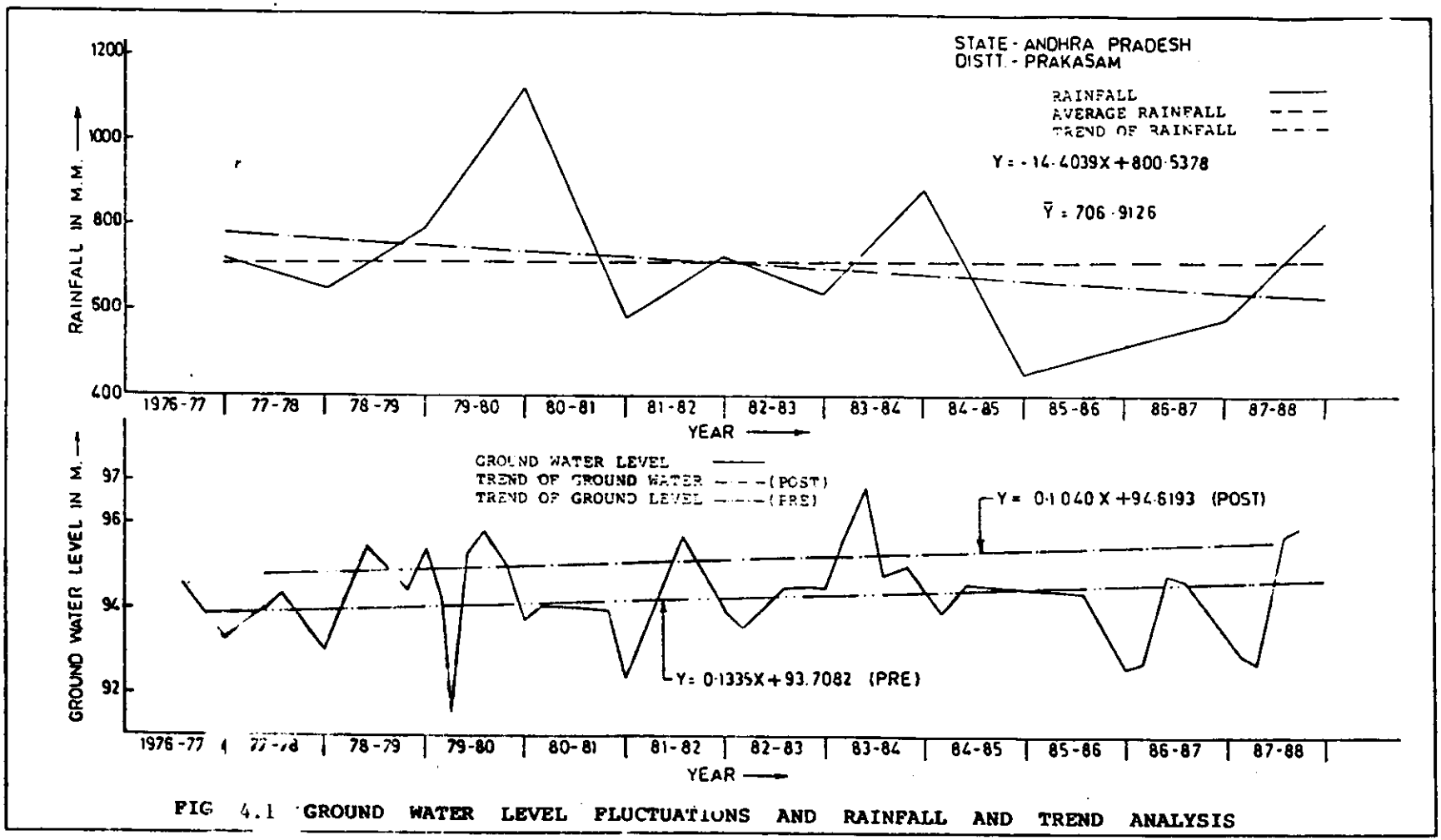


FIG 4.1 GROUND WATER LEVEL FLUCTUATIONS AND RAINFALL AND TREND ANALYSIS

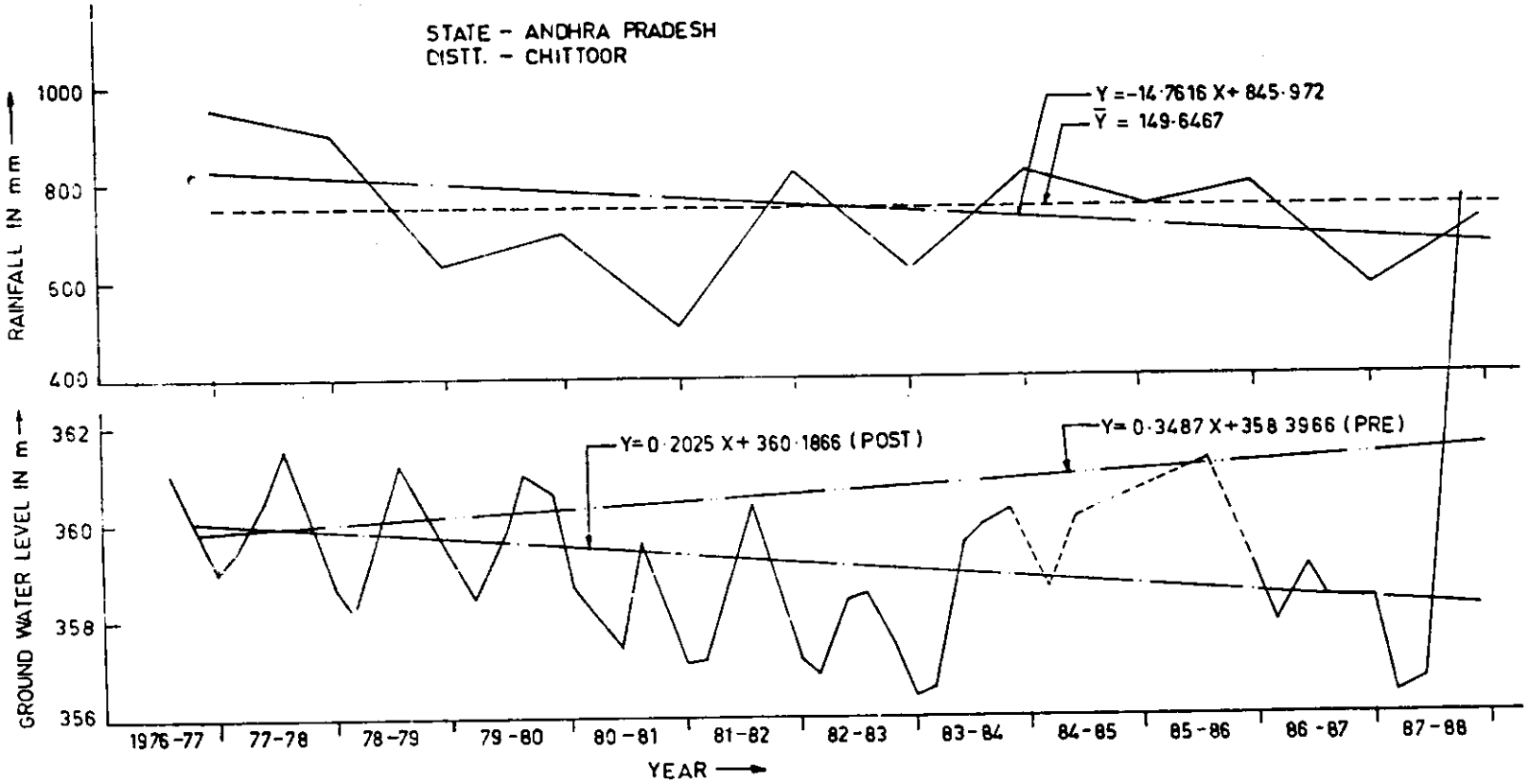


Fig.4.2 : Ground Water Level Fluctuations and Rainfall and Trend Analysis

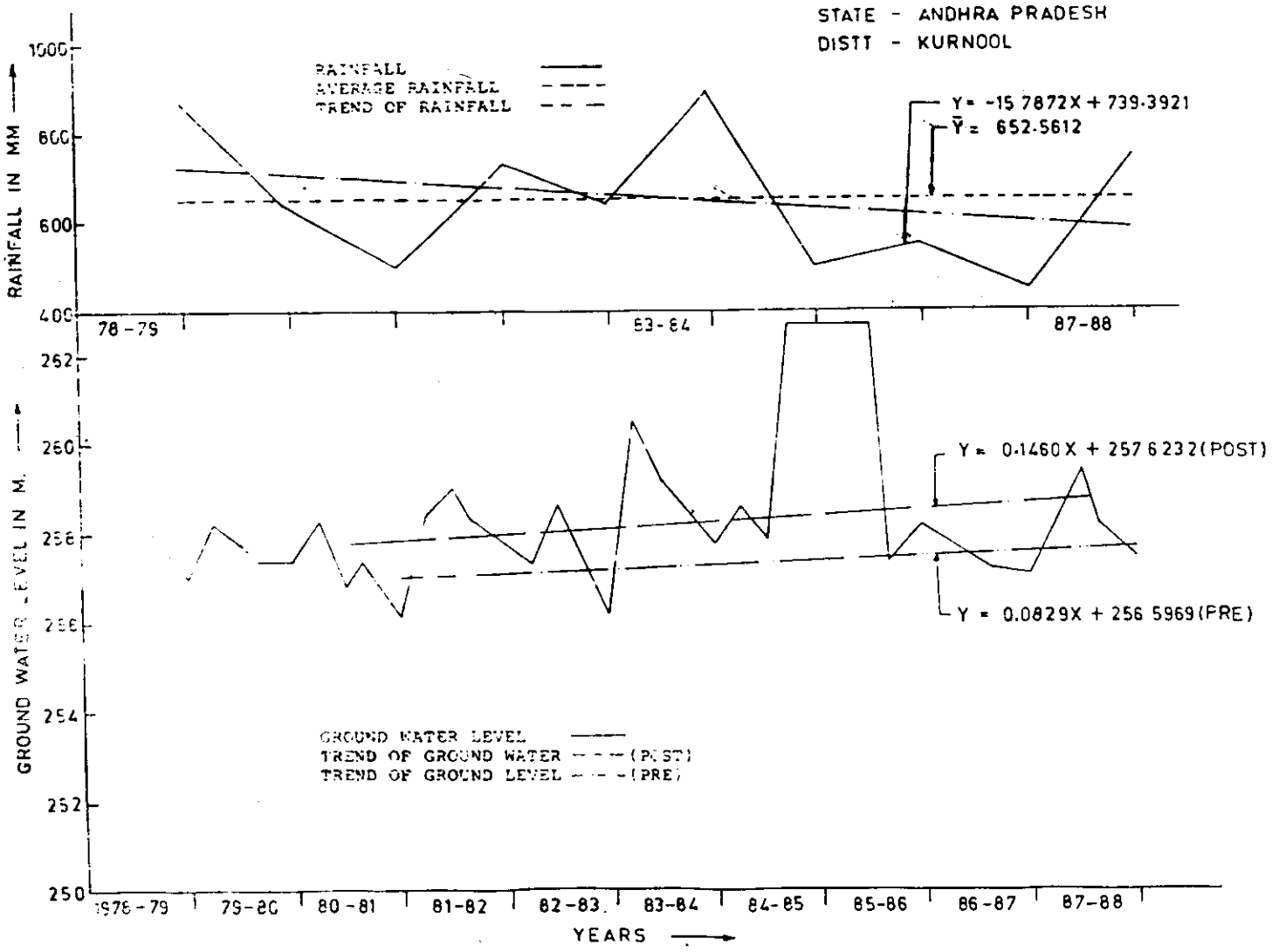


FIG 4.3 :GROUND WATER LEVEL FLUCTUATIONS AND RAINFALL AND TREND ANALYSIS

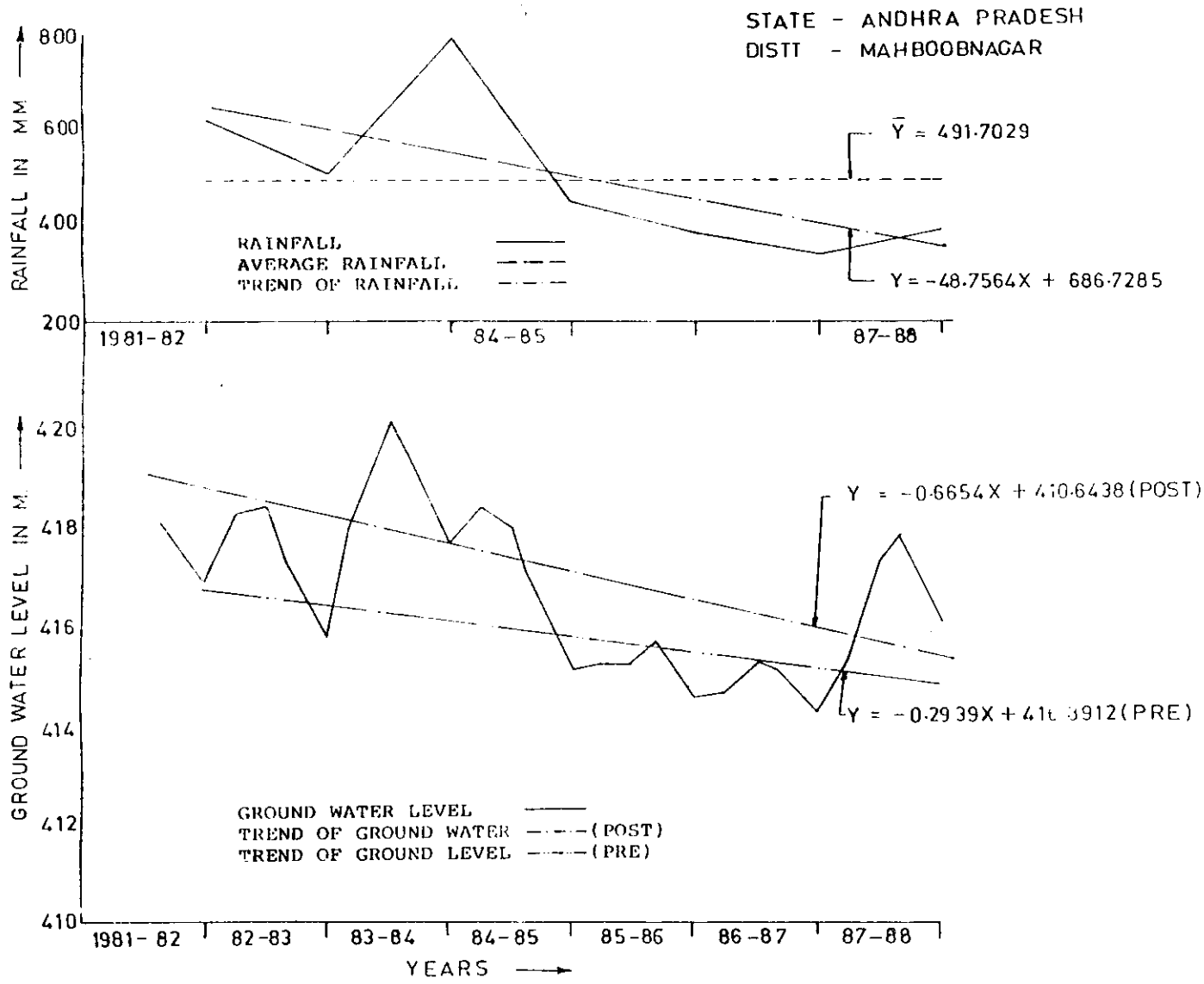


FIG 4.4 : GROUND WATER LEVEL FLUCTUATIONS AND RAINFALL AND TREND ANALYSIS

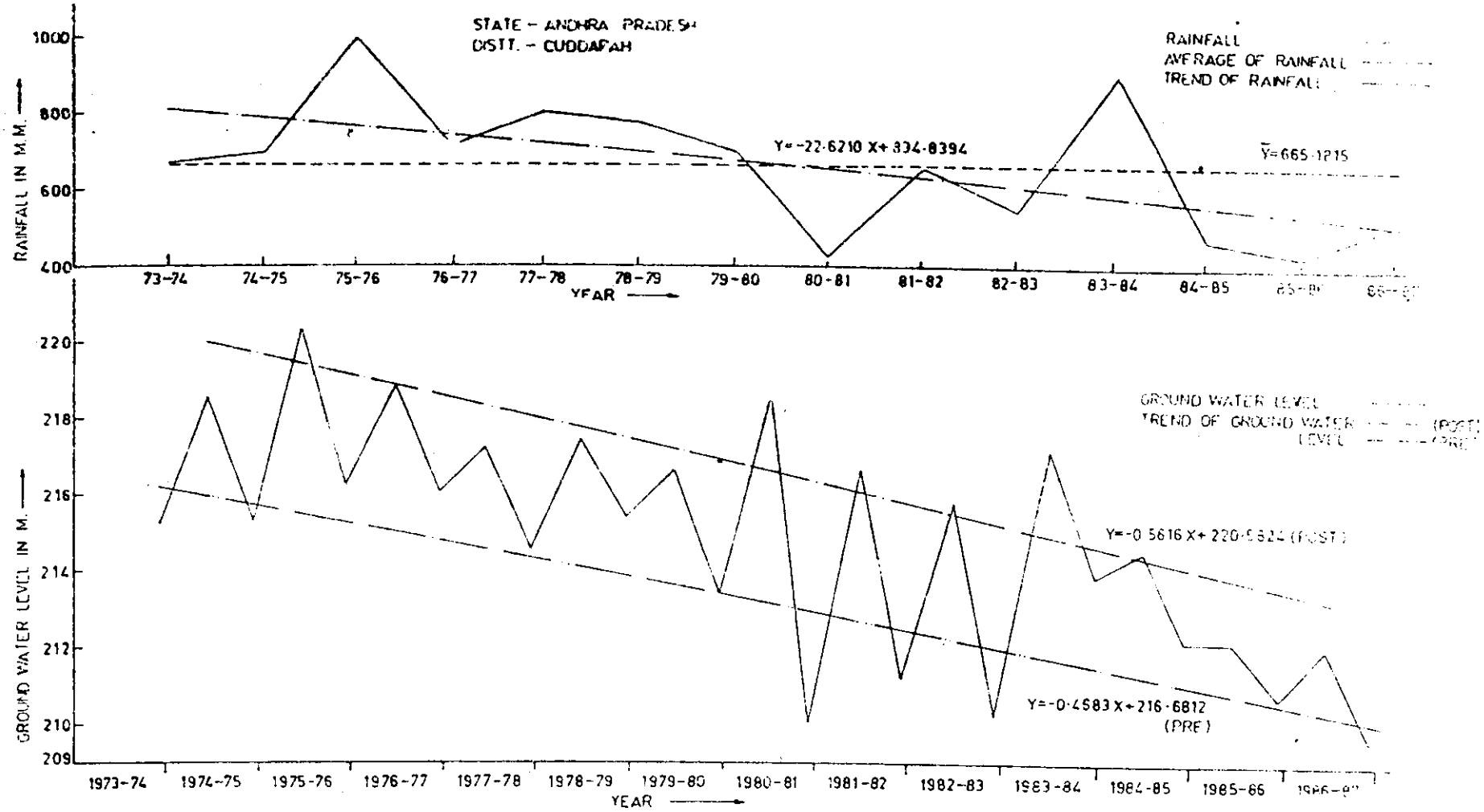


FIG 4.5 GROUND WATER LEVEL FLUCTUATIONS AND RAINFALL AND TREND ANALYSIS

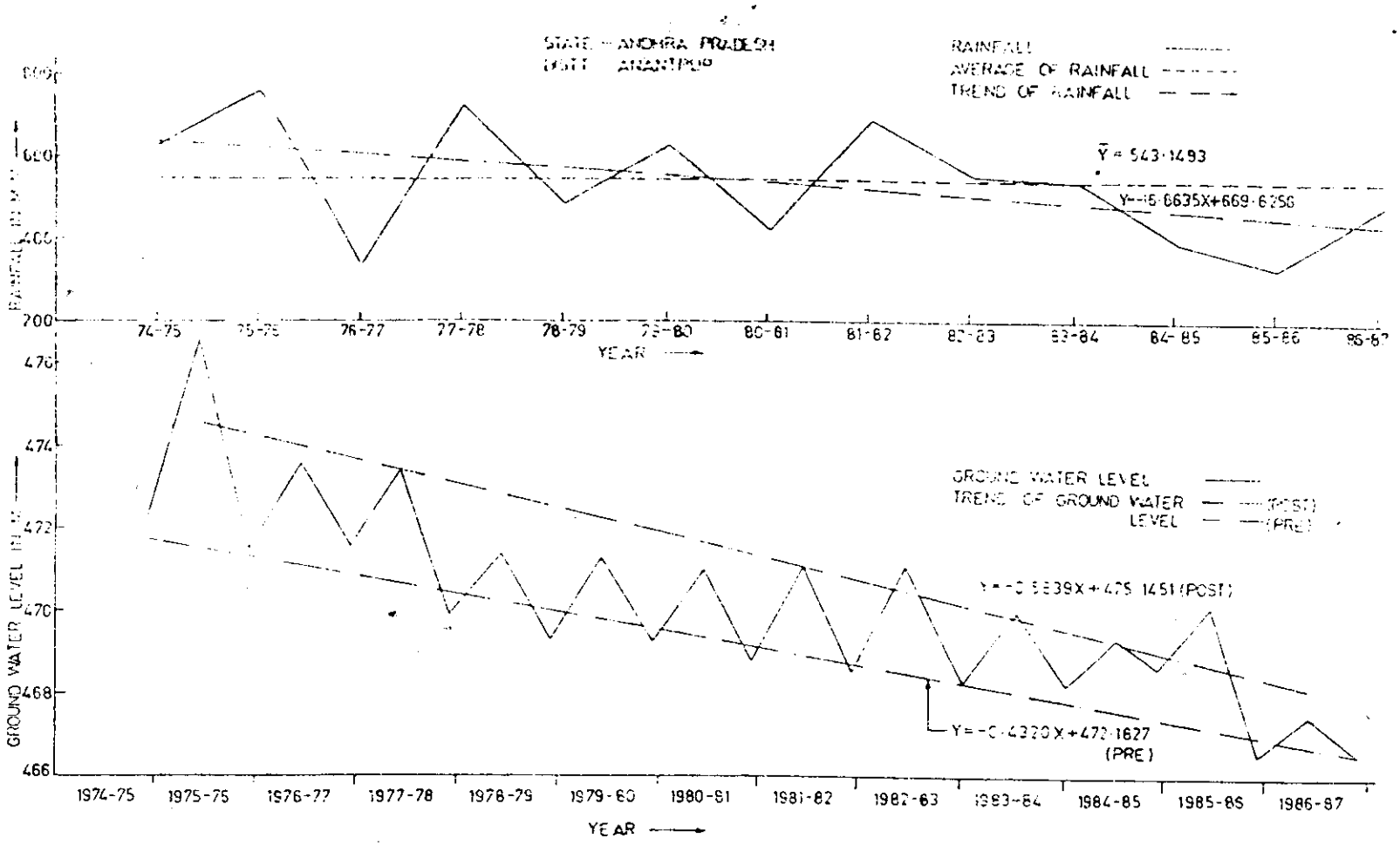


FIG. 4.6 GROUND WATER LEVEL FLUCTUATIONS AND RAINFALL AND TREND ANALYSIS

water table is certainly attributed to failure of monsoon due to which the draft of ground water also gets increased because of increase in demand. The rise in water table as found in some cases can be attributed to the positive ground water in balances created by surface water irrigation projects. Better analysis to correlate rainfall failure and ground water regime can be done by taking into account the well abstraction data, which has not been done in the present case due to non-availability of relevant data.

5.0 ANALYSIS OF RESERVOIR STORAGE

In order to see the impact of failure of monsoon on storage reservoirs, an attempt has been made to compare the storages in Srisailam and Nagarjunasagar of the state of Andhra Pradesh. For this purpose, the live storages & corresponding reservoir level in some selected months have been plotted against time. The weekly reservoir level data as supplied by Central Water Commission(CWC) from 1984 till 1987, have been used for this analysis. Fig 5.1 shows the position of storages during 1984 to 1987 in the reservoirs. The following inferences which can be drawn from the figure 5.1 are as below:

It can be seen from Fig.5.1 that in case of Sri Sailam reservoir the pre and post monsoon storages were least in year 1987 as compared to previous two years. In case of Nagarjunasagar the storages in the month of May and August were minimum during year 1987 as compared to years 1985 and '86. However, the storage by the end of Nov.in 1987 was better than year 1986. Keeping in view the storage position, the drought impacts in 1987 were more or less similar in 1986 and 1987 with few exceptions.

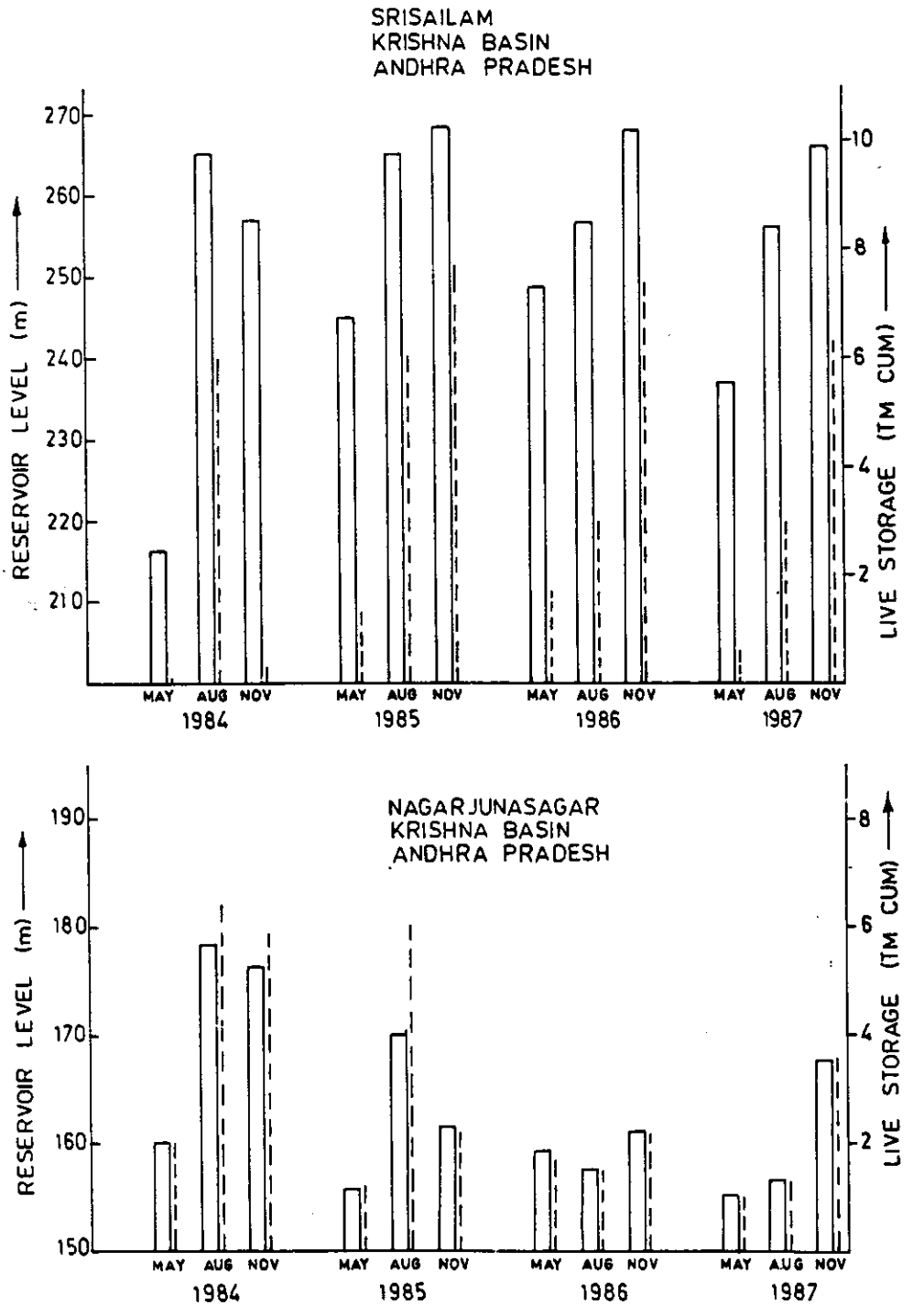


FIG. 5.1 - RESERVOIR LEVELS AND STORAGES FOR SRI SAILAM, NAGARJUNASAGAR RESERVOIRS

6.0 CONCLUSIONS AND RECOMMENDATIONS

1. The present report presents monthly/daily and seasonal data for six selected districts in the state of Andhra Pradesh with the objective to find out deficiencies in the rainfall (monthly and seasonal) in order to classify drought conditions. The data have been collected by undertaking field trips from various government organisations.

2. The analysis of rainfall data on seasonal basis indicate that in general seasonal rainfall departure of about 10% has been experienced barring the districts of Kurnool, Prakasam and Mahbubnagar. The pattern of seasonal rainfall deficiency has been more or less similar in the case of Cuddapah and Anantpur district which are adjoining. The deficiency pattern in case of Kurnool and Mahbubnagar has also matched to some extent while districts Prakasam and Chittoor show a very indefinite pattern of seasonal deficiency.

3. The monthly rainfall departure for the water year 1987-88 in rainfall values were also worked out for all the six selected districts and the departure values were characterised in two ranges from 20-50% and more than 50%. The departure values indicate that most of the district lie in the monthly rainfall deficiency range of 20-50% deficiency in the monthly rainfall in September months. The monthly deficiency pattern has been found similar for districts of Kurnool and Cuddapah.

4. To work out probability of occurrence of annual rainfall at 75% level and occurrence of 75% of the normal rainfall for two taluks and district as a whole. The group range of 75% range of probability was worked out for all the six districts and it has been found that for the districts of Mahbubnagar,

Kurnool, Prakasam, and Cuddapah. the group range of rainfall is 600-700. The probability values of occurrence of 75% normal rainfall in the districts Anantpur, Cuddapah, Chittoor, Prakasam, Kurnool and Mahbubnagar are 82, 84, 87, 85, 87 and 83 respectively which are all above 80%, indicating that all the six districts can not be classified as drought prone districts based on the frequency analysis of rainfall as per IMD criteria.

5. Analysis of monthly rainfall data using Harbst' Approach has been carried out to identify the drought spells for which data of year 1951-87 have been used .It was observed that all the six districts except Chittoor fell under drought spells during year 1985-87. The districts of Cuddapah, Kurnool and Anantpur recorded similar spells of drought intensity and duration during 1984-87. In general, all the six districts recorded about 12 spells of drought since 1951 till 1987. The approach has yielded comparable results of drought analysis and has further scope of improvement taking into account the revision of monthly weightage factors keeping in view the agriculturally important months in the state.

6. Analysis of daily rainfall data for dry spell analysis has been carried out and duration of likely dry spells at 75% probability has been worked out. It was found that all the six selected taluks of six selected districts had 75% probability of having a dry spell of duration of 21-28 days except taluk Mahbubnagar of district Mahbubnagar which has 75% probability of having a dry spell of duration 14-21 days.

7. Ground water analysis has been done for the districts of A.P. state for evaluating the impacts of drought on ground water regime. The analysis was restricted to four districts namely Chittoor, Prakasam, Kurnool,& Mahbubnagar in view of non

availability of data of the year 1977-88 for the districts of Anantpur and Cuddapah. The analysis of ground water levels based on the water table fluctuation data of post 10-12 years has yielded in knowing the ground water level trends (Pre and Post) as a result of seasonal rainfall departure. In most cases the water table has been recorded falling and the rate of recharge was found lesser in 1987-88 as compared to previous year. The continuous decline in water table is certainly attributed to failure of monsoon due to which the draft of ground water also gets increased because of increase in demand. The rise in water table as found in some cases can be attributed to the positive ground water in balances created by surface water irrigation projects. Better analysis to correlate rainfall failure and ground water regime can be done by taking into account the well abstraction data,which has not been done in the present case due to non availability of relevant data.

8. In order to see the impacts of failure of monsoon on storages of the reservoirs, an attempt has been made to compare the storages in Srisailam and Nagarjunasagar reservoirs of the state of Andhra Pradesh. In case of Nagarjunasagar the storages in the month of May and August were minimum during year 1987 as compared to years 1985 and '86. However, the storage by the end of Nov.in 1987 was better than year 1986. Keeping in view the storage position, the drought impacts in 1987 were more or less similar in 1986 and 1987 with few exceptions.

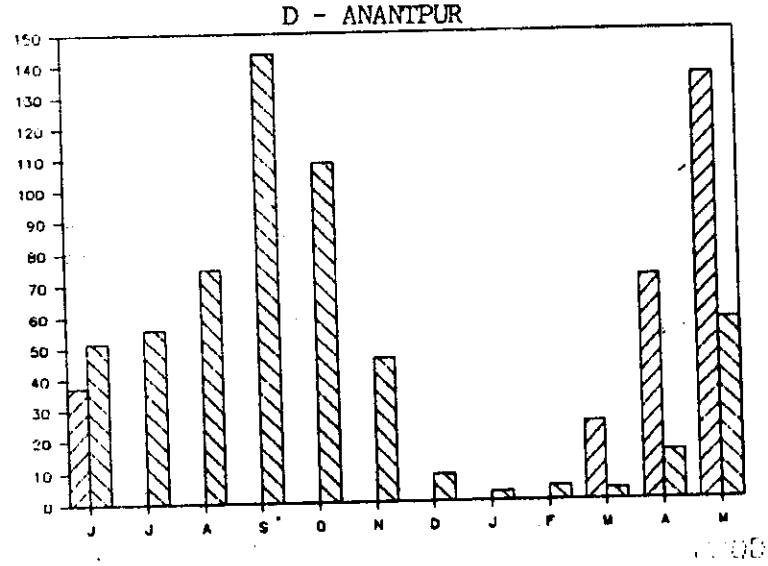
LIST OF OFFICES AND PLACES FROM WHERE DATA AND INFORMATION WERE COLLECTED

ANDHRA PRADESH

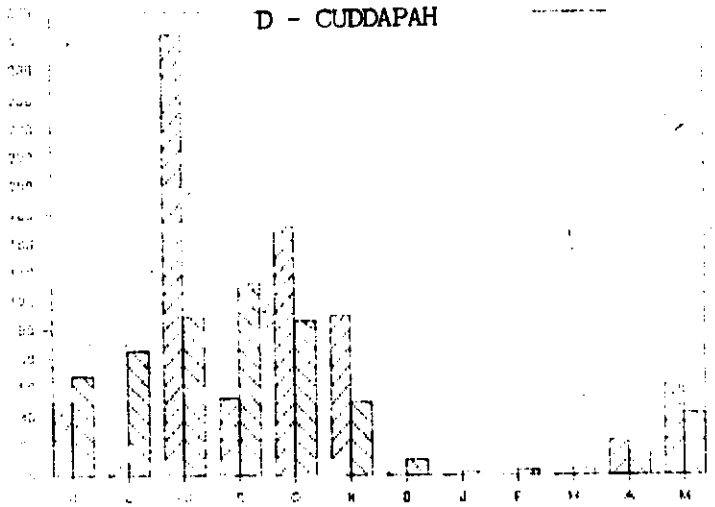
PLACE :	
Hyderabad	Irrigation Office, State Ground Water Board Office Bureau of Economics of Statistics Panchayat Raj and Rural Development Department of Agriculture C.W.C. P.H.E.D.
Mahaboobnagar	Irrigation Office Deputy Director,Agriculture Planning Office,
Prakasam	Irrigation Circle Office Deputy Director,Agriculture Dy.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

STATE - ANDHRA PRADESH

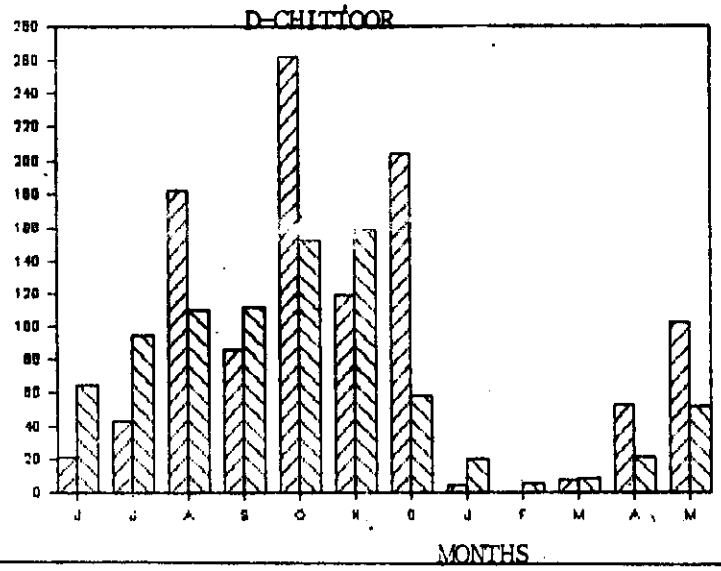
T–ANANTPUR
D - ANANTPUR



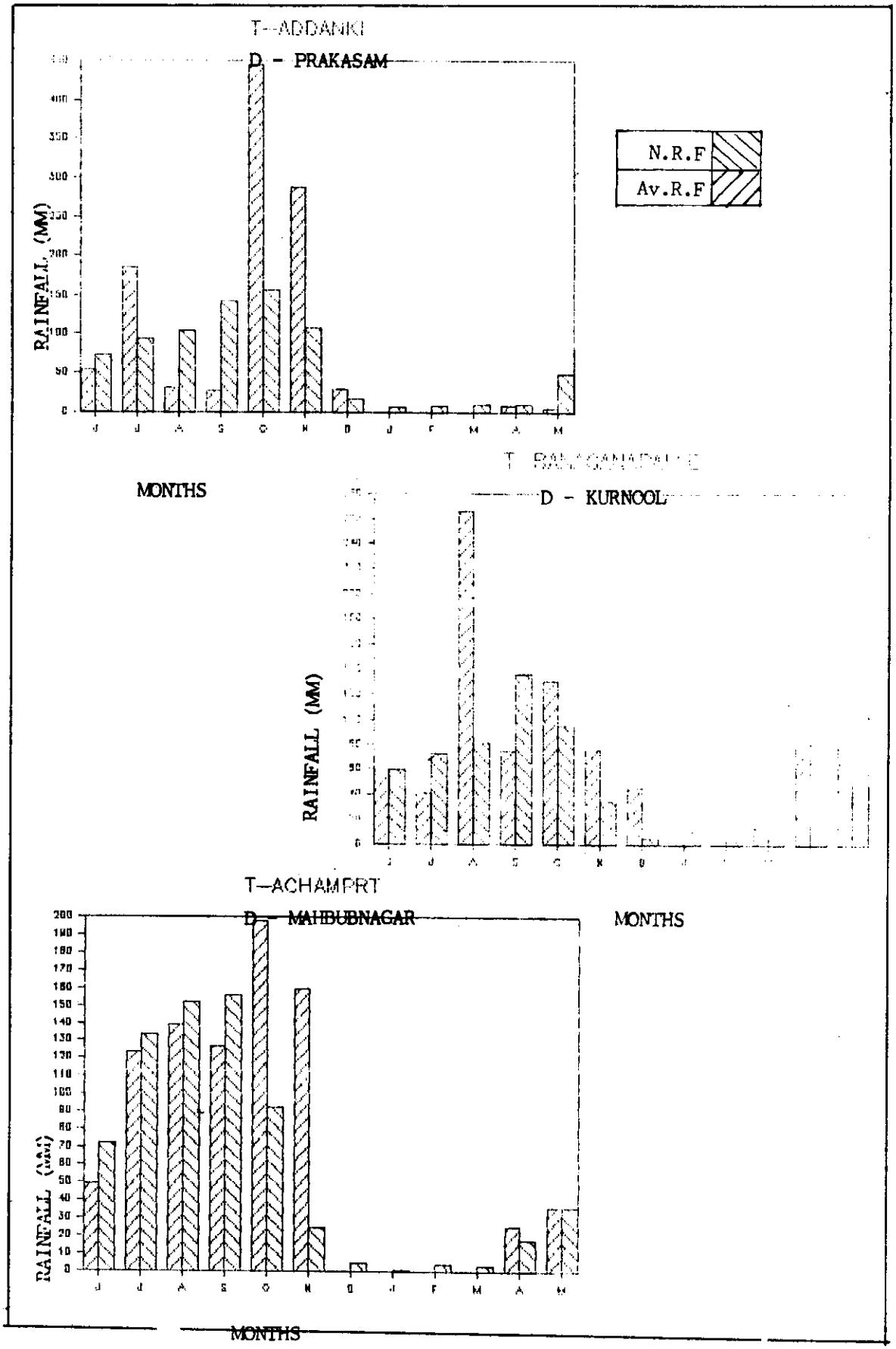
D - CUDDAPAH

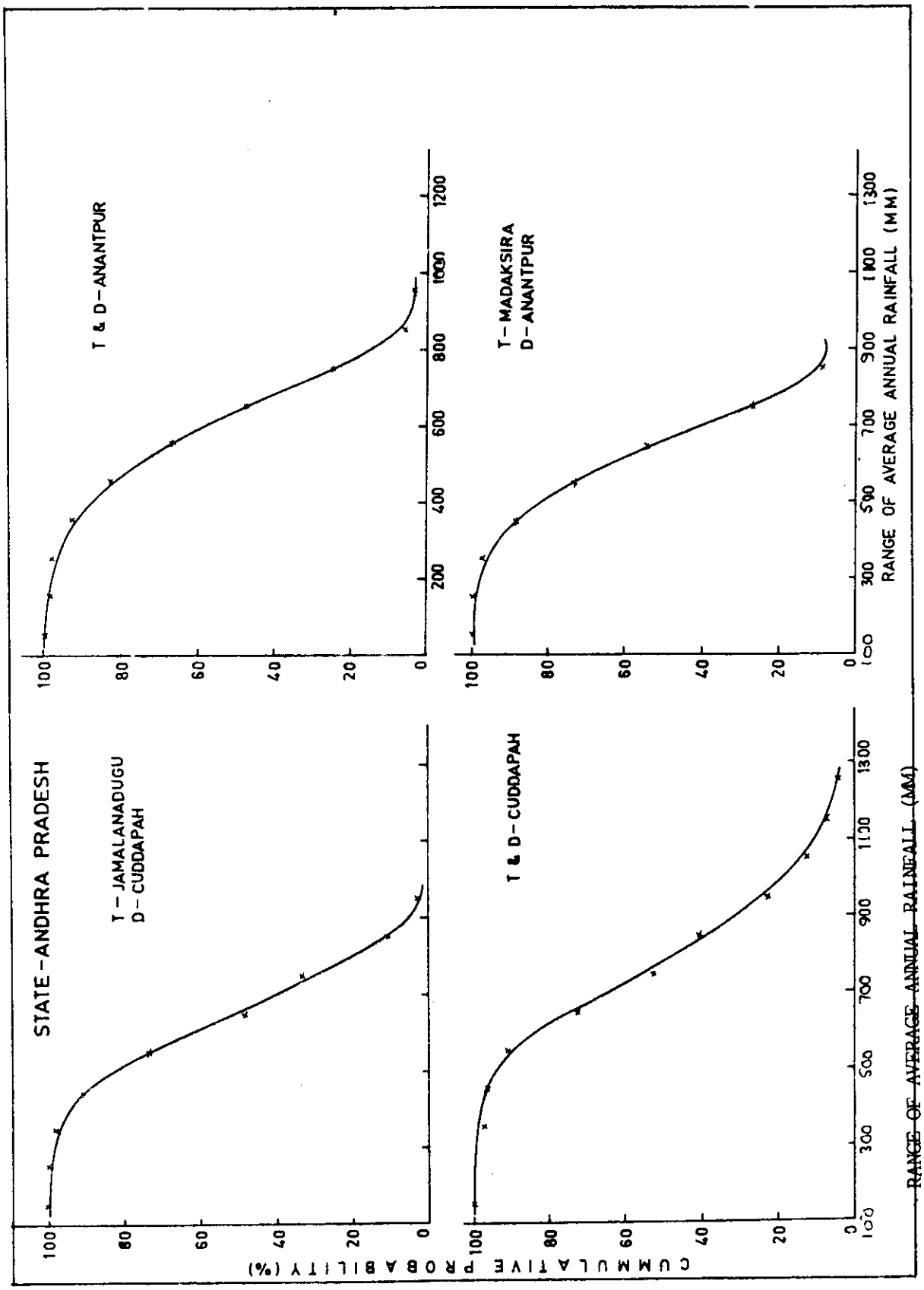


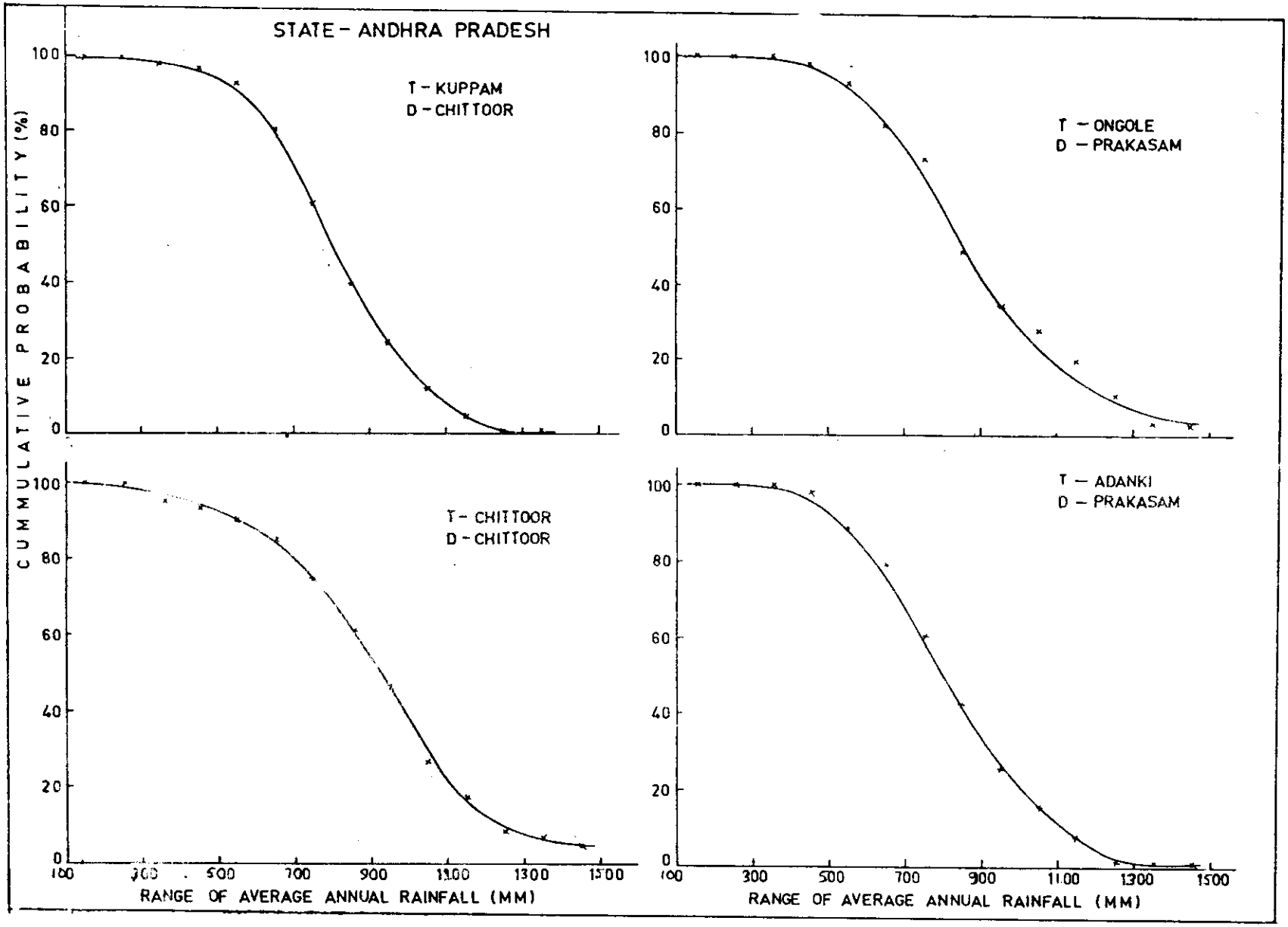
T–CHANDRAGIR
D-CHITTOOR

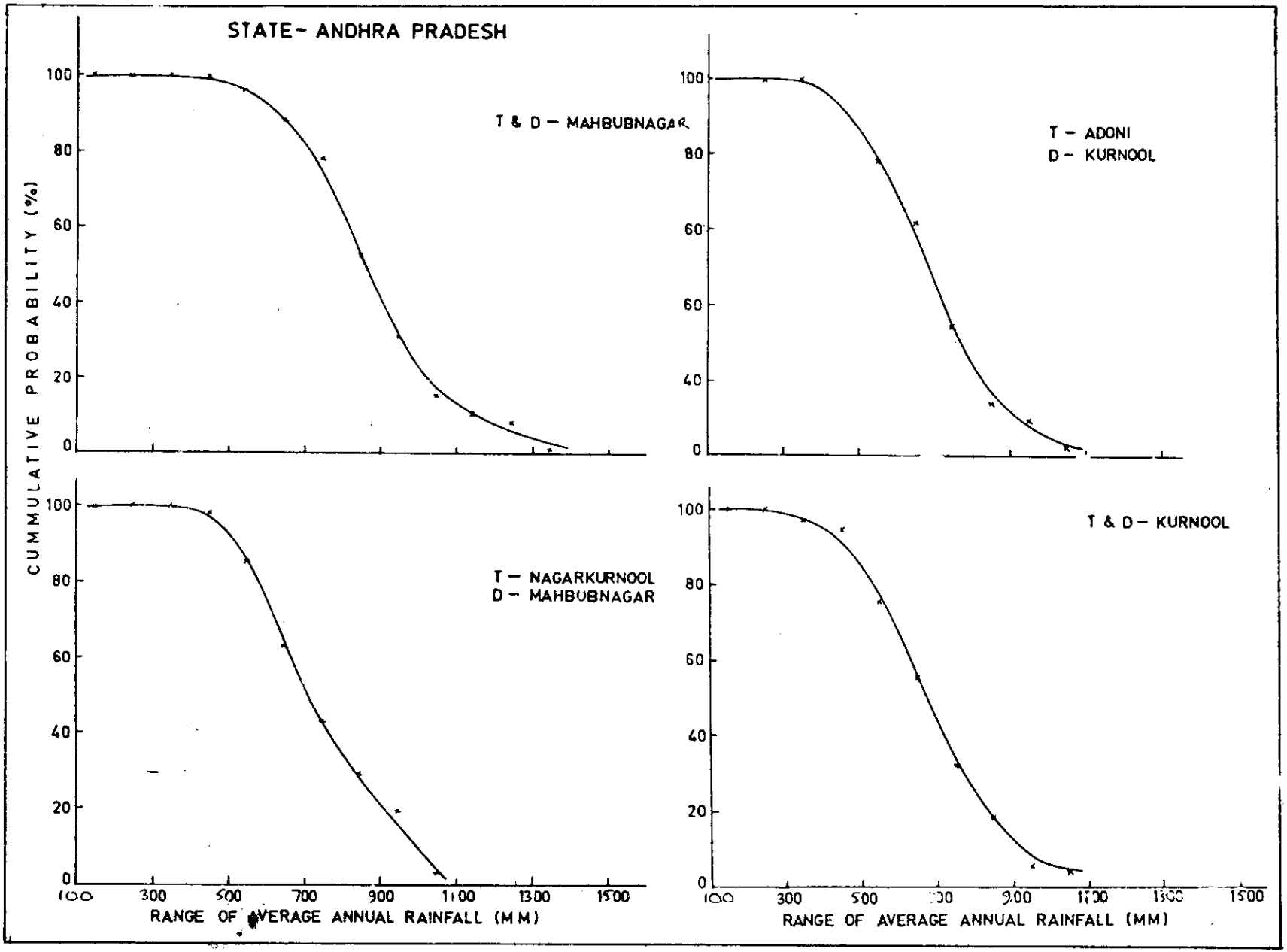


STATE - ANDHRA PRADESH




STATE-ANDHRA PRADESH
T - JAMALANADUGU
D - CUDDAPAH
T & D - ANANTPUR
T - MADAKSIRA
D - ANANTPUR
T & D - CUDDAPAH
CUMMULATIVE PROBABILITY (%)
RANGE OF AVERAGE ANNUAL RAINFALL (MM)


STATE - ANDHRA PRADESH
T - KUPPAM
D - CHITTOOR
T - ONGOLE
D - PRAKASAM
T - CHITTOOR
D - CHITTOOR
T - ADANKI
D - PRAKASAM
CUMMULATIVE PROBABILITY (%)
RANGE OF AVERAGE ANNUAL RAINFALL (MM)
RANGE OF AVERAGE ANNUAL RAINFALL (MM)
0
20
40
60
80
100
100
300
500
700
900
1100
1300
1500

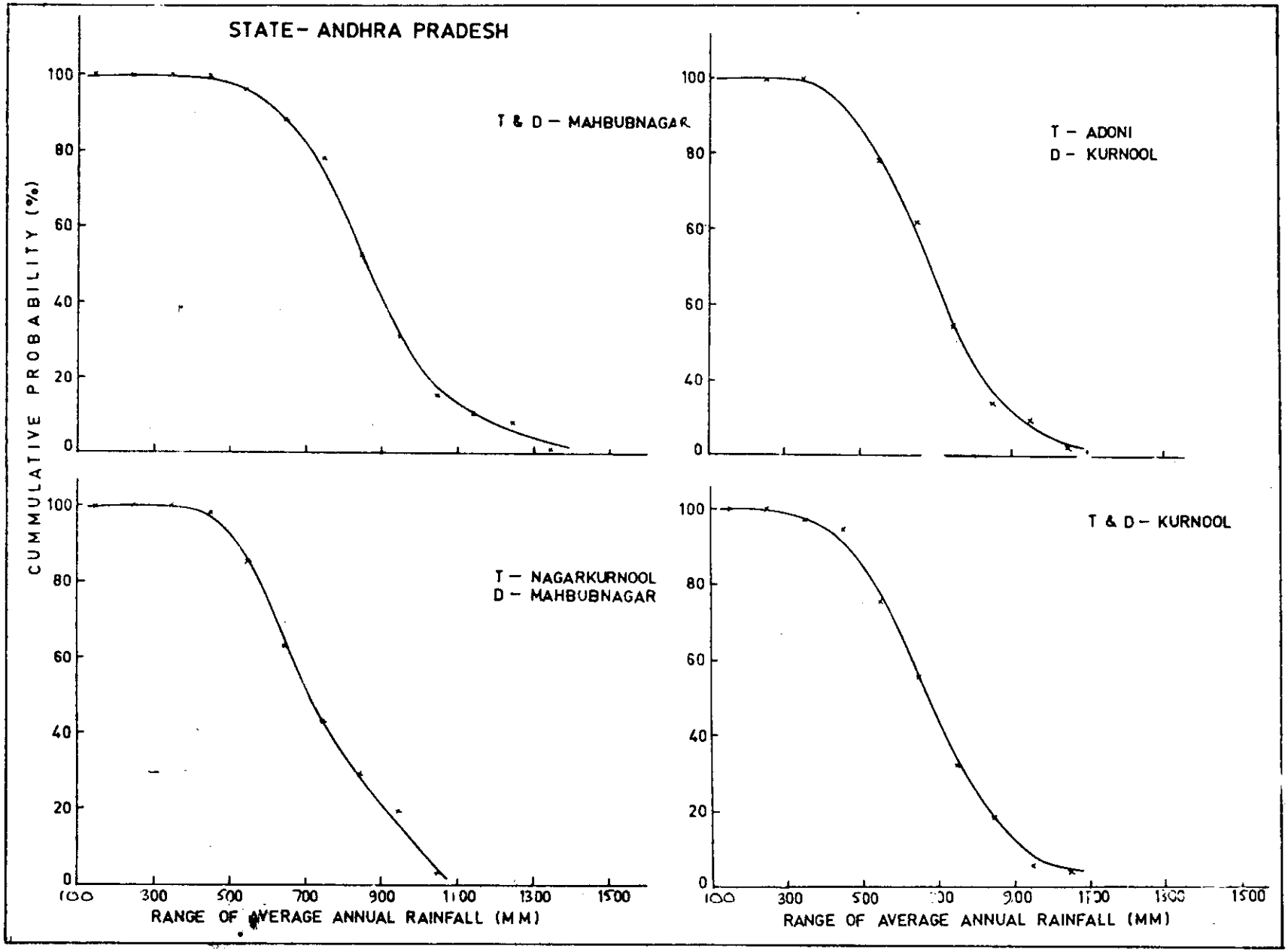

STATE- ANDHRA PRADESH
CUMMULATIVE PROBABILITY (%)
T & D – MAHBUBNAGAR
T – ADONI
D – KURNOOL
T – NAGARKURNOOL
D – MAHBUBNAGAR
T & D – KURNOOL
RANGE OF AVERAGE ANNUAL RAINFALL (MM)
RANGE OF AVERAGE ANNUAL RAINFALL (MM)

DROUGHT ANALYSIS FOR DISTRICT AS A WHOLE OF DISTRICT ANANTPUR

MONTHLY INTENSITY OF ACESS DEFICIT

MONTH / YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DE
1951	0.000	1.651	0.000	0.000	0.000	0.000	0.000	1.659	0.623	1.972	2.077	1.6
1952	[illegible]	0.000	[illegible]	0.[illegible]44	0.000	0.274	0.026	1.259	1.727	0.426	1.879	0.0
1953	[illegible]	[illegible]19	0.[illegible]95	0.000	1.747	0.000	0.000	0.923	0.000	0.000	0.000	0.6
1954	[illegible]	0.515	0.000	1.[illegible]3	0.000	1.001	0.000	0.000	3.195	0.000	1.655	0.0
1955	0.000	0.256	0.000	0.000	0.000	0.000	0.899	0.000	0.000	0.000	0.000	0.0
1956	[illegible]	0.000	[illegible]52	0.000	0.000	0.000	0.000	0.173	0.000	0.000	0.000	0.0
1957	0.000	0.000	0.[illegible]01	0.000	0.000	0.000	0.000	0.000	0.105	0.000	0.000	0.9
1958	0.[illegible]11	0.[illegible]01	0.[illegible]01	0.[illegible]0[illegible]	0.000	0.000	0.[illegible]24	0.000	0.000	0.000	0.000	0.0
1959	0.000	0.000	0.[illegible]74	0.[illegible]5[illegible]	0.000	0.000	0.000	0.000	0.000	0.000	0.966	0.0
1960	0.000	0.[illegible]43	[illegible]00[illegible]	0.000	0.525	1.752	0.000	0.000	0.000	0.896	0.000	0.5
1961	0.[illegible]6[illegible]	0.000	0.[illegible]00[illegible]	0.000	0.000	0.000	0.000	1.593	4.256	0.145	0.566	1.1
1962	0.[illegible]74	0.000	0.000	0.000	0.000	0.000	0.150	0.000	1.161	0.000	0.910	0.0
1963	0.000	0.[illegible]54	0.[illegible]62	0.000	0.000	1.[illegible]65	1.820	0.000	0.000	0.000	0.640	1.1
1964	0.773	0.555	0.707	1.[illegible]04	3.116	1.115	0.000	0.000	0.000	0.000	0.000	0.5
1965	0.[illegible]52	0.[illegible]17	0.000	0.000	1.[illegible]07	1.[illegible]26	1.456	0.000	0.751	3.870	0.971	0.0
1966	0.000	0.000	0.[illegible]45	0.[illegible]00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
1967	0.000	0.[illegible]33	0.000	0.[illegible]93	0.000	0.000	0.000	0.554	0.932	0.000	0.611	0.0
1968	0.[illegible]06	0.000	0.000	0.000	0.000	0.000	0.953	2.620	0.000	0.000	0.000	0.0
1969	0.000	0.[illegible]42	0.[illegible]97	0.[illegible]32	0.000	0.014	1.[illegible]75	0.000	1.738	0.000	0.762	0.9
1970	0.[illegible]00	0.[illegible]15	[illegible]05[illegible]	0.[illegible]0[illegible]	1.000	1.[illegible]50	0.751	0.[illegible]5[illegible]	0.000	0.000	0.000	0.7
1971	0.[illegible]43	0.[illegible]5[illegible]	0.000	0.000	0.[illegible]75	1.[illegible]2[illegible]	1.[illegible]50	0.000	0.000	0.000	0.669	0.7
1972	0.[illegible]52	0.[illegible]5[illegible]	0.[illegible]70[illegible]	0.[illegible]05	0.000	0.000	1.622	2.639	0.000	0.000	0.000	0.0
1973	0.000	0.[illegible]23	[illegible]0[illegible]5	1.[illegible]37	2.[illegible]77	0.000	0.000	0.000	0.000	0.000	0.000	0.0
1974	0.[illegible]3[illegible]	0.[illegible]0[illegible]	[illegible]21[illegible]	0.[illegible]0[illegible]	0.000	0.000	0.000	1.[illegible]15	0.000	0.000	0.705	1.1
1975	0.[illegible]11	0.[illegible]5[illegible]	0.000	0.[illegible]99[illegible]	0.[illegible]29	1.[illegible]96[illegible]	0.000	0.000	0.000	0.000	0.000	0.0
1976	0.[illegible]2[illegible]	[illegible]0[illegible]1	0.[illegible]0[illegible]	0.000	1.[illegible]7[illegible]	1.211	0.416	0.000	2.391	3.259	1.262	1.2
1977	0.[illegible]7[illegible]	0.[illegible]5[illegible]	[illegible]39[illegible]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
1978	0.[illegible]0[illegible]	0.[illegible]00	0.[illegible]0[illegible]	0.000	0.[illegible]72[illegible]	0.[illegible]7[illegible]	0.000	0.000	0.416	0.000	[illegible]47	0.0
1979	0.000	[illegible]000	0.000	1.[illegible]1[illegible]	0.[illegible]5[illegible]	0.[illegible]47[illegible]	0.000	0.000	[illegible]51[illegible]	0.000	0.000	0.0
1980	0.[illegible]0[illegible]	[illegible]47[illegible]	0.[illegible]00[illegible]	0.000	0.000	1.[illegible]75	0.[illegible]75	0.[illegible]32	1.[illegible]55	0.000	0.[illegible]1[illegible]	0.1
1981	0.[illegible]0[illegible]	[illegible]0[illegible]2	0.[illegible]70[illegible]	1.[illegible]44[illegible]	0.000	2.[illegible]1[illegible]	0.000	0.000	0.000	0.000	0.000	0.4
1982	0.[illegible]45	0.[illegible]2[illegible]	[illegible]70[illegible]	1.[illegible]6[illegible]	0.[illegible]0[illegible]	0.[illegible]0[illegible]	0.000	1.752	0.000	1.699	0.000	0.0
1983	0.000	0.[illegible]4[illegible]	[illegible]6[illegible]	1.[illegible]6[illegible]	0.000	0.000	0.[illegible]3[illegible]	0.000	0.000	0.000	[illegible]15	1.4
1984	0.[illegible]0[illegible]	[illegible]16[illegible]	0.[illegible]70[illegible]	1.[illegible]6[illegible]	2.[illegible]45[illegible]	2.[illegible]1[illegible]	0.000	1.[illegible]6[illegible]	0.[illegible]6[illegible]	0.[illegible]67	1.321	0.[illegible]
1985	0.[illegible]2[illegible]	0.[illegible]5[illegible]	[illegible]73[illegible]	1.[illegible]4[illegible]	0.[illegible]60	1.[illegible]4[illegible]	0.000	1.[illegible]5[illegible]	1.[illegible]7[illegible]	1.116	1.491	1.4
1986	[illegible]000	[illegible]0[illegible]	0.000	0.[illegible]1[illegible]	[illegible]2[illegible]	[illegible]0[illegible]	0.000	1.[illegible]45	0.[illegible]99	0.000	[illegible]71	0.2
1987	0.[illegible]5[illegible]	0.[illegible]51[illegible]	[illegible]70[illegible]	1.[illegible]4[illegible]	[illegible]5[illegible]	0.000	[illegible]5[illegible]	0.000	1.[illegible]0[illegible]	0.000	0.000	0.0

DROUGHT BEGAN		DROUGHT TERMINATED		DROUGHT DURATION	DROUGHT INTENSITY	SEVERITY INDEX
MONTH	YEAR	MONTH	YEAR			
5	1951	10	1953	[illegible]	[illegible]	22.17
7	1954	12	1954	6	[illegible]	[illegible]
7	1957	12	1958	17	[illegible]	14.55
11	1959	7	1960	9	[illegible]	11.[illegible]
10	1960	12	1961	15	[illegible]	15.93
6	1962	5	1963	13	[illegible]	7.12
12	1963	4	1964	17	[illegible]	24.13
6	1965	5	1966	12	0.75	13.31
6	1966	11	1966	6	3.90	3.60
10	1966	12	1967	51	0.92	46.92


STATE- ANDHRA PRADESH
CUMMULATIVE PROBABILITY (%)
T & D – MAHBUBNAGAR
T – ADONI
D – KURNOOL
T – NAGARKURNOOL
D – MAHBUBNAGAR
T & D – KURNOOL
RANGE OF AVERAGE ANNUAL RAINFALL (MM)
RANGE OF AVERAGE ANNUAL RAINFALL (MM)

DROUGHT ANALYSIS FOR DISTRICT AS A WHOLE OF DISTRICT CUDDAPAH

MONTHLY INTENSITY OF EXCESS DEFICIT

MONTH / YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DE
1951	0.000	0.437	0.000	0.000	0.000	0.629	0.822	2.356	1.478	1.459	0.432	1.3
1952	1.175	0.000	0.000	0.000	0.000	0.000	1.441	0.217	2.571	1.601	1.670	0.0
1953	0.000	0.000	0.479	0.000	1.557	1.525	0.000	1.531	0.289	0.000	0.697	1.3
1954	0.981	1.857	0.512	0.023	0.000	0.554	0.000	0.000	0.000	0.000	1.392	0.0
1955	0.000	0.067	0.000	0.575	0.000	0.000	0.000	0.000	0.310	0.483	0.354	0.0
1956	0.000	0.449	0.502	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
1957	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.765	2.460	1.280	1.5
1958	0.710	0.001	0.000	0.000	0.153	2.342	0.372	0.000	0.000	0.000	0.000	0.0
1959	0.000	0.000	0.452	0.000	0.000	0.000	0.000	0.000	0.490	1.631	1.663	0.9
1960	0.692	0.655	0.407	0.662	0.000	0.614	0.836	1.195	0.000	0.000	0.000	0.0
1961	0.000	0.000	0.210	1.139	0.029	0.000	0.000	0.000	1.554	0.181	0.000	1.0
1962	1.051	0.000	0.000	0.000	0.000	0.000	1.855	0.000	0.000	0.000	0.000	0.0
1963	0.000	0.000	0.245	0.000	0.961	0.000	0.000	0.000	0.000	0.000	1.359	0.0
1964	0.450	0.555	0.507	0.753	1.002	0.000	0.000	0.000	0.000	1.059	0.000	0.0
1965	0.000	0.545	0.000	0.000	0.252	1.528	0.000	0.000	0.000	2.529	2.191	0.0
1966	0.000	0.195	0.485	0.000	0.191	0.000	0.000	0.000	0.104	1.624	0.000	0.0
1967	0.000	0.000	0.000	0.108	0.000	0.000	0.000	0.257	0.000	0.000	1.007	0.0
1968	0.000	0.000	0.000	0.000	0.326	1.919	0.000	5.107	0.000	0.000	0.000	0.0
1969	0.000	0.532	0.413	0.910	0.000	0.000	0.000	0.000	2.234	0.000	0.000	0.0
1970	0.000	0.141	0.000	0.489	0.000	0.000	0.721	0.000	0.000	0.000	1.674	1.7
1971	1.455	0.000	0.000	0.000	0.000	0.799	1.666	0.110	1.717	0.371	1.990	1.1
1972	0.450	0.513	0.595	0.000	0.000	0.000	0.326	5.052	0.000	0.000	0.000	0.9
1973	0.000	0.000	0.473	1.097	0.452	1.303	0.000	0.000	0.000	0.000	0.000	1.0
1974	1.019	0.000	0.514	0.000	0.000	0.000	1.246	0.899	0.000	0.000	0.000	1.1
1975	1.067	0.695	0.000	0.969	0.752	1.095	0.000	0.000	0.000	0.000	0.000	0.0
1976	0.000	0.339	0.497	0.000	1.654	0.000	0.000	0.000	1.045	1.292	0.000	0.5
1977	0.750	0.000	0.511	0.000	0.000	0.000	0.000	0.000	1.269	0.000	0.000	0.2
1978	0.478	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.815	0.000	0.0
1979	0.000	0.000	0.114	0.367	0.000	0.000	2.549	0.000	0.000	1.039	0.000	0.0
1980	0.000	0.329	0.285	0.922	0.312	0.000	0.067	0.320	0.773	2.910	0.000	0.0
1981	0.652	0.514	0.000	1.135	1.044	0.063	0.210	0.000	0.000	0.000	0.666	1.3
1982	1.220	0.728	0.316	1.137	0.000	0.000	0.431	2.849	0.907	0.000	0.000	0.7
1983	0.755	0.542	0.514	1.134	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.1
1984	1.055	0.000	0.514	1.136	1.472	2.144	0.000	2.140	0.000	1.176	0.850	1.4
1985	1.055	0.733	0.514	1.137	1.789	0.532	0.000	0.920	2.211	0.000	0.000	1.0
1986	0.000	0.000	0.128	0.772	1.755	1.527	2.513	1.722	0.000	0.000	0.000	0.1
1987	0.582	0.561	0.000	0.550	1.919	1.347	2.738	0.000	1.170	0.000	0.000	0.0

DROUGHT BEGAN		DROUGHT TERMINATED		DROUGHT DURATION	DROUGHT INTENSITY	SEVERITY INDEX
MONTH	YEAR	MONTH	YEAR			
8	1951	7	1954	40	0.65	34.24
9	1957	7	1959	22	0.65	14.35
7	1959	5	1961	22	0.59	13.04
9	1961	8	1962	12	0.56	6.75
10	1962	12	1965	3	2.02	6.06
5	1966	11	1968	7	0.70	4.89
6	1971	4	1972	11	1.03	11.32
7	1972	10	1972	4	0.78	3.11
9	1976	5	1977	9	0.67	6.03
1	1980	9	1981	21	0.56	11.79
11	1981	10	1982	12	0.81	9.71
11	1982	12	1987	50	0.85	42.52

DROUGHT ANALYSIS FOR DISTRICT AS A WHOLE OF DISTRICT CHITTOOR

MONTHLY INTENSITY OF EXCESS DEFICIT

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DE
YEAR												
1951	0.3[illegible]	[illegible]	0.000	0.000	0.000	5.450	0.000	0.194	3.488	[illegible].167	1.772	[illegible].1
1952	1.717	[illegible]	[illegible]	[illegible].418	0.000	[illegible].000	0.153	0.427	5.262	[illegible].276	2.194	0.0
1953	0.000	0.000	[illegible]	0.000	1.577	0.000	0.000	0.068	0.000	0.000	0.000	1.5[illegible]
1954	0.000	0.264	0.000	1.130	0.000	1.676	0.000	3.030	0.000	0.000	1.599	0.0[illegible]
1955	0.000	0.000	[illegible].711	0.000	0.000	[illegible].[illegible]	0.000	0.238	0.000	0.000	1.521	0.0
1956	0.000	[illegible].451	[illegible].[illegible]	0.000	0.000	0.000	0.000	0.452	0.000	0.000	0.000	0.2[illegible]
1957	0.905	0.674	0.000	1.042	0.741	0.000	1.357	0.965	2.571	2.224	3.326	2.6[illegible]
1958	0.535	[illegible].001	[illegible].[illegible]	0.000	0.000	0.000	2.527	0.000	0.000	0.000	0.000	0.0
1959	0.[illegible]	0.000	[illegible].[illegible]	0.000	0.000	0.000	2.164	0.000	0.000	[illegible].966	0.000	0.[illegible]
1960	0.909	[illegible].[illegible]	[illegible].[illegible]	0.000	0.914	0.000	0.000	2.255	0.000	1.505	0.000	0.1[illegible]
1961	0.000	0.000	[illegible].595	1.[illegible]00	1.[illegible]50	0.000	0.000	0.000	0.000	0.000	0.006	1.2[illegible]
1962	[illegible].401	0.000	0.000	0.000	0.000	0.111	2.376	0.000	0.000	0.000	[illegible].740	0.0[illegible]
1963	0.000	[illegible].[illegible]22	[illegible].000	0.000	0.[illegible]47	[illegible].[illegible]09	0.374	0.460	0.453	0.000	0.000	0.0[illegible]
1964	0.[illegible]60	[illegible].[illegible]65	[illegible].[illegible]75	1.[illegible]30	1.[illegible]33	0.447	0.000	0.000	0.000	[illegible].471	0.000	0.2[illegible]
1965	0.[illegible]94	[illegible].[illegible]55	0.[illegible]47	0.000	1.[illegible]16	2.356	1.[illegible]93	0.000	0.42[illegible]	2.[illegible]40	0.263	0.0[illegible]
1966	0.000	[illegible].561	0.[illegible]62	1.[illegible]67	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
1967	0.000	[illegible].000	0.000	0.000	1.[illegible]45	0.000	0.000	2.[illegible]94	1.[illegible]83	1.503	0.475	0.0
1968	0.000	0.000	0.[illegible]27	0.000	1.151	1.[illegible]29	1.[illegible]89	2.[illegible]68	0.000	0.000	1.136	0.0
1969	0.000	[illegible].[illegible]33	0.[illegible]90	1.[illegible]85[illegible]	0.000	0.[illegible]07[illegible]	0.719	0.000	2.602	[illegible].000	0.000	0.0[illegible]
1970	0.160	0.000	[illegible].538	0.[illegible]97	0.000	0.000	0.000	0.000	0.000	0.000	0.215	1.7[illegible]
1971	0.000	0.000	[illegible].000	0.000	0.000	3.562	0.000	0.000	0.000	0.000	0.446	0.0[illegible]
1972	[illegible].000	[illegible].[illegible]57	[illegible].[illegible]72	0.[illegible]09	0.000	0.000	1.[illegible]70	2.[illegible]12	0.000	0.000	0.000	0.0[illegible]
1973	0.000	0.[illegible]21	[illegible].[illegible]34	1.[illegible]45	0.000	0.000	0.000	0.000	0.000	0.000	1.586	0.5[illegible]
1974	1.[illegible]12	[illegible].[illegible]66	[illegible].[illegible]47	[illegible].[illegible]29	0.000	0.075	0.000	0.[illegible]10	0.000	0.000	1.[illegible]76	2.0[illegible]
1975	1.[illegible]55	0.[illegible]00	[illegible].000	1.[illegible]44	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0[illegible]
1976	0.11[illegible]	[illegible].[illegible]35	[illegible].[illegible]77[illegible]	[illegible].[illegible]475	[illegible].[illegible]80[illegible]	1.[illegible]95[illegible]	0.000	0.000	1.153	[illegible].[illegible]98	0.000	0.5[illegible]
1977	1.021	[illegible].[illegible]13[illegible]	[illegible].[illegible]57[illegible]	0.000	0.000	0.000	[illegible].582	0.000	1.714	0.000	[illegible].000	0.5[illegible]
1978	1.[illegible]34	[illegible].[illegible]06	[illegible].[illegible]60[illegible]	0.000	0.000	[illegible].[illegible]56[illegible]	0.000	1.[illegible]05	0.000	1.345	0.000	0.0[illegible]
1979	0.000	0.000	[illegible].[illegible]40	1.[illegible]33	[illegible].505	0.000	0.000	0.000	0.000	1.[illegible]75	0.000	0.0[illegible]
1980	[illegible].[illegible]49	[illegible].[illegible]61[illegible]	[illegible].[illegible]00[illegible]	[illegible].[illegible]29	0.000	1.[illegible]49[illegible]	1.[illegible]29	0.000	2.[illegible]16	[illegible].[illegible]07	0.000	0.17
1981	[illegible].[illegible]55	[illegible].[illegible]90	[illegible].[illegible]00	0.000	0.000	0.000	[illegible].000	[illegible].000	0.000	0.000	[illegible].[illegible]44	0.0[illegible]
1982	[illegible].[illegible]21	[illegible].[illegible]42	[illegible].[illegible]27	[illegible].[illegible]43	[illegible].11[illegible]	[illegible].000	0.000	1.[illegible]75	0.000	1.[illegible]66	0.000	1.31
1983	1.[illegible]64	[illegible].[illegible]2[illegible]	[illegible].000	1.[illegible]4[illegible]	[illegible].000	[illegible].000	0.000	0.000	0.000	0.000	1.646	0.0[illegible]
1984	0.000	[illegible].000	[illegible].000	0.000	[illegible].[illegible]35	[illegible].[illegible]00[illegible]	0.000	1.[illegible]26	0.000	[illegible].000	0.000	0.0
1985	0.000	[illegible].[illegible]76	[illegible].000	0.[illegible]52	2.[illegible]25[illegible]	[illegible].000	0.000	0.000	0.000	0.000	[illegible].000	0.0[illegible]
1986	0.000	[illegible].000[illegible]	[illegible].[illegible]00	0.000	1.[illegible]77	1.[illegible]07[illegible]	[illegible].[illegible]18	[illegible].[illegible]35	0.000	0.000	[illegible].000	1.2
1987	1.[illegible]55	[illegible].[illegible]72[illegible]	[illegible].000	[illegible].000	[illegible].000	[illegible].000	0.000	[illegible].[illegible]97	0.000	[illegible].000	[illegible].000	0.0[illegible]

DROUGHT BEGAN		DROUGHT TERMINATED		DROUGHT DURATION	DROUGHT INTENSITY	SEVERITY INDEX
MONTH	YEAR	MONTH	YEAR			
6	1951	[illegible]	[illegible]952	12	1.50	18.01
7	1952	12	1952	[illegible]	1.[illegible]0	6.45
[illegible]	1954	12	1954	[illegible]	1.1	4.40
12	1955	[illegible]	1956	57	0.7[illegible]	43.[illegible]3
10	1964	12	1965	15	0.8[illegible]	13.25
[illegible]	1967	11	1968	[illegible]5	[illegible].41	22.5[illegible]
[illegible]	1975	[illegible]	1975	[illegible]9	[illegible].[illegible]	13.37
12	1977	11	1978	12	[illegible].[illegible]1	7.57
10	1979	[illegible]	1981	1[illegible]	0.77	13.89
11	1981	[illegible]	1985	[illegible]0	0.[illegible]0	10.0[illegible]

DROUGHT ANALYSIS FOR DISTRICT AS A WHOLE OF DISTRICT PRAKASAM

MONTHLY INTENSITY OF EXCESS DEFICIT

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
YEAR												
1951	0.150	0.000	0.000	0.000	0.000	0.000	0.000	1.805	1.086	2.658	2.134	1.61
1952	1.114	0.334	.17	1.714	0.000	0.252	2.625	2.134	2.666	0.163	2.542	0.0
1953	0.000	0.455	0.000	0.000	0.721	0.257	0.000	0.000	0.000	0.000	1.019	1.2
1954	0.451	0.937	0.000	1.241	0.783	2.061	0.000	0.000	0.000	0.000	0.000	0.0
1955	0.000	0.455	0.655	0.825	0.000	0.000	0.000	0.000	0.000	0.604	1.324	1.2
1956	0.277	0.935	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1957	0.000	0.459	0.277	0.111	0.522	0.000	0.000	0.000	0.000	0.815	1.313	1.3
1958	1.012	0.000	.277	0.145	0.000	1.423	0.000	0.000	0.000	0.000	0.000	0.34
1959	0.000	0.000	0.277	0.000	0.014	0.000	0.000	0.000	0.000	1.143	1.822	0.2
1960	0.555	0.000	0.000	0.750	0.000	0.001	0.000	0.956	0.000	1.351	0.000	0.5
1961	0.471	0.000	0.000	1.411	0.437	0.000	0.000	0.000	0.531	0.000	0.000	0.7
1962	0.721	0.000	0.000	0.000	0.000	0.433	1.642	0.000	0.699	0.000	0.000	0.0
1963	0.000	0.671	0.000	0.000	0.164	1.171	0.936	0.000	0.000	0.000	1.629	1.4
1964	1.045	0.916	0.916	0.727	0.627	0.537	0.000	0.000	0.000	0.000	0.000	0.61
1965	0.732	0.455	0.000	0.000	0.000	0.000	0.000	0.000	0.731	2.728	2.549	0.00
1966	0.000	0.000	0.771	0.364	0.000	1.219	0.000	0.000	0.000	0.678	0.000	0.00
1967	0.000	0.727	0.000	0.364	0.705	0.000	0.000	1.563	0.643	2.334	2.495	0.00
1968	0.000	0.221	0.000	0.000	0.509	0.397	2.770	2.933	0.000	1.654	0.105	0.00
1969	0.526	0.000	0.445	0.000	0.000	0.000	0.000	0.000	1.275	0.000	0.000	0.00
1970	0.000	0.000	0.000	0.000	0.000	0.000	0.045	0.000	0.329	0.079	1.174	0.4
1971	0.273	0.000	0.000	0.000	0.000	0.000	3.366	0.073	0.000	0.000	1.387	1.14
1972	0.768	0.000	0.617	0.273	0.701	0.000	1.704	2.998	1.404	0.000	0.000	0.00
1973	0.000	0.554	0.000	1.301	1.026	1.144	2.715	0.000	0.260	0.000	0.000	0.00
1974	0.273	0.504	0.395	0.000	0.286	0.000	0.000	1.230	0.000	0.000	0.000	0.71
1975	0.000	0.000	0.000	1.500	0.796	0.103	0.000	0.000	0.000	0.000	0.000	0.7
1976	0.795	1.050	0.611	0.049	1.726	1.627	0.000	0.000	0.000	1.224	0.000	0.00
1977	0.172	0.767	0.494	0.000	0.000	0.000	2.027	0.607	1.782	0.000	0.000	0.00
1978	0.000	0.000	0.494	0.000	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1979	0.000	0.000	0.000	1.342	0.000	0.000	0.000	0.655	0.000	1.607	0.000	0.0
1980	0.054	1.772	0.671	0.000	0.000	0.000	0.313	0.000	0.000	0.896	0.000	0.4
1981	0.000	0.457	0.000	0.501	0.226	2.355	0.000	0.000	0.000	0.000	0.164	0.9
1982	0.466	0.000	0.277	0.137	0.000	0.000	1.115	1.409	0.000	0.962	0.000	0.25
1983	0.297	0.000	0.160	0.479	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.17
1984	0.191	0.000	0.000	0.479	1.053	1.255	0.000	2.463	2.042	0.455	0.000	0.0
1985	0.000	0.000	0.000	1.153	0.890	0.000	0.000	0.176	0.448	0.000	0.289	0.00
1986	0.000	0.000	0.000	0.000	0.227	0.741	0.000	0.000	0.519	0.000	0.000	0.64
1987	0.770	0.871	0.000	0.446	0.205	0.429	0.000	1.347	2.426	0.000	0.000	0.00

DROUGHT BEGAN		DROUGHT TERMINATED		DROUGHT DURATION	DROUGHT INTENSITY	SEVERITY INDEX
MONTH	YEAR	MONTH	YEAR			
5	1951	12	1956	20	1.26	25.24
11	1952	7	1956	33	0.42	13.92
6	1957	8	1958	15	0.55	7.10
10	1959	8	1961	23	0.61	12.73
1	1963	7	1964	19	0.55	10.48
5	1965	12	1965	8	1.07	8.57
6	1967	5	1969	22	1.05	23.74
11	1971	10	1972	12	1.02	12.26
2	1973	10	1973	9	0.66	5.92
11	1951	7	1953	21	0.26	5.40
4	1954	12	1955	21	0.57	11.93
2	1987	12	1987	11	0.49	5.35

DROUGHT ANALYSIS FOR DISTRICT AS A WHOLE OF DISTRICT KURNOOL

MONTHLY INTENSITY OF EXCESS DEFICIT

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DE
YEAR												
1951	0.000	0.504	0.000	0.000	0.000	0.000	0.000	0.381	0.936	1.222	1.901	1.7
1952	0.140	0.134	0.735	1.615	0.000	0.000	1.342	1.607	2.166	0.398	1.712	0.00
1953	0.116	0.500	0.747	0.000	1.452	0.392	0.000	1.615	0.300	0.000	0.000	0.47
1954	0.000	0.436	0.515	0.133	1.544	1.078	0.000	0.000	0.223	0.162	1.644	0.14
1955	0.470	0.41	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.21
1956	0.000	0.000	0.736	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1957	0.000	0.554	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1958	0.000	0.000	0.000	0.000	0.000	0.423	0.000	0.000	0.000	0.000	0.000	0.00
1959	0.000	0.000	0.000	0.000	0.000	0.595	2.293	0.000	0.000	0.000	0.000	0.40
1960	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1961	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.249	1.696	1.12
1962	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1963	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.361	0.000	0.206	0.000	0.45
1964	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.167	0.000	0.195	0.72
1965	0.000	0.000	0.000	0.000	0.000	0.000	0.159	1.390	0.000	0.000	0.000	0.00
1966	0.000	0.000	0.000	0.000	0.217	0.000	1.120	0.000	0.000	0.000	0.967	0.94
1967	0.744	0.456	0.750	1.220	1.395	0.574	0.000	0.000	0.000	0.000	0.000	0.41
1968	0.535	1.114	0.753	1.192	1.713	0.000	0.000	0.000	0.000	2.447	1.526	1.16
1969	0.000	0.000	0.717	0.795	0.595	1.525	0.000	0.000	0.000	0.399	0.000	0.00
1970	0.000	0.361	0.000	0.000	1.024	0.325	0.000	0.083	0.000	0.976	1.650	0.00
1971	0.402	0.00	0.000	0.000	0.929	1.766	1.042	3.460	0.000	0.000	0.000	0.00
1972	0.301	0.403	0.237	1.225	0.000	0.000	0.000	0.000	1.605	0.202	0.000	0.00
1973	0.000	0.225	0.000	0.000	0.000	1.069	0.000	0.000	0.000	0.000	1.166	1.00
1974	0.782	0.457	0.000	0.111	0.000	0.000	2.484	0.000	2.069	0.000	0.460	0.80
1975	0.287	0.444	0.749	0.000	0.000	0.000	0.973	5.131	0.700	1.577	0.000	0.00
1976	0.000	0.259	0.742	1.542	1.592	1.159	1.722	0.000	0.000	0.000	0.000	0.64
1977	0.026	0.461	0.744	0.642	0.000	0.037	2.164	0.732	0.000	0.000	0.000	0.60
1978	0.611	0.440	0.000	1.518	0.000	2.054	0.000	0.000	0.000	0.000	0.000	0.00
1979	0.000	1.564	0.745	0.000	0.000	0.000	0.050	0.000	0.875	2.685	0.000	0.31
1980	0.497	0.428	0.742	0.000	0.000	0.000	0.000	0.000	1.662	0.000	0.000	0.00
1981	0.000	0.000	0.321	0.000	0.354	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1982	0.000	0.000	0.353	1.503	0.000	0.000	1.914	2.814	0.000	0.878	0.000	0.00
1983	0.000	0.375	0.000	0.000	1.297	0.000	0.000	0.738	0.202	3.313	0.763	0.00
1984	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.104	0.42
1985	0.241	1.457	1.718	0.000	0.000	0.000	0.000	0.646	0.689	0.000	0.000	0.00
1986	0.000	0.252	0.742	2.152	0.000	0.000	0.000	0.000	0.000	0.000	0.104	0.00
1987	0.000	0.251	0.000	0.914	0.762	0.612	0.000	1.250	1.726	0.000	1.291	0.23
1988	0.027	1.570	1.605	0.000	0.425	0.106	0.000	0.592	1.906	0.000	0.330	0.11
1989	0.000	0.000	0.501	0.000	1.122	0.775	1.665	1.646	0.789	1.741	0.000	0.00
1990	0.000	0.000	0.175	2.091	0.000	0.000	3.013	0.000	0.000	0.000	0.000	0.00

DROUGHT BEGAN		DROUGHT TERMINATED		DROUGHT DURATION	DROUGHT INTENSITY	SEVERITY INDEX
MONTH	YEAR	MONTH	YEAR			
6	1951	5	1952	10	0.85	8.45
7	1952	5	1955	33	0.71	23.99
5	1957	4	1958	10	1.17	11.77
10	1959	12	1964	51	0.61	31.09
11	1970	11	1972	25	0.98	24.49
11	1973	9	1974	11	0.57	6.27
1	1975	4	1977	16	0.58	9.34
7	1979	8	1981	26	0.76	19.74
11	1982	12	1987	50	0.74	36.94

DROUGHT ANALYSIS FOR DISTRICT AS A WHOLE OF DISTRICT MAHBUBNAGAR

MONTHLY INTENSITY OF EXCESS DEFICIT

MONTH / YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1951	2.401	1.759	1.057	1.595	1.5[illegible]	4.377	5.420	4.602	4.762	3.324	2.130	1.6[illegible]
1952	0.995	1.4[illegible]	0.501	1.4[illegible]	0.000	1.451	3.157	1.839	3.584	2.168	1.708	0.00
1953	0.000	0.555	0.[illegible]	0.572	1.465	1.10[illegible]	2.171	2.408	0.092	0.000	0.656	0.9[illegible]
1954	0.[illegible]	0.454	0.000	1.481	1.457	0.949	0.000	1.200	1.374	1.993	1.644	1.34
1955	0.[illegible]	0.459	0.000	1.[illegible]	0.942	1.629	1.561	0.000	1.302	1.594	1.447	1.27
1956	0.[illegible]	0.[illegible]	0.000	0.557	0.000	0.[illegible]	0.000	0.000	0.000	0.122	0.402	0.00
1957	0.[illegible]	0.[illegible]	0.561	0.000	0.000	0.000	0.000	0.000	0.000	1.207	1.539	1.1[illegible]
1958	0.[illegible]	0.000	0.000	0.000	0.000	0.411	0.000	0.000	0.000	0.000	0.000	0.3[illegible]
1959	0.[illegible]	0.[illegible]	0.[illegible]	1.509	0.412	0.001	0.000	0.000	0.303	0.000	0.621	0.91
1960	0.[illegible]	0.217	0.000	0.000	0.000	0.000	0.150	1.247	0.000	0.000	0.404	0.7[illegible]
1961	0.[illegible]	0.21[illegible]	0.[illegible]	1.[illegible]	0.000	0.000	0.000	0.000	0.565	0.000	0.000	0.5[illegible]
1962	0.[illegible]	0.000	0.000	0.000	0.000	0.000	0.759	0.000	0.000	0.000	0.000	0.0[illegible]
1963	0.000	0.000	0.[illegible]	0.000	0.000	0.000	0.000	0.000	0.361	0.000	0.176	0.[illegible]
1964	0.[illegible]	0.215	0.[illegible]	1.557	1.[illegible]	0.000	0.000	0.000	0.000	1.211	1.340	0.00
1965	0.[illegible]	0.[illegible]	0.[illegible]	1.557	1.497	0.000	0.000	0.000	0.000	0.781	0.000	0.00
1966	0.003	0.[illegible]	0.[illegible]	1.557	1.497	5.263	0.000	0.000	0.000	0.781	0.000	0.00
1967	0.000	0.[illegible]	0.[illegible]	0.000	0.[illegible]	0.000	0.000	0.000	0.000	1.012	1.275	0.5[illegible]
1968	0.000	0.000	0.000	0.000	0.000	1.230	0.000	1.749	0.195	0.000	0.000	0.00
1969	0.000	0.[illegible]	0.[illegible]	1.099	0.000	0.000	0.000	0.000	0.060	0.000	0.000	0.00
1970	0.000	0.[illegible]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.850	0.9[illegible]
1971	0.[illegible]	0.217	0.000	0.000	0.[illegible]	0.000	1.184	0.000	0.784	0.000	0.068	0.64
1972	0.299	0.007	0.[illegible]	0.000	0.471	0.000	0.920	3.226	2.066	0.443	0.000	0.00
1973	0.327	0.200	0.[illegible]	0.769	1.259	0.000	0.275	0.000	0.000	0.000	0.000	0.06
1974	0.121	0.204	0.000	0.000	0.000	0.000	0.854	0.000	0.000	0.000	0.000	0.0[illegible]
1975	0.000	0.000	0.000	0.490	0.512	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1976	0.000	0.192	0.157	0.000	0.000	1.705	0.091	0.000	0.000	1.266	0.000	0.00
1977	0.000	0.185	0.000	0.000	0.000	0.000	0.000	0.000	0.863	0.000	0.000	0.00
1978	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1979	0.000	0.000	0.000	0.650	0.000	0.000	0.000	2.256	0.000	0.050	0.000	0.00
1980	0.000	0.190	0.000	0.000	1.156	0.000	0.000	0.000	0.000	1.369	0.000	0.04
1981	0.000	0.000	0.000	0.000	0.000	0.000	0.046	0.000	0.000	0.000	0.281	0.7[illegible]
1982	0.563	0.[illegible]	0.[illegible]	0.000	0.000	0.000	0.000	0.[illegible]	0.000	0.000	0.000	0.00
1983	0.000	0.[illegible]	0.[illegible]	0.[illegible]	0.000	0.[illegible]	0.000	0.000	0.000	0.000	0.000	0.0[illegible]
1984	0.000	0.[illegible]	0.000	0.000	0.[illegible]	0.[illegible]	0.000	0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible]	0.51
1985	0.000	0.000	0.000	0.000	0.[illegible]	1.103	0.000	1.073	1.381	0.000	0.177	0.00
1986	0.000	0.000	0.000	0.000	1.154	0.000	1.055	1.416	1.165	1.074	0.000	0.00
1987	0.000	0.000	.[illegible]	0.[illegible]	0.[illegible]	1.[illegible]	0.629	0.000	0.284	0.000	0.[illegible]	0.00

DROUGHT BEGAN MONTH	DROUGHT BEGAN YEAR	DROUGHT TERMINATED MONTH	DROUGHT TERMINATED YEAR	DROUGHT DURATION	DROUGHT INTENSITY	SEVERITY INDEX
1	1951	7	1958	91	1.35	122.40
7	1960	5	1961	11	0.39	4.30
10	1966	5	1967	21	0.64	13.45
5	1955	10	1956	6	0.57	3.43
10	1970	9	1973	36	0.61	22.10
7	1979	4	1981	22	0.42	9.19
11	1955	12	1[illegible]	38	0.70	26.77

Duration and Number of Dry Spells during Monsoon (4th June to 15th Sept.)

ANANTPUR (ANANTPUR)

First day of monsoon	Date of beginning of dry spell	Duration of dry spells (2 weeks in days)	Total no. of dry spells in a year
1	2	3	4
2.8.81	4.6.81	59	2
	3.8.81	10	
15.6.82	27.7.82	15	2
	14.8.82	24	
5.6.83	26.6.83	15	1
11.7.84	4.6.84	37	4
	14.7.84	18	
	2.8.84	21	
	28.8.84	19	
6.6.85	7.6.85	44	2
	8.8.85	20	
4.6.86	15.6.86	18	3
	15.7.86	27	
	13.8.86	21	
24.6.87	4.6.87	20	3
	29.6.87	48	
	15.8.87	32	
			17

CUDDAPAH(CUDDAPAH)

1	2	3	4
27.6.81	4.6.81	23	3
	28.6.81	35	
	9.8.81	18	
18.6.82	18.6.82	20	3
	14.7.82	15	
	30.7.82	47	
5.6.83	nil	Nil	-
11.6.84	12.6.84	30	2
	3.8.84	29	
7.6.85	8.6.85	20	4
	30.6.85	20	
	20.7.85	10	
	28.8.85	19	
4.6.86	16.6.86	27	2
	14.7.86	17	
20.6.87	4.6.87	16	3
	21.6.87	44	
	18.8.87	29	
			17

ONGOLE (PRAKASAM)

1	2	3	4
20.6.81	‘.6.81	22	3
	1.7.81	33	
	5.8.81		
15.6.82	9.7.82	14	3
	27.7.82	15	
	14.8.82	24	
23.6.83	4.6.833	19	1
11.6.84	13.6.84	20	2
	25.7.844	48	
11.6.85	21.6.85	23	2
	8.8.85	15	
8.6.86	16.6.86	29	2
	30.8.86	14	
9.6.87	23.6.87	16	2
	16.8.8/	27	
			15

CHITTOOR (CHITTOOR)

1	2	3	4
6.1.81	4.7.81	16	1
8.6.82	9.6.82	22	2
	10.8.82	34	
8.6.83	13.6.83	41	1
18.6.84	4.6.84	14	4
	19.6.84	20	
	29.7.84	18	
	23.8.84	24	
5.6.85	6.6.85	18	1
4.6.86	5.6.86	21	2
	4.8.86	41	
21.6.87	4.6.87	17	3
	26.6.87	28	
	15.8.87	32*	
			14

KURNOOL (KURNOOL)

1	2	3	4
1.7.81	4.6.81	27	2
	2.7.81	25	
10.6.82	21.8.82	20	1
16.6.83	26.6.83	28	1
7.6.84	23.6.84	15	2
	2.8.84		
19.6.85	4.6.85	15	2
	20.6.85	16	
4.6.86	22.6.86	23	2
	13.8.86	27	
10.6.87	25.6.87	40	2
	17.8.87	17	
			12

MAHBUBNAGAR (MAHBOOBNAGAR)

1	2	3	4
8.6.81	1.7.81	31	2
	15.7.81	18	
18.6.82	4.6.82	14	2
	17.8.82	23	
5.6.83	13.6.83	19	2
	13.8.83	14	
11.6.84	10.8.84	32	1
7.6.85	7.7.85'	14	2
	15.8.85	24	
8.6.86	22.8.86	26	1
5.6.87	18.7.87	18	1
			11

Probability Analysis of Dry Spells

Taluk/Station (Distt.)	Class Interval (in day)	No. of Spells	Percentage	Cummulative Probability
Cuddapah	14-21	9	53.0	100.0
(Cuddapah)	22-28	2	11.8	47.1
	29-35	4	23.6	35.4
	> 35	2	11.8	11.8
		17		
Anantpur	14-21	10	58.8	100.0
(Anantpur)	22-28	2	11.8	41 2
	29-35	1	5.9	29.4
	> 35	4	23.5	23.5
		17		
Chittoor	14-21	7	50.0	100.0
Chittoor))	22-28	3	21.4	50.0
	29-35	2	14.3	28.6
	> 35	2	14.3	14.3
		14		
Ongole	14-21	7	46.7	100.0
(Prakasam)	22-28	5	33.3	53.3
	29-35	2	13.3	20.0
	> 35	1	6.6	6.6
		14		
Kurnool	14-21	5	41.7	100.0
(Kurnool)	22-28	5	41.7	58.4
	29-35	-	-	16.7
	> 35	2	16.7	16.7
		12		
Mahbubnagar	14-21	6	54.5	100.0
(Mahbubnagar)	22-28	3	27.3	45.5
	29-35	2	18.2	18.2
	> 35	-	-	-
		11		

SL. NO.	WELL NO.	LOCATION	LAT.	LONG.	ELEV. (m)	AREA INFLUENCED BY WELL(Sq.Km.)	WEIGHT
1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1577.[illegible]	[illegible]
3.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	119[illegible]	[illegible]
6.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SL. NO.	WELL NO.	LOCATION	LAT.	LONG.	ELEV. (m)	AREA INFLUENCED BY WELL(Sq.Km.)	WEIGHT
1.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2.	[illegible]	[illegible]	[illegible]	7 47 [illegible]	[illegible]	[illegible]	[illegible]
3.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]1.72	[illegible]
6.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]11.1[illegible]	[illegible]

LIST OF OBSERVATIONS

STATION-WISE PRICE DATA
DISTRICT-SUNGOL

SL. NO.	MKT. NO.	MKT. NAME	LAT.	LONG.	N.E.S.W. (P.P.C.T.C.E)	AREA INFLUENCED BY WELL(Sq.Kms.)	WEIGHT
1	1	[illegible]	15°00"	78°57"	+44.020		0.0915
2	4	[illegible]	15°01"	78°55"	+62.14		0.3499
3	14	[illegible]	15°00"	78°00"	+11.340		0.2711
4	15	[illegible]	15°02"	78°15"	[illegible]		0.1527

STATION-WISE PRICE DATA
DISTRICT-[illegible]

SL. NO.	MKT. NO.	MKT. NAME	LAT.	LONG.	N.E.S.W. (P.P.C.T.C.E)	AREA INFLUENCED BY WELL(Sq.Kms.)	WEIGHT
1	3	[illegible]	15°01"	77°40"	[illegible]		[illegible]
2	12	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
3	6	[illegible]	[illegible]	77°[illegible]	[illegible]		[illegible]
4	13	[illegible]	[illegible]	77°37'24"	[illegible]		[illegible]
5	16	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
6	17	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
7	18	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
8	21	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
9	22	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
10	23	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

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