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DROUGHT IN A P IMPACTS AND ADAPTIONS STRATEGIES WITH REFERENCE TO THE ALL MANDALS OF PRAKASAM DISTRICT BASED ON 2011 AGRICULTURAL YEAR

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1. OBJECTIVE OF THE STUDY

The Department of Planning, with the technical help of CRIDA, has also developed, as part of preparing a drought management plan, a real-time decision support system to forecast, and warn the farmers about, the likely upcoming drought and suggest actions such as cropping patterns, to mitigate these impacts. Research institutions, such as ICRISAT and the Agricultural University, have been conducting extensive research on drought resistant crops, appropriate agricultural strategies in drought prone regions and the socio-economic impact of drought in select rural communities. Among these districts in this project I have taken Prakasam District.

In Prakasam District Agriculture operations in Kharif season depends largely on South-West monsoon rains only in Prakasam District. Most of the area cultivated in Kharif is Rain fed. During the present Kharif season (South-west monsoon), 277.8 mm rainfall received as against the normal rainfall of 388.3 mm. The deficit rainfall is -28.5%. Agriculture and its allied sectors are the main source of income of the people in the District. In the south-west monsoon, 20 average rainy days recorded as against 28 normal rainy days. The rainfall received is not wide spread and only scattered. Prolonged dry spells i.e., 21 to 58 days have been continued in the most of the Mandals. Out of 56 Mandals in the District, scanty rainfall was recorded in 4 Mandals, deficit rainfall recorded in 36 Mandals and normal rainfall recorded in 14 Mandals.

GENERAL DESCRIPTION OF THE DISTRICT

1.2 INTRODUCTION

Ongole district was formed in the year 1970 by the amalgamation of backward areas of erstwhile Guntur, Nellore and Kurnool districts with head quarters at Ongole. Ongole district was later re-named as Prakasam district in the honor of great freedom fighter, Sri. T. Prakasam pantulu.

Administrative divisions and planning unit

Prakasam district is divided into 56 mandals and 1041 gram panchayats. The area of a mandal ranges between 15000 and 25000 ha after excluding forest area and non-agricultural land and a gram panchayat, on an average, extends over 1000 ha.

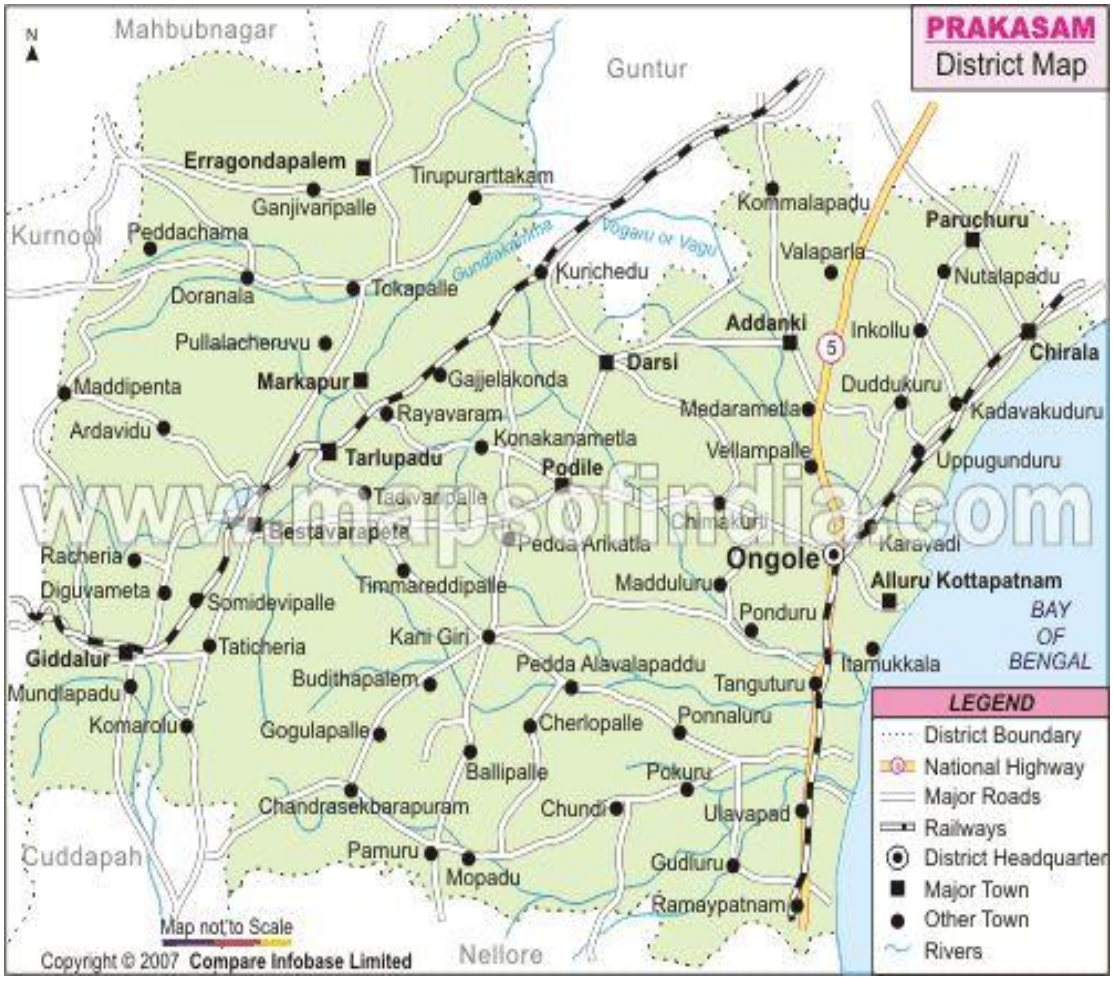
The 56 mandals in the district are listed below:

1	Ongole	21	Tallur	41	Komarole
2	Kothapatnam	22	Mundlamur	42	Kanigiri
3	Tangutur	23	Darsi	43	Pamur
4	Chimakurthy	24	Podili	44	Veligandla
5	S.N.Padu	25	K.K.Mitla	45	H.M.Padu
6	Chirala	26	Kurichedu	46	C.S.Puram
7	Vetapalem	27	Donakonda	47	P.C.Palli
8	Chinaganjam	28	Marripudi	48	Kandukur
9	N.G.Padu	29	Y.Palem	49	Ponnalur
10	Parchur	30	Dornala	50	V.V.Palem
11	Inkollu	31	Tripuranthakam	51	Gudlur
12	Karamchedu	32	Pullalacheruvu	52	L.Samudram
13	Yaddanapudi	33	Markapur	53	S.Konda
14	Martur	34	Tarlupadu	54	Ulavapadu
15	J.Pangulur	35	Peddaraveedu	55	Zarugumalli
16	Santhamagulur	36	Cumbum	56	Kondepi
17	Ballikurava	37	Ardhaveedu		
18	Addanki	38	Giddalur		
19	Korisapadu	39	Racherla		
20	Maddipadu	40	B.Peta		

These 56 mandals are aggregated in to 12 ADA circles.Since the gram panchayat is too small a unit to be considered as a planning and monitoring unit, the next unit in hierarchy i.e. mandal has been considered as the

planning unit for various agricultural and allied activities. Therefore, in this report, constraints, strategies and schemes relevant to each mandal have been worked out and are aggregated at ADA circle level for reporting purpose. An ADA circle comprises of three to six mandals and is akin to a taluk in other states in terms of geographical coverage. The data are finally aggregated at the district level.

2. DISTRICT MAP



2.1GENERAL STATISTICS

There are 1093 revenue villages in Prakasam district and they are organized in to 1043 gram panchayats.. Ongole and chirala ADA circles have the highest population, while Purchur and Singaraya Konda ADA circles have the lowest population. The scheduled caste population is concentrated more in Ongole, Addanki and Darsi ADA circles. The scheduled tribe population is concentrated more in Yerragonda palem and Chirala ADA circles . In 2011 census, Prakasam district had population of 3,397,448 of which male and female were 1,714,764 and

1,682,684 respectively. In 2001 census, Prakasam had a population of 3,059,423 of which males were 1,552,332 and remaining 1,507,091 were females.. There was change of 11.05 percent in the population compared to population as per 2001. In the previous census of India 2001, Prakasam District recorded increase of 10.88 percent to its population compared to 1991.

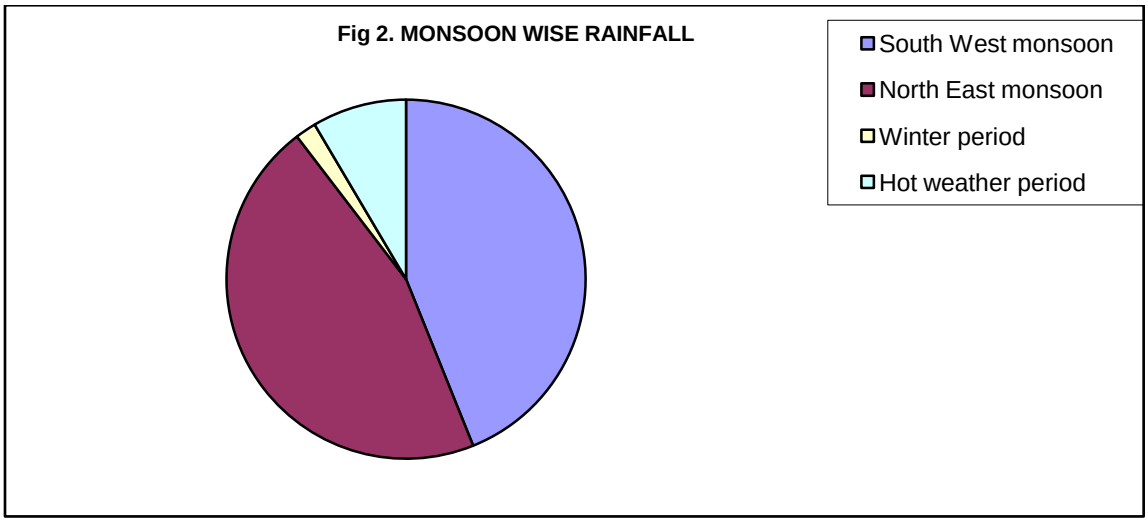
2.2 DISTRICT AT A GLANCE

2.2.1 Location and geographical units

The district lies between $14.57^{0'}$ and $16.17^{0'}$ northern latitude and $78.43^{0'}$ and $80.25^{0'}$ eastern longitude. The district is bounded by Bay of Bengal in the east, Nellore and Kadapa districts in the south, Kurnool district in the west and Guntur and Mahabubnagar districts in the North. The district comprises of three revenue divisions with 56 mandals. It has 1092 revenue villages and is organized in to 12 agricultural sub-divisions. The district is having 102 km long coastline spanning over eleven mandals.

Rainfall

The rainfall of the district is influenced by both the south-west and north-east monsoons. Total normal rainfall of the district is 871.5 mm. The contribution from south west monsoon (June - Sept) is 388.3 mm and from north east monsoon (Oct-Dec) is 393.0 mm. The remaining rainfall of 89.5 mm is received in winter season (17.0 mm) and in hot summer period (73.2 mm) .



Drought is a common phenomenon in the district due to scanty and uneven rainfall in the monsoon seasons (south west & north east monsoon)

Dry Spells

During South-west monsoon period, dry spells recorded in 45 Mandals. Out of which Severe Dry spell (43 Days and above) recorded in 1 Mandal, Moderate Dry Spells (29 to 42 Days) in 16 Mandals and Mild Dry spells (21 to 28 Days) in 30 Mandals recorded. Due to these dry spells the crops like Redgram, Cotton, Chillies, Paddy, Groundnut etc. will suffer badly and Horticulture Crops like Sweet Orange, Batavia, Acid Lime etc, are also affected.

Crop Coverage

An extent of 1,87,439 Ha. area sown as against the Normal area of 2,33,580 Ha. which comes to 80%. Most of the area covered under Rain fed crops only. At present rain fed crops are in withering condition.

The predominant crops viz., Red gram (Ha.38,353), Cotton (54,083), Chilies (Ha.21,257) were cultivated in Prakasam District, which accounts 61% of the total Normal Area. The remaining 39% area sown in different crops during Kharif.

The present stage of the Cotton crop is Vegetative to picking stage and condition of the crop is stunted growth. The present sown crops viz., Bajra, Green gram, Red gram, Chilies and Vegetables are in withering stage and stunted growth.

Horticulture Crops

Horticulture is one of the thrust areas in the overall development of the Prakasam District. The major horticulture crops grown in the District are Sweet Orange, Mango, Sapota, Cashew, Papaya, Chilies and Vegetables. Depletion of water tables and drying of bore wells leading to dry-up of Sweet Orange gardens in upland area of the district.

Due to shortage of rainfall, discharge of water from Bore wells reduced in upland Mandals. Area under Vegetables particularly Tomato in upland areas is reduced to below 50% as against the normal area. 50% of Chilies crop grows under rain fed area, and growth of Chilies also effects adversely. The yield is expected to reduce in Sweet Orange, Acid Lime, Chilies and Vegetables above 50%. The Sweet Orange and Acid Lime gardens in upland mandals of the district started drying due to drying of bore wells.

2.3 TOPOGRAPHY AND AGRO-CLIMATIC CHARACTERISTICS

A) Rivers

Gundlakamma, Manneru, Musi and Paleru rivers flow through the district. The Gundlakamma river flows at an altitude of about 2,700 ft near Gundla Brahmeswaram of Nallamala forest. It enters the plains through the Cumbum gorge. It runs in north-east direction and touches Mundlamur, Addanki, Maddipadu and Ongole Mandals and falls into Bay of Bengal near Devarampadu of Ongole mandal. The important tributaries are Kandaleru, Chilamaleru and Dornapuvagu. The total length of the river is about 265 Km, out of which about 220 Km is in the district. The projects across this river are the Thippayapalem reservoir, Duvvaleru Project, Cumbum and Bhavanasi tanks.

The river Manneru in the Veligondas at Balupalli of C.S.Puram mandal flows through Nellore district and takes a turn at Pentrala of Lingasamudram mandal in this district. It flows a distance of 112 Km and falls into Bay of Bengal near Karedu of Ulavapadu mandal. The Dokkalavagu and Nerellavagu fall into this river. It feeds Mopadu reservoir, Rallapadu reservoir and V.R.Kota channel.

The river Musi flows near Dokkalasala in the Veligondas. It flows first in the eastern direction and then in southern direction through Markapur, Darsi, northern boarder of Podili, Kondepi, Tangutur and Kothapatnam mandals and falls into the Bay of Bengal near Madanur of Kothapatnam mandal. It is joined by Gajjaleru, Dondaleru and Atleru in its course and it feeds tanks in Podili and Konakanamitla mandals.

2.4 LAND USE PATTERN AND LAND HOLDINGS

The total geographical area of the district is 17.14 lakh ha.

Agrarian structure

Marginal and small farm category farmer together account for 79 per cent of the total land holdings, but their combined share in the land was only 44 per cent. 56 per cent of the land is owned by 21 per cent of the farmers belonging to medium and large farm categories.

2.5 IRRIGATION AND GROUND WATER

The area irrigated in Prakasam district is about 2.15 lakh ha, which represent 32% of the cultivable area. The details of area under different irrigation sources in the district are presented in table

IRRIGATION
MAJOR (NSP), MEDIUM AND MINOR IRRIGATION)

Irrigation Circle, Ongole is having Major (NSP) Medium (5 Projects) and Minor Irrigation (368 M.I.Tanks + 589 PR Tanks = 957 Tanks) with an ayacut of 4,29,747 Acres, 40,992 Acres and 1,36,532 Acres respectively in Prakasam District.

Major NSP

Jurisdiction	Covering Mandals	Villages	Ayacut in Acres
M.85/3 onwards & M.18/0 of ABC	25 Nos.	50	4,29,749

Medium Irrigation - 5 Nos.

Name of Project	Mandals	Villages	Ayacut in Acres
Rallapadu	7 Nos.	50	40992
Mopadu			
Cumbum tank			
P.B.Anicut			
V.R.Kota anicut			

Minor Irrigation

M.I.Tanks (368)	Entire Prakasam District	1,36,532 Acres
P.R.Tanks (589)		

Total ayacut in Prakasam District – 6,07,291 Acres

AYACUT DEVELOPED FOR THE LAST 2YEARS IN PRAKASAM DISTRICT

Major Irrigation NSP

	Wet	**I.D.**	**Total**	
I.P.created ayacut in Acres	180538	249209	429747	
Khariff 2009-10	158109	170146	328253	
Khariff 2010-11	169470	162915	332385	(late khariff)
As on 21-11-2011	107100	58630	165730	Transplantation in progress

Medium Irrigation (5 Nos.)

Sl. No.	**Name of Project**	**Registered ayacut**	**2009-10**	**2010-11**	**As on today**
1	Mopadu	8040	8040	9600	200
2	V.R.Kota	5555	6500	5000	--
3	P.B.Anicut	7262	6500	7000	--
4	Cumbum Tank	6944	3180	1400	--
5	Rallapadu	13191	13193	13191	5000
	Total	**40992**	**37411**	**36193**	**5200**

Note:- Transplantation is under progress

Minor Irrigation:- Transplantation is not yet started

MAJOR IRRIGATION (NSP)

Statement showing the number of water distressed villages in Prakasam District as on 21.11.2011.

Sl. No	Name of Mandal	Wet	I.D.	Total	No.of villages	Water supplied to the villages	Distressed villages
1	Addanki	16919	18617	35636	27	8	19
2	Ballikurava	7278	14043	21321	35	15	20
3	Chimakurthy	8637	25169	33806	45	16	29

4	Chinaganjam	2567	30	2597	3	0	3
5	Darsi	9196	21048	30244	58	7	51
6	Donakonda	878	53	931	7	3	4
7	Eddanapudi	1074	1718	2792	3	0	3
8	Inkollu	11360	11124	22484	18	6	12
9	J.Pangulur	8056	17820	25876	22	4	18
10	Karamchedu	12229	7838	20067	12	0	12
11	Koresapadu	2663	3760	6423	5	0	5
12	Kothapatnam	12797	--	12797	7	0	7
13	Kurichedu	1891	4482	6373	15	9	6
14	Maddipadu	6959	3510	9469	10	0	10
15	Martur	5532	13154	18686	37	0	37
16	Mundlamur	1360	30592	44272	37	13	24
17	N.G.Padu	948	--	948	3	0	3
18	Ongole	12490	4675	17165	18	0	18
19	Parchur	4459	3424	7883	6	2	4
20	Pullalacheruvu	1743	2148	3888	6	4	2
21	S.N.Padu	13387	16426	29813	43	11	32
22	S.Magulur	6622	9743	16365	19	8	11
23	Talluru	6937	17314	24251	28	10	18
24	Tangutur	7529	8037	15566	14	0	14
25	Tripuranthakam	7357	14671	22028	27	13	14
	Total	**180538**	**249209**	**429747**	**505**	**129**	**376**

MEDIUM IRRIGATION

No. of distressed villages in Prakasam District

Name of Project	Name of Mandal	Ayacut	No.of villages	Water supplied to the villages	Distressed villages
Rallapadu	1) Lingasamudram	6954.60	5	1	4
	2) Gudlur	6235.69	7	7	0
	Total	**13190.29**			
Mopadu	Pamur	12500	10	Nil	10

Cumbum Tank	1) Cumbum	5350	16	7	9
	2) B.Peta	1594	5	3	2
	Total	**6944**			
P.B.Anicut	1) Zarugumalli	1131	1	0	1
	2) S.Konda	6131	6	4	2
	Total	7262			
V.R.Kota anicut	Kandukur	5555	7	2	5
	Total	**40992**	**57**	**24**	**33**

Water storage in Major Irrigation Project

Sl. No.	*Irrigation Project*	*Full level (FRL)*	*Live storage (Mcft.)*			*Last Year (Mcft.)*
			Projected	*Today*	*%*	
1	*Ramatheertham Balancing Reservoir*	*85.34 Mts. 1514 Mcft.*	*78.00 Mts. 400 Mcft.*	*76.0 Mts. 349 Mcft.*	*87.25%*	*83.60 Mts. 1290 Mcft.*

Water storage in Medium Irrigation Project

Sl. No.	*Irrigation Project*	*Full level (FRL)*	*Live storage (Mcft.)*			*Last Year (Mcft.)*
			Projected	*Today*	*%*	
1	*Cumbum Tank*	*2800 Mcft.*	*800 Mcft.*	*NIL*	*NIL*	*1088 Mcft.*
2	*Rallapadu*	*1106 Mcft.*	*1106 mcft.*	*776 mcft.*	*70.16%*	*1106 Mcft.*
3	*Mopadu Reservoir*	*2092 Mcft.*	*126*	*123*	*97.60%*	*603 Mcft.*
4	*V.R.Kota Anicut*	*20.72 ft.*	*10 Mcft.*	*6 Mcft.*	*60%*	*10 Mcft.*
5	*P.B.Anicut*	*13.34 ft.*	*15 Mcft.*	*3 Mcft.*	*20%*	*15 Mcft.*

I submit that the following 38 mandals have been identified as eligible mandals for declaration of drought affected mandals as per the norms prescribed in drought manual.

			CATEGORY – B			CATEGORY - C	
Sl. No.	Mandal		Sl. No.	Mandal		Sl. No.	Mandal
1	S.Magulur		1	Chimakurthy		1	Ongole
2	Pamur		2	Addanki		2	Kothapatnam
3	Donakonda		3	Korisapadu		3	S.N.Padu
4	Tarlupadu		4	J.Pangulur		4	Kandukur
5	Markapur		5	Yaddanapudi		5	Gudlur
6	Pedaraveedu		6	Vetapalem		6	V.V.Palem
7	Y.Palem		7	Chinaganjam		7	Kondepi
8	Tripurantakam		8	Parchur		8	Lingasamudram
9	Pullalacheruvu		9	Inkollu			
10	Racherla		10	Ponnalur			
			11	Kanigiri			
			12	H.M.Padu			
			13	P.C.Palli			
			14	Konakanamitla			
			15	Marripudi			
			16	Darsi			
			17	Tallur			
			18	Mundlamur			
			19	Kurichedu			
			20	Dornala			

GROUND WATER LEVELS

The Ground water levels in the district depend up on the rainfall and Ground water exploitation. The water levels are being monitored through 56 Piezometer bore wells and 150 Observation open wells.

The monthly average water levels of the district from the month of October, 2010 to October, 2011 is

Water levels			Remarks
October, 2010 in Mts	October, 2011 in Mts	Fluctuations in Mts	
6.00	9.37	-3.38	Fall in water levels

The maximum water level is 42.0 m at Pullalacheruvu (V) & (M) which falls in Non-command and up land area. The minimum water level is 0.80 M at Parchur (V) & (M) which falls in command and coastal plain.

The net fall of ground water levels in the upland mandals is 4 to 17 m. The maximum water level at Tarlupadu mandal is 36.14 m during the month of October, 2011 and the minimum water level at Tripuranthakam mandal is 5.11 m.

The depletion of Ground water levels in the district is attributed to -26% of deficit rainfall during the water year 2011-12.

If the same weather conditions continuous, there is chance for further depletion of Ground water levels and leads to acute shortage of ground water for both drinking and irrigation purpose.

As per the GEC -2007 estimation out of 62 minor basins in the district, 06 basins fall in Over exploited category, 02 basins falls in Critical category, 07 in Semi critical category and remaining 47 basins falls in safe category.

As per AP WALTA 121 villages in the district are declared as over exploited villages where further ground water exploitation for irrigation is banned until the ground water conditions improves.

RURAL WATER SUPPLY

Status of Habitations

NSS	:	235
NC	:	0
PC1 (Up to 10 LPCD)	:	282
PC2 (10 to 20 LPCD)	:	423
PC3 (20 to 30 LPCD)	:	376
PC4 (30 to 40 LPCD)	:	315
FC (Above 40 LPCD)	:	711
Total	:	2342

Projects as on 18.11.2011

No. of ongoing works	:	16
Habs to be covered	:	805
Population to be covered (in lakhs)	:	7.74
Estimated Cost (Rs. In Crores)	:	240.40
Expenditure incurred (Rs. In Crores)	:	128.69

2.6ASSESSMENT OF ELIGIBILITY OF MANDALS FOR DECLARATION UNDER DROUGHT:

56 mandals are existing in the district are divided into three categories depending upon the annual average rainfall usually received.

Category –A: Annual Normal rainfall below 750 mm
(deficiency 15% and above)

Category –B: Annual Normal rainfall from 750 to 1000 mm
(deficiency 20% & above)

Category –C: Annual Normal rainfall above 1000 mm
(deficiency 25% and above)

The following four parameters have been prescribed for assessing the eligibility of a Mandal for declaration under drought affected Mandals.

1. 1st Parameter : Deficiency in rainfall(compulsory parameter)
2. 2nd Parameter : Compression or reduction in cropped area of 50% and above under all principal crops
3. 3rd Parameter : Reduction in crop yields of 50% and above.
4. 4th Parameter : Dry spells its impact on crop damages

Of the above 4 Parameters, 3 Parameters including rainfall parameter must be justified for a Mandal to become eligible for declaration of drought. Based on the above parameters, the Mandals eligible and ineligible for proposing them as drought Mandals in all three categories (Rainfall categories) are furnished in the annexure for kind perusal.

	sno.	**MANDAL**	Cate-gory	**Parameter-I**	**Parameter-II**	**Parameter-III**	**Parameter-IV**	**Identified as Drought affected Mandal for Declaration**
				Deficiency in rainfall (compulsory parameter)	**Compression or reduction in cropped area of 50% and above under all principal crops**	**Reduction in crop yields of 50% and above.**	**Dry spells its impact on crop damages**	
	1	ONGOLE(s17)	C	**Eligible**	**Eligible**	**Eligible**		**Eligible**
	2	TANGUTUR	C		**Eligible**	**Eligible**		
	3	KOTHAPATNAM(s01)	C	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	4	N.G.PADU	B		**Eligible**	**Eligible**	**Eligible**	
	5	CHIMAKURTHY(s16)	B	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	6	MADDIPAD	B		**Eligible**	**Eligible**	**Eligible**	

		U						
	7	S.N.PADU(s02)	C	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	8	ADDANKI	B	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	9	KORISAPADU(s15)	B	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	10	J.PANGALUR(s14)	B	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	11	BALLIKURAVA	B		**Eligible**	**Eligible**		
	12	S.MAGULUR	A	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	13	MARTUR	B		**Eligible**	**Eligible**		
	14	YADDANAPUDI(s13)	B	**Eligible**	**Eligible**	**Eligible**		**Eligible**
	15	CHIRALA	C		**Eligible**	**Eligible**	**Eligible**	
	16	VETAPALEM	B	**Eligible**	**Eligible**	**Eligible**		**Eligible**
	17	CHINAGANJAM(s12)	B	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	18	PARCHUR	B		**Eligible**	**Eligible**		
	19	INKOLLU	B	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	20	KARAMCHEDU	B		**Eligible**	**Eligible**		
	21	KANDUKUr	C	**Eligible**	**Eligible**	**Eligible**		**Eligible**
	22	GUDLUR(s3)	C	**Eligible**	**Eligible**	**Eligible**		**Eligible**
	23	V.V.PALEM(s04)	C	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	24	PONNALUR	B	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	25	KONDEP(s08)	C	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	26	ZARUGUMALLI(s09)	C		**Eligible**	**Eligible**		
	27	S.KONDA(s10)	C		**Eligible**	**Eligible**		
	28	ULAVAPADU	B		**Eligible**	**Eligible**		
	29	LINGASAMUDRAM(s07)	C	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	30	KANIGIRI	B	**Eligible**		**Eligible**	**Eligible**	**Eligible**

	31	H.M.PADU	B	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	32	PAMUR	A	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	33	VELIGANDLA	B			**Eligible**	**Eligible**	
	34	C.S.PURAM	B		**Eligible**	**Eligible**		
	35	P.C.PALLI	B	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	36	PODILI	B			**Eligible**	**Eligible**	
	37	K.K.MITLA	B	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	38	MARRIPUDI	B	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	39	DARSI	B	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	40	TALLUR	B	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	41	MUNDLAMUR	B	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	42	DONAKONDA	A	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	43	KURICHEDU	B	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	44	TARLUPADU	A	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	45	MARKAPUR	A	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	46	DORNALA	B	**Eligible**	**Eligible**	**Eligible**	**Eligible**	**Eligible**
	47	PEDARAVEEDU	A	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	48	Y.PALEM	A	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	49	TRIPURANTHAKAM	A	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	50	PULLALACHERUVU	A	**Eligible**		**Eligible**	**Eligible**	**Eligible**
	51	GIDDALUR	A		**Eligible**	**Eligible**		
	52	RACHERLA	A	**Eligible**		**Eligible**		
	53	KOMAROLE	A		**Eligible**	**Eligible**		
	54	B.PETA	B		**Eligible**	**Eligible**		
	55	CUMBUM	A			**Eligible**	**Eligible**	
	56	ARDHAVEEDU	A		**Eligible**	**Eligible**		
	Total		**37**	**34**	**56**	**37**	**36**	

3. METHODOLOGY

3.1 DISTRIBUTIONS

Three distributions are used in the fitting of the drought distribution. The first is exponential distribution that is known as a class of continuous probability distributions in probability theory and statistics with the following probability density function (pdf) and cumulative distribution function (cdf):

$$f(x) = \lambda e^{-\lambda x},\ x \geq 0,\ \lambda \geq 0 \qquad (1)$$

where λ is the rate parameter of the distribution .$F(x)= 1- e^{-\lambda x}$ (2)

Next is gamma distribution that is known as a two-parameter family of continuous probability distributions in probability theory and statistics with the following probability density function (pdf) and cumulative distribution function (cdf):

$f(x)= \frac{e^{-x} x^{\lambda-1}}{\Gamma(\lambda)}$, $x \geq 0, \lambda > 0$. where $\Gamma(\lambda) = \int_0^\infty e^{-x} x^{\lambda-1}$. (3)

The p.d.f. of gamma distribution with two parameters

$f(x)= \frac{a^{\lambda}}{\Gamma(\lambda)} e^{-ax} x^{\lambda-1}$, $x \geq 0, \lambda > 0$. (4)

Finally, weibull distribution that is known a continuous probability distribution in probability theory and statistics with the following probability density function (pdf) :

$$f(x;c,\alpha,\mu) = \frac{c}{\alpha}\left(\frac{x-\mu}{\alpha}\right)^{c-1} \exp\text{-}\left(\frac{x-\mu}{\alpha}\right)^{c-1} ;\ x>\mu, c>0. \qquad (5)$$

A drought threshold is an essential element in categorizing the drought events in drought analysis. Drought threshold is a constant demand where the droughts are defined as periods during which the discharge is below the threshold level. A threshold that applied commonly in monitoring rainfall and preparing drought alerts is at the seventieth percentile of the rainfall when the rainfall in a certain period is less than seventy percent of normal Precipitation.(Precipitation means the quantity of water falling to earth at a specific place with in specific period

of time)

In determining the threshold values, the data of rainfall amount are sorted in ascending order where the value at the seventy percent of the rainfall data is recognized as the seventieth percentile of the rainfall series, p70 which is then set as the threshold.

$$L = (PN)/100 \qquad (12)$$

where L is the number of measurements under the seventieth percentile, P=70 as the selected percentile and N is the total number of measurements in the data set. Therefore, the threshold is the L^{th} value of amount of rainfall.

3.2 MAXIMUM LIKELIHOOD ESTIMATION

Maximum likelihood estimation (MLE) is a general and popular statistical method in fitting a statistical model to data and estimating the parameters of the corresponding model that maximize the probability or likelihood of the sample data.

Suppose x is a continuous random variable with pdf $f(x;\theta_1,\theta_2,...,\theta_k)$ where $\theta_1,\theta_2,...,\theta_k$ are k unknown constant parameters which need to be estimated with an experiment conducted to obtain N independent observations, $x_1, x_2, ..., x_N$,

the estimation of parameters, $\hat{\theta}_1,\hat{\theta}_2,...,\hat{\theta}_k$ can be obtained by solving the differentiation of logarithmic likelihood function below:

$$\frac{d\sum_{i=1}^{N}\ln f(x_i;\theta_1,\theta_2,...,\theta_k)}{d\theta_j} = 0 \qquad (13)$$

where $j = 1,2,..., k$.

3.3 GOODNESS-OF-FIT TESTS

It is commonly applicable to verify the compatibility of a model and data by the statistical goodness-of-fit (GOF) tests. The GOF tests are applied in describing the fitness of a distribution to a set of observations. Measures of GOF typically summarize the discrepancy between observed values with the expected values under the specific

model selected.

The best fitted distribution will be determined based on the minimum error produced, which is measured by the techniques shown below:

(1) Akaike Information Criterion (AIC) is a method used for measuring the goodness-of-fit of an estimated statistical model that ranked based on the minimum error produced.

The formula of AIC is shown below:

$$AIC = 2k - 2\ln L \qquad (14)$$

where k is the number of parameters in the statistical model, and L is the maximized value of the likelihood function for the estimated model.

(2) Kolmogorov-Smirnov (KS) test is a form of minimum distance estimation that quantifies a distance between the empirical distribution function of the sample and the cumulative distribution function of the reference distribution.

The KS test statistic is defined as:

$$D = \max_{1 \le i \le N} \left(\left| F(x_i) - \frac{i-1}{N} \right|, \left| \frac{i}{N} - F(x_i) \right| \right)$$

where x_i is the increasing ordered data, F the theoretical distribution and N is the number of sample size.

3.4. RESULTS AND DISCUSSION

3.4.1 Descriptive Statistics

The descriptive statistics computed are mean, variance, standard deviation, coefficient of variation, skewness, kurtosis and the maximum rainfall amount for each station. The summary of the descriptive statistics for each station is shown in Table 2.

Table 2. The descriptive statistics of the daily rainfall amount in prakasam

Stations	Mean	Variance	Standard Deviation	Coefficient Variation	Skewness	Kurtosis	Maximum Amount
S01	7.0471	152.91	12.3660	1.7547	3.4581	21.560	137.5
S02	5.8803	107.68	10.3770	1.7647	3.4151	25.040	152.0
S03	6.1321	185.04	13.6030	2.2183	6.3572	73.591	234.8
S04	6.5637	161.12	12.6930	1.9339	4.9975	45.891	188.0
S05	6.8607	208.08	14.4250	2.1026	6.8322	85.481	261.0
S06	5.6709	243.81	15.6140	2.7534	9.2645	157.100	398.0
S07	5.5118	183.20	13.5350	2.4557	4.8424	38.444	189.5
S08	5.4471	175.09	13.2320	2.4293	5.2733	50.828	227.0
S09	7.1123	179.95	13.4140	1.8861	4.1730	32.092	172.0
S10	4.5302	69.67	8.3469	1.8425	3.8164	24.391	87.8
S11	7.0900	171.11	13.0810	1.8450	4.8445	43.850	183.7
S12	5.4008	156.12	12.4950	2.3135	4.7372	40.403	196.0
S13	5.5472	90.42	9.5091	1.7142	4.8446	64.779	204.7
S14	6.8804	199.74	14.1330	2.0541	6.1923	80.647	298.0
S15	6.0165	108.57	10.4200	1.7319	4.4725	45.706	193.3
S16	5.9719	136.67	11.6910	1.9576	7.5171	143.760	311.0
S17	5.4816	108.69	10.4250	1.9019	4.9849	55.252	205.3

From the summary, the mean or average of precipitation amount during the ten years period for all the stations lies between 4.50 mm per day and 7.20 mm per day with the highest mean value of 7.11 mm per day from S09 while the lowest mean of 4.53 mm per day from S10.

The variance for all the daily rain gauge stations is in the range of 69.60 mm^2 per day^2 to 243.90 mm^2 per day^2. The standard deviation for all the seventeen stations is ranged from 8.30 mm per day to 15.70 mm per day. S06 obtains the highest standard deviation with the value of 15.61 mm per day which indicates the large variation in the daily rainfall amount series while S10 receives the lowest standard deviation with the value of 8.35 mm per day which implies the small variation in the daily rainfall amount series. Furthermore, it is clear that the standard deviation for each station is always larger than the mean by referring to the fact that there are some effects caused by the extreme value to the large values in the raw data.

The coefficient of variations for the seventeen rain gauge stations will represent the irregularity of the daily precipitation between stations. However, the results of the coefficient of variation show that the values for each station are quite homogeneous where the range is between 1.70 and 2.80. S06 displays the highest value of coefficient of variation, which is 2.75 while S13 has the smallest value of coefficient of variation, which is 1.71.

The coefficient of skewness is used to verify the degree of asymmetric of a distribution around the mean. The values of skewness lie in between 3.40 and 9.30 where these positively results indicate that all the skewness are positively skewed for all stations. S06 receives the highest value of skewness with the value 9.26 which gives a clear indication that this station is very obviously skewed and the asymmetric tail is extending to the right while S02 with the smallest skewnes value of 3.42 indicates that the asymmetric tail is also extending to the right with less skewed.

The value of kurtosis can be used to determine the relative peakness or flatness of a distribution. The values of kurtosis are all positive in the range of 21.50 to 157.10. S06 obtains the highest value of kurtosis with the value 157.10 which implies the possibility of a leptokurtic distribution where the data set tend to have a distinct peak near to the mean with a heavy tail since the peak of distribution is too high around the mean. S01 receives the smallest value of kurtosis with the value 21.56 which indicates that the data set tend to have a flat peak near to the mean.

The maximum daily rainfall amount is ranged between 87.80 mm per day and 398.00 mm per day where S06 receives the highest maximum rainfall amount of 398.00 mm per day followed by S16 with the maximum rainfall amount of 311.00 mm per day. S10 on the other hand obtains the lowest maximum rainfall amount which is 87.80 mm per day.

3.4.2 Threshold

In finding the best fitted distribution to represent the drought events, it is essential to determine a threshold where the data fall below the corresponding threshold is categorized as drought and these data are used in the fitting of distribution. The threshold values for all the stations are shown in Table 3.

Table 3. The threshold values for each station

Station	Threshold
S01	13.2
S02	14.3
S03	16.3
S04	12.0
S05	13.0
S06	9.8
S07	11.5
S08	13.0
S09	14.7
S10	7.3
S11	9.8
S12	11.0
S13	10.5
S14	14.0
S15	10.8
S16	12.0
S17	10.0

3.4.3 Goodness-of-Fit Tests

The best fitted distribution can be verified using Goodness-of-Fit (GOF) tests. In this study, three types of GOF tests were applied, namely Akaike Information Criterion (AIC), Kolmogorov-Smirnov (KS) test and Cramer-von-Mises (CVM). By referring to the definition of Goodness-of-Fit (GOF) tests, the best fitted distribution was selected based on the minimum error produced. The results of the GOF tests were shown in Table 4.

Table 4. The results of three GOF tests for daily rainfall amount in Prakasam.

Station	AIC			KS		
	EXP	GAM	WBL	EXP	GAM	WBL
S01	7960.2	7884.9	7859.2	0.07787	0.06198	0.05949
S02	6895.3	6411.9	6353.4	0.19120	0.07673	0.07603
S03	6477.0	6389.8	6355.3	0.09439	0.07187	0.06349
S04	7655.7	7570.2	7550.1	0.07674	0.06658	0.06832
S05	7548.7	7498.4	7471.9	0.07848	0.06515	0.06265
S06	5733.3	5735.1	5734.9	0.11033	0.10661	0.10598
S07	5419.0	5414.8	5416.1	0.07817	0.09110	0.08949
S08	5590.2	5591.9	5592.2	0.10569	0.11010	0.10725
S09	7684.6	7542.8	7511.3	0.25071	0.07525	0.06324
S10	6491.4	6393.1	6362.7	0.09052	0.06713	0.06175
S11	5849.8	5565.0	5501.9	0.16040	0.08455	0.06363
S12	5629.6	5605.9	5612.3	0.11063	0.11242	0.10793
S13	7421.7	7321.2	7292.6	0.08733	0.06568	0.06322
S14	7435.5	7266.1	7244.3	0.09930	0.07411	0.07240
S15	7711.2	7579.6	7523.6	0.11636	0.07236	0.06430
S16	7276.2	7077.7	7030.3	0.12547	0.07248	0.06557
S17	7055.0	6946.9	6918.2	0.09789	0.07122	0.06884

Table 4 shows the results of the three GOF tests for daily rainfall amount in Prakasam. The best fitted distribution is selected according to the minimum error produced.

From the results displayed above, many stations have resulted in weibull distribution to be the best fitted distribution to represent the drought event. Further, by using either the AIC, KS , it is found that weibull is still the distribution having the most minimum error .Therefore, weibull distribution is ranked first as the best fitted distribution in representing the drought events in Prakasam while gamma distribution is ranked second and exponential distribution is ranked last using all the results of GOF tests for each rain gauge station. Hence,

weibull distribution is the most appropriate distribution to represent the drought event in Prakasam.

3.5. CONCLUSIONS

The fitting of the most appropriate distribution to characterize the drought events starts with measuring the threshold value applied at the seventieth percentile. The data which fall below the threshold values is then used in the fitting distribution and weibull distribution has been found to be the best fitted distribution for the representation of the daily drought event in Prakasam District. However, gamma distribution is ranked second while exponential distribution is ranked last in the fitting of drought event in Prakasam District. Weibull is just like Gamma distribution is a two-parameters distribution. Clearly these two distributions outperform the exponential distribution that is a one-parameter distribution.

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