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RESEARCH NOTE

Changing Dew Patterns in Anantapur District, Andhra Pradesh: A Generalistic Observation

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I

INTRODUCTION

Anantapur district is one of the southern districts of Andhra Pradesh State spread between 13' 40" and 15' 15" northern Latitude and 76' 50" and 78' 30" eastern Longitude. The district has been divided into three revenue divisions - Anantapur, Dharmavaram and Penukonda - consisting of 63 revenue mandals.[1] The district capital Anantapur is located at the north-central part of the district at an average elevation of 1100 ft above mean sea level. There is a general rise in elevation towards south of the district to join the Karnataka plateau where the average elevation is 2000 ft. The minimum and maximum temperatures range between 14^{o} C to 40^{o} C. The total population of Anantapur district is 40,83,315 as per the Census of India 2011.

The district has normal rainfall of 553 mm. The normal rainfall for the South-West monsoon period (June-September) is 338 mm, which is 61.2 per cent of the total rainfall for the year. The rainfall for North-East monsoon period (October-December) is 156 mm only, which is 28.3 per cent of total annual rainfall (Government of Andhra Pradesh, 2009). The district is endowed with red soils, covering about 76 per cent of the district. In few northern mandals black and red soils occur in equal proportion. Black soils are in 24 per cent of the district, spread in 14 northern mandals.

The district has a total geographical area of 19.13 lakh ha. The cultivated area of the district is 11.88 lakh ha out of which 10.27 lakh ha is under *kharif* and 1.61 lakh ha is under *rabi* season during the year 2007-08. Groundnut is the predominant *kharif* crop grown in around 8.5 lakh ha. The district occupies the lowest position in respect of surface irrigation facilities with only 11 per cent of the gross cropped area during 2007-08 (Government of Andhra Pradesh, 2009).

II

FOCUS OF THE PAPER

The focus of this paper is on the changing dew patterns during *rabi* season in the district. Residual moisture towards end of the *kharif* season; rainfall during North-

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East monsoon period (October-December) and dew deposition during October-January are the three significant factors that impact the moisture availability to the *rabi* rainfed crops and hence their yields. This paper tries to capture long-term trends in dew deposition in the district based on the dew data obtained from Indian Meteorological Department (IMD) and compare these findings with trends in the area of rainfed crops, especially over the period 2004-08. Field observations from Peddavaduguru mandal are used to supplement the broad trends emerging from the analysis of dew deposition and crop areas at district level.

III

METHODOLOGY

To study and understand the changing patterns of dew in the district, the dew normals and number of dew nights for the period of 1971-89 were compared with that of the period 1998-2008. For both the data periods, the primary data collected by Indian Meteorological Department (IMD), Pune from its weather observatory close to Anantapur town was used. The rainfall data on South West and North East monsoon for 2004-08 at district level and in one mandal (Peddavaduguru) were also analysed.

The data on district as well as mandal level cropped areas in *rabi* season for the year 2004-08 are obtained from the *Handbooks of Statistics* published by Chief Planning Officer, Anantapur district. Data at the district level and one mandal level (Peddavaduguru) was analysed to understand the changes in the *rabi* rainfed crops and their areas vis-à-vis the climate parameters. In addition to the dew data analysis, field observations and interactions with about 10 farmers, on a sample basis, were done to capture the perceptions of the farmers on the long-term changes in the climate.

IV

RAINFALL PATTERN

The rainfall data for South-West monsoon and North-East monsoon season both at district level and in Peddavaduguru mandal has been extracted and compiled to compare against the long-term normal values (Table 1).

It is observed from Table 1, that overall there is deficit rainfall in 2004-05 and 2006-07 and surplus rainfall in 2005-06 and 2007-08 during South-West monsoon period in the district. Peddavaduguru received deficit rainfall only in 2006-07. Rainfall in 2007-08 is exceptionally high, with as high as 130 per cent surplus in the mandal.

TABLE 1. SEASONAL RAINFALL – DISTRICT AND MANDAL LEVEL

Year (1)	District (2)	Peddavaduguru mandal (3)
South-West Monsoon		
Normal	338.0	277.0
2004-05	262.8	353.2
2005-06	426.6	411.2
2006-07	202.4	209.2
2007-08	529.4	635.8
North-East Monsoon		
Normal	156.0	99.0
2004-05	80.5	89.6
2005-06	252.3	149.8
2006-07	120.2	132.2
2007-08	121.4	71.6

At the district level, rainfall during North-East monsoon was deficit in 2004-05, 2006-07 and 2007-08 and surplus in 2005-06. Peddavaduguru does not reflect this trend. In this mandal, rainfall is deficit only in 2007-08. In both seasons, it can be observed that the year-to-year variability is high both at the district and mandal levels.

V

DEW DEPOSITION PATTERN

Dew is defined as the deposition of water drops by direct condensation of water vapour from the adjacent clear air, upon surfaces cooled by nocturnal radiation. Dew is an important secondary source of moisture for crops during the non-rainy season and plays vital role in plant growth. Dew occurrences benefit the plants in different forms. Dew is directly used by plants from absorption by leaf surface; dew reduces transpiration and helps conserve moisture; and it helps acceleration of photosynthesis by plants in forenoon hours due to water saturation of leaves during night. These benefits are significant particularly in arid and semi-arid areas.

In India, IMD measures dew using a Drosometer (Duvdevani dew gauge) as per the BIS specifications (BIS, 2002). Dew is recorded at four height levels (5, 25, 50 and 100 cm) above the ground surface. The amount of dew is recorded by means of comparing the droplets deposited on wooden planks at four heights to standardised photographs. Dew deposition is normally measured in millimetres (mm) where, 1 mm is equal to 10 grams of moisture deposited per 100 m^2 of exposed surface area.

Artificial surface devices, only provide a measure of the meteorological potential for dew formation. The actual amount of dew in a specific place is strongly dependent on surface properties. Dew measurements commenced in India since 1968 and presently dew is measured at 75 stations. The only dew measuring station in Anantapur district is located in Anantapur town.

Few experiments were done in semi-arid coastal region of Kutch in north-west of India, where dew condensers made of different material, such as galvanised iron sheet, aluminium sheet and PETB film (Polyethylene mixed with 5 per cent TiO_2 and 2 per cent $BaSO_4$) were tested for their dew deposition capabilities. PETB film with an emissivity[2] of 0.83, found to be able to collect 19.4 litres/m^2 , followed by GI sheet (emissivity -0.23) with 15.6 litres/m^2 and aluminium sheet (emissivity - 0.216 with 9 litres/m^2 (Sharan, 2008). Recent studies on the dew catching properties of spider silk revealed interesting facts about the structural properties of the silk material that enhance dew deposition on it (Fang, 2010). Relationships among formation of dew and meteorological elements is better illustrated by a schematic diagram by Tuller and Chilton (1973).

Based on the above, it can be concluded that, for dew deposition to occur following are the three important pre-requisites (i) A physical surface, with more infra-red radiation properties (emissivity) and low conductivity, that facilitates condensation of water vapour in the surrounding air; (ii) Ambient air temperature to drop to dew point temperatures, for water vapour to condense and (iii) Calm and clear nights that facilitate downward movement of hot air and nocturnal radiation from surfaces.

5.1. *Dew Normals for 1971-89 and 1998-2008*

Dew is observed mostly from September to April. Mean monthly values of dew deposits (in mm) at each of the four heights mentioned above are given in Tables 2 and 3. Along with dew deposits, number of dew nights has also been given.

TABLE 2. MEAN MONTHLY DEW DEPOSITION FOR 1971-89 AT ANANTAPUR

	Amount of dew (mm) at				No. of dew nights			
Month	5 cm	25 cm	50 cm	100 cm	5 cm	25 cm	50 cm	100 cm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Jan	0.4070	0.4070	0.4070	0.4070	12	12	12	12
Feb	0.0430	0.0430	0.0430	0.0420	2	2	2	2
March	0.0090	0.0090	0.0090	0.0090	0	0	0	0
April	0.0000	0.0000	0.0000	0.0000	0	0	0	0
Sept	0.0460	0.0440	0.0430	0.0430	2	2	2	2
Oct	0.4450	0.4400	0.4130	0.4200	11	11	10	10
Nov	0.7010	0.7010	0.6950	0.6790	15	15	15	15
Dec	0.8130	0.7980	0.8070	0.8090	19	19	19	19
Total	2.4640	2.4420	2.4170	2.4090	61	61	60	60

Source: (IMD, 1991).

It is quite obvious from this data that the dew deposition almost doubled during last decade, as compared to 1971-89 period. The number of dew nights also increased by 30 per cent over this period. Both these observations have recorded data at the same location and using same technique. Hence, it can be concluded that the natural factors, such as wind velocities, atmospheric humidity and night temperatures, are more favourable for increased dew deposition now compared to few decades ago.

TABLE 3. MEAN MONTHLY DEW DEPOSITION FOR 1998-2008 AT ANANTAPUR

	Amount of dew (mm) at				No. of dew nights			
Month	5 cm	25 cm	50 cm	100 cm	5 cm	25 cm	50 cm	100 cm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Jan	0.8355	0.8665	0.8975	0.8920	16	16	16	16
Feb	0.1206	0.1206	0.1178	0.1144	4	4	4	4
March	0.0406	0.0406	0.0383	0.0383	1	1	1	1
April	0.0044	0.0044	0.0044	0.0044	0	0	0	0
Sept	0.1235	0.1235	0.1260	0.1255	3	3	3	3
Oct	0.5756	0.5733	0.5967	0.5917	11	11	11	11
Nov	1.1615	1.2165	1.2740	1.2850	20	20	20	20
Dec	1.6430	1.6840	1.7155	1.7035	25	25	25	25
Total	4.5046	4.6294	4.7702	4.7549	80	80	80	79

Source: Daily dew deposition data from Anantapur station given by IMD, Pune, India.

Tables 4A and 4B compare the dew normals with the actual dew deposition reported from Anantapur station, at 5 cm height, for the years 1998 to 2009. Data for 2002-03, 2003-04 and 2004-05 is partially not available due to data gaps from the station. Dew normals indicate that dew deposition is predominantly over four months, i.e., October to January and total is 2.64 mm in a year. But, the recent data of dew deposition shows substantial increase in the amount.

TABLE 4A. COMPARISON OF DEW NORMALS WITH DEPOSITION IN 1998-2004

Month	Dew Normals (1971-89) at 5 cm height	Dew Deposition (mm)					
		1998-99	1999-00	2000-01	2001-02	2002-03	2003-04
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
September	0.046	0.28	0	0.305	0.185	0	0
October	0.445	1.19	0.855	0.63	0.6	0.085	0.265
November	0.701	3.205	0.745	1.17	1.025	0.61	0.43
December	0.813	2.5	2.55	2.86	0.615	0.635	0.42
January	0.407	1.705	0.815	0.395	0.305	0.125	N.A.
February	0.043	0.5	0	0	0.08	N.A.	N.A.
March	0.009	0.095	0.045	0.04	0	N.A.	N.A.
April	0.000	0	0	0	0	0	N.A.
Total	2.640	9.475	5.01	5.4	2.81	--	--

* N.A. – Data not available from the weather station.

TABLE 4B. COMPARISON OF DEW NORMALS WITH DEPOSITION IN 2004-2009

Month	Dew Normals (1971-89) at 5 cm height	Dew Deposition (mm)				
		2004-05	2005-06	2006-07	2007-08	2008-09
(1)	(2)	(3)	(4)	(5)	(6)	(7)
September	0.046	N.A.	0	0	0.02	0.445
October	0.445	N.A.	0.135	0.36	0.39	1.03
November	0.701	N.A.	1.125	1.09	1.195	1.02
December	0.813	N.A.	2.085	1.14	0.95	2.675
January	0.407	0.3	0.91	0.535	0.835	N.A.
February	0.043	0.075	0.1	0.04	0.145	N.A.
March	0.009	0	0.165	0	0.02	N.A.
April	0.000	0	0	0	0	N.A.
Total	2.640	--	4.520	3.165	3.555	5.17

Source: Daily dew deposition data from Anantapur station given by IMD, Pune, India.
* N.A. – Data not available from the weather station.

VI

CROPPING PATTERNS AND CLIMATE PARAMETERS

The above analysis on rainfall patterns in South-West and North-East monsoon seasons; and dew deposition at Anantapur attempts to understand the patterns and changes occurring in the climate parameters. Due to limitations on availability of rainfall at mandal level, the analysis of rainfall data is restricted to 2004-05 to 2007-08. Dew deposition data for 1998-2009 given by IMD, Pune is also analysed. As per this analysis, there is high degree of variability, in terms of year-to-year change and against normals, in South-West and North-East monsoon in Anantapur district in general and in Peddavaduguru mandal studied. Secondly, dew deposition has significantly increased over last 10 years, compared with the normals computed for the period 1971-89. This being the broad trends in climate parameters studied, following key questions arise:

(a) what is the combined effect of rainfall variability and increased dew deposition on rainfed crops grown in *rabi* season?
(b) whether changes in cropping patterns, if any, can be related with changes in climate parameters?

To search for answers to these questions, data related to rainfall, dew deposition and rainfed crop areas in *rabi* season, both at district and mandal level are put together in following tables. For Peddavaduguru mandal, after the data table, a synthesis of observations made by the farmers is also given. At the end, conclusions are drawn towards answering these key questions.

6.1. *District Level Data*

Table 5 below presents data of rainfall, dew deposition and rainfed *rabi* crops at the district level. The data clearly brings out the variability in rainfall of -22 to +62 per cent compared to normals, while dew deposition increased significantly. Rainfall in SW season is an important trigger that impacts the cropping patterns in *rabi* season. While *kharif* season rainfall influences farmers choice of whether to cultivate *rabi* crops and area extent of the same, *rabi* rainfall influences the yield of crops grown during *rabi* season. Drought conditions beyond a threshold limit, results in failure of *kharif* groundnut crop. This in turn leads to shortage of fodder. The farmers, who lost the groundnut crop substantially or who could not sow in *kharif* season (such as in 2006-07), increased the area under sorghum in *rabi* in red soils and area under Bengal gram in black soils as a drought-resistant alternative and source of fodder. With normal rainfall during *kharif* 2005-06, most of the fodder needs of the farmers for the entire year were met from groundnut crop sown in *kharif* season.

TABLE 5. RAINFALL, DEW DEPOSITION AND AREA OF RAINFED *RABI* CROPS AT DISTRICT LEVEL

Parameter (1)	2004-05 (2)	2005-06 (3)	2006-07 (4)	2007-08 (5)
SW rainfall (mm)				
Normal	338.0	338.0	338.0	338.0
Actual	262.8	426.6+26	202.4	529.4
Deviation (per cent)	-22		-40	+57
NE rainfall (mm)				
Normal	156	156	156	156
Actual	80.5	252.3	120.3	121.4
Deviation (per cent)	-48	+62	-23	-22
Dew Deposition (mm)				
Normal	2.640	2.640	2.640	2.640
Actual	N.A.	4.520	3.165	3.555
Area of *rabi* rainfed crop (ha)				
Red soils:				
Maize	0	81	4	8
Sunflower	27228	14814	21347	16229
Groundnut	0	0	0	0
Coriander	0	2558	1225	2771
Sorghum	7989	9726	22116	9560
Black soils:				
Bengal gram	42106	46326	81629	73761
Horse gram	225	205	1689	462

Source: (Government of Andhra Pradesh, 2006, 2007, 2008, 2009).
* N.A. – Data not available from the weather station.

Therefore, the area under sorghum crop during that year remained low. Fifty per cent increase of area under Bengal gram in black soils; irrespective of deficit SW monsoon in 2006-07 and surplus in 2007-08, could be related to better market opportunities and indirectly to increased dew deposition. Yield analysis of Bengal gram, as a measure of net impact of North-East rainfall variation and increased dew deposition could not be done due to lack of data.

6.2. *Peddavaduguru Mandal*

Table 6 presents data of rainfall, dew deposition and rainfed *rabi* crops in Peddavaduguru mandal. As per this data, variability in rainfall is -24.5 to +129.5 per cent compared to normals, while dew deposition is taken same as at Anantapur due to lack of locally measured data.

In this mandal, which has predominantly black soils, deficit rainfall in SW season seems to have triggered expansion of area under Bengal gram in *rabi* during 2006-07. Over this, a good NE monsoon during *rabi* and good crop yield might have created new hope on this crop among farmers and might have unlocked the potential for Bengal gram in black soils in the subsequent year. There is a consistent increase in area cultivated under Bengal gram irrespective of good or poor rainfall in *kharif* season across the years.

TABLE 6. RAINFALL, DEW DEPOSITION AND AREA OF RAINFED RABI CROPS IN PEDDAVADUGURU

Parameter (1)	2004-05 (2)	2005-06 (3)	2006-07 (4)	2007-08 (5)
SW rainfall (mm)				
Normal	277.0	277.0	277.0	277.0
Actual	353.2	411.2	209.2	635.8
Deviation (per cent)	+27.5	+48.4	-24.5	+129.5
NE rainfall (mm)				
Normal	99	99	99	99
Actual	89.6	149.8	132.2	71.6
Deviation (per cent)	-9.5	+51.3	+33.5	-27.7
Dew deposition (mm)				
Normal	2.640	2.640	2.640	2.640
Actual	N.A.	4.520	3.165	3.555
Area of *rabi* rainfed crop (ha)				
Red soils:				
Maize	0	0	0	0
Sunflower	433	0	340	0
Groundnut	0	0	0	0
Coriander	0	0	0	0
Sorghum	20	326	300	408
Black soils:				
Bengal gram	45	106	988	1191
Horse gram	0	0	0	0

Source: Same as in Table 5.

Farmer's Views and Perceptions

The author visited Kasepalli village in Peddavaduguru mandal and interacted with ten farmers randomly to capture their views and perceptions on dew deposition in the mandal. The following points synthesise their understanding:

- A good monsoon during previous rainy season results in a good dew deposition in consequent winter. Thick foggy mist in early mornings indicate more dew 'fall' in the night. As an example, the farmers quoted excellent rainfall during 2007-08 followed by good dew fall (in terms of mist and cold) in subsequent winter.
- In 2009-10 *kharif*, due to delayed monsoon, groundnut was not sown in the entire village. During *rabi*, since it is predominantly black soil, about 300 acres was brought under Bengal gram cultivation. In the event of South-West monsoon failures, normal practice is to increase the Bengal gram cultivation. Good rain during end of October 2009 saved this crop.
- Dew fall (i.e., mist seen in early morning hours) is reducing over years and less in the current season. Though market price has not increased much (remained between 1900 to 2300/quintal) over last 5 years, marketing facilities and opportunities increased with buyers coming to villages for

procuring the crop. And, hence Bengal gram is the obvious choice in black soils.

VII

LIMITATIONS OF THE STUDY

This is a rapid study done with the help of limited secondary and field data. There is a possibility and scope for more in-depth and more scientific study of dew deposition in Anantapur District. There is only one dew measuring station in Anantapur district, maintained by IMD, Pune. Hence, for Peddavaduguru also same data is assumed to be relevant. As we move away from the Anantapur station towards farthest Peddavaduguru mandal, there is a possibility of changes in the dew deposition patterns significantly. Systematic data collection from a sample of large farmers could have been more useful. Continuous monitoring of few selected fields where *rabi* crops are grown, would also be helpful in tracking the soil moisture status and role of dew in mitigating it. Due to non-availability of mandal level published rainfall data for years before 2004-05, this analysis was restricted to the period 2004 to 2008. Also, there was no standard methodology to convert dew into equivalent of rainfall or vice-versa to estimate the total moisture availability in a given season. Relation between dew fall changes and pest/disease incidence could not be established due to limited field study.

VIII

STUDY FINDINGS AND CONCLUSION

8.1. *Changing Rainfall, Dew and Crop Patterns*

Variability of rainfall, both in South-West monsoon and North-East monsoon period is very high, ranging from -24.5 to +129.5 per cent compared to normals. High degree of year-to-year variations has become the order in Anantapur district. Uncertainties associated with such variations are seriously affecting the crops and their yields, resulting in serious economic losses to the farmers. A comparison of dew normals with dew deposition in the last 10 years reveals that there is significant increase in the amount of dew deposition; period of dew deposition as well as number of dew nights compared to the period 1971-89. This implies that more moisture is available to the *rabi* crops in pre-winter and during winter time. Observed increase and decrease in the crop areas during 2004-2008, particularly of sorghum are related to the variations in South-West monsoon. When drought conditions cross threshold level, crops fail substantially resulting in fodder shortage. In such cases, as in 2006-07, farmers tend to increase area under sorghum in *rabi* under rainfed conditions in red soils. In black soils, area under Bengal gram doubled in 2006-07 and continued at that level afterwards. Though the drought in 2006-07 is a trigger, more moisture availability (possibly from increased dew deposition) and better market opportunities could be the reason for its continuation in later years. Increased dew deposition might be playing critical role in survival of Bengal gram crop whose area has consistently increased over the last few years. In addition to the ability of black soils to absorb and retain moisture for longer duration, the Bengal gram plants might also be having higher "infra-red radiation" properties, which facilitate deposition of more dew on this crop compared to other *rabi* crops. This aspect requires further study and analysis. The overall increasing dew intensity and amounts is a favourable factor and has positive impact on climate change phenomenon.

8.2. *Scope for Further Work*

Unlike rain 'fall' and snow 'fall' which fall on the earth's surface due to climate variations, dew depositions not only depend on climate parameters (such as wind speed, humidity and temperature) but also on the surface properties on which deposition takes place. Hence, the amount of deposition varies from surface to surface depending on its ability to lose energy in terms of infra-red radiation.

It is also important to note that dew measurements from weather observatories are only an indication of potential of dew formation but not actual dew deposition on crops in the area. Surface properties of various objects, such as, trees, crops etc., is a strong factor that influence actual amount of dew deposition. Therefore, unlike rainfall, dew deposition is a surface phenomenon. Also, fog and mist that appears in early hours of the day should not be taken as an indication for amount of dew deposition.

For a given location and time, the air temperature, humidity, wind speeds remain constant but the modification in surface properties, such as introducing surfaces with higher infra-red radiation, may result in net increase in infra-red radiation from a particular field. This may increase the deposition of dew in such a location. Further work on both identifying crops that emit more infra-red radiation as well as possibilities of augmenting dew deposition in rainfed crops by introducing surfaces that stimulate formation of more dew are interesting possibilities. Developing new strains of winter crops that have more infra-red radiation properties may also be considered. Generating more location-specific data on dew deposition potential in mandals shall be considered by the local research institutions, on priority basis.

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NOTES

1. A geographical and revenue sub-unit of a district in Andhra Pradesh with average area of around 25,000 ha.
2. The emissivity of a material (usually written as ε or *e*) is the relative ability of its surface to emit energy by radiation. It is the ratio of energy radiated by a particular material to energy radiated by a black body at the same temperature. A true black body would have an ε = 1 while any real object would have ε < 1. Emissivity is a dimensionless quantity. (Excerpt from http://en.wikipedia.org/wiki/Emissivity).

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