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DROUGHT VULNERABILITY AND ITS IMPLICATIONS ON AGRICULTURE IN ORISSA STATE

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Abstract

Drought is a condition of moisture deficit to such a degree to have an adverse effect on vegetation, livestock and man over a sizable area. Orissa state is not only susceptible to frequent cyclones but also to droughts. Analysis of droughts at 15 representative stations was carried out based on water balance technique. The study revealed that on an average Orissa has experienced 11 drought years during the period extending from 1976 to 1999. Of these, the droughts occurred in 1979 and 1996 were very disastrous in terms of intensity. Similarly, a maximum number of droughts in the state were recorded during 1980-1989. The study indicates that overall drought proneness of the state ranges between 47.8 to 56.3 per cent. The drought vulnerability of the state is more in its southern parts. The agro-climatic regionalization suggests that more than half of the agricultural area is suitable to millets only. Correlation of paddy yield with the drought incidence indicated high negative deviations. The study is helpful to assess the crop suitability and to prepare a systematic irrigation scheduling and crop weather calendar in order to minimize the impacts of droughts in the state.

The term disaster evolved from a French word *'disastr'* which is the combination of two words *'des'* means 'bad' and *'astre'* means a 'star'. Disaster is the sudden onset of major misfortune. It is a catastrophic situation in which normal conditions were disrupted and dislocated. Vulnerability indicates the susceptibility to the disaster. Disasters are either natural and man-made. Natural disaster, which are induced by natural events may happen suddenly or develop gradually. The disaster like earthquakes, volcanic eruptions, tsunamis and cyclones are of sudden category, whereas droughts, epidemics, desertification, etc., are of gradual type disasters.

Drought is the single most significant weather-related natural disaster. In India, 33 per cent of the area receives less than 750 mm rainfall and is chronically drought-prone, and 35 per cent of the area with 750-1125 mm rainfall is also subjected to droughts once in every four to five years. Thus, 68 per cent of the net area sown covering about 142 million hectares of the country is vulnerable to droughts.

Drought is a natural meteorological phenomenon that has periodically been affecting one or other parts of the world. Floods and droughts associated with global climate change could undermine health in other ways as well. These could damage crops and make them vulnerable to infection and infestations by pests and choking weeds, thereby reducing food supplies and potentially contributing to the malnutrition (Epstein, 2000). Recently, meteorologists put forwarded a theory of *'tele-connection'* of the meteorological and weather phenomena of the different regions of the world that explains the occurrence, periodicity and severity of droughts. Apart from these, the other factors which attribute and aggravate drought severity are deforestation and desertification (Sharma, 1998). In terms of agriculture, drought can be said to occur whenever the supply of water in the form of rainfall or soil moisture storage is insufficient to fulfill the requirements of plants (Ayoade, 1983). Aridity is a climatic term applied to permanent lack of water for established use, whereas drought is of a comparatively shorter period of transient nature without adequate water supply mainly from precipitation (Subrahmanyam, 1980). To a farmer, agricultural drought is a period during which his normal farm operations are disturbed and economic output from agriculture is reduced due to deficiency of rainfall. Meteorologists, generally, consider drought as a situation in which rainfall decreases by a certain percentage below to its long-run normal value of the region. Pedologists and ecologists view drought in the context of the water balance of the soil.

Droughts can be identified as permanent, seasonal, contingent and invisible. Permanent drought is a climatic character of arid areas where rainfall is very meagre to fulfill the water requirements of the plants. Crop cultivation is not at all possible in these areas without supplemental irrigation. Seasonal drought occurs in areas where wet and dry seasons prevail. The incidence of drought follows the seasonal changes of atmospheric circulations. Crop cultivation is possible without irrigation during rainy season and with irrigation during dry season. Contingent and invisible droughts are unpredictable and occur in areas of erratic rainfall with high variability. These types of droughts are common in humid and sub humid areas. In general, wilting of crops or sparseness in its extent indicates the drought condition. In the case of invisible drought, there would be no wilting; rather the crop fails to grow to its optimum level. Thus, the crop yield would be reduced to less than its normal. The drought management practices include increasing the water supply through irrigation, growing drought resistant crops, assessing crop suitability, etc. But as an initial step, it is essential to assess the nature, duration and proneness of droughts in a particular region. Identification of the beginning of a drought spell and its intensity in time helps to prevent damage to the growing crops due to drought through supplemental irrigation. Hence, for the prosperous agricultural activity it is essential to identify and categorize the droughts in a particular area to get an overall impact of drought in that area.

The techniques that are employed for the study of drought include statistical, non-statistical and water balance. The statistical techniques have usually no physical basis while the non-statistical techniques are purely empirical whereas water balance methods are realistic and objective as they are based on rational concepts (Subrahmanyam and Sastry, 1967). This technique has multiple applications in various aspects such as climatic analysis, assessment of droughts and identification of crop suitability regions.

A clear understanding and better appreciation of the problem of droughts and aridity became possible after the subject of water balance analysis has been developed by Thornthwaite (1948) and Thornthwaite and Mather (1955). Drought, in terms of water balance analysis, which takes into account the soil properties, can be expressed as a meteorological situation in which the amount of water required for maximum evapotranspiration exceeds the amount available from rainfall.

Water balance analysis is not only useful for identification of the climatic types and evaluation of crop suitability and capabilities but also useful for identification of drought spells, their duration, intensity and spread. This type of analysis of climate is essential for the farmers and planners enableing them to select suitable crops, to develop crop-weather calendar, to implement effective irrigation facilities by irrigation scheduling in the drought prone areas. The main objective of the study is to assess the frequency and severity of droughts apart from delineating the drought prone areas of the state.

Study Area

Orissa state is located along the eastern coast of India extending between the latitudes 17º 49' N and 22º34' N, and the longitudes 81º 29'E and 87º 29'E, covering an area of about 1,55,000 km2 (Fig.1). According to 2001 Census, the population of the state was 36,804,660 persons. The state can be divided into four physiographic units, namely, Northern Plateau, Central Tableland, Eastern Ghat Hills and Eastern Coastal Plains.

In general, Orissa experiences a tropical monsoon type of climate with four distinct seasons. Most of the rainfall is received during the south-western monsoons. The areas of the highest rainfall are the northern portions of Eastern Ghats and along the coast (Negi and Singh, 1999). The rainfall decreases towards interior regions with the driest parts of the state lying in its southwestern part. Apart from monsoonal rainfall, Orissa gets rainfall from cyclonic activity too. The Eastern Coastal Plain receives its maximum rainfall during the retreating monsoon season (October-November).

The main occupation of the state is agriculture. Total area under crops is 58.29 million hectares, which is 37.43 per cent of the total geographical area of the state. Of this, about 27 per cent is under irrigation and the remaining 73 per cent is dependent upon the vagaries of monsoon rainfall.

Database and Methodology

Data pertaining to monthly average temperatures and rainfall recorded at 15 weather stations in Orissa were collected from the records of India Meteorological Department, Pune for a period of 24-years (i.e. from 1976 to1999). These15 stations are taken as representative stations to study drought vulnerability of the state as a whole (Table.1 and Fig.1).

Table1
Representative stations and their locations

Sr.no	Name of the Station	District
1	Bhubaneswar	Khurdha
2	Cuttack	Cuttack
3	Puri	Puri
4	Gopalpur	Ganjam
5	Chandbali	Bhadrak
6	Jharsuguda	Jharsuguda
7	Baripada	Mayurbhanj
8	Keonjhar	Keonjhar
9	Paradeep	Kendrapara
10	Balasore	Balasore
11	Titlagarh	Bolangir
12	Sambalpur	Sambalpur
13	Bhawanipatna	Kalahandi
14	Bolangir	Bolangir
15	Phulbani	Kandhamal

Drought Analysis

Entire Orissa state is experiencing sub-humid type of climate, except its southwestern parts. Earlier studies indicated that among the climatic types, sub-humid type of climate

Fig. 1

possess critical water balances which fluctuate violently from year to year and is liable to incidence of droughts of various kinds (Subrahmanyam and Hema Malini, 1979). Keeping this in view droughts of Orissa were analyzed in the present study.

For the analysis of droughts, water deficit data which were obtained from water balance computations of about 24 years (1976 – 1999) have been taken into consideration. The percentage ratio between water deficit and water need, which constitutes aridity index was computed for all the representative stations for all the years. The statistical technique namely standard deviation () of the aridity index values has been computed for the analytical study of drought situation. Departures of yearly aridity indices from the median values were used as the base of reference. Yearly departures of aridity index at a station under consideration from the median when graphically plotted against the successive years provide not only the information of years of drought incidence but also the intensity of drought. Fig.2 illustrates the identification of drought years with their intensities at Paradeep representative station during the period between 1976- 1999. Categorization of droughts on annual basis has

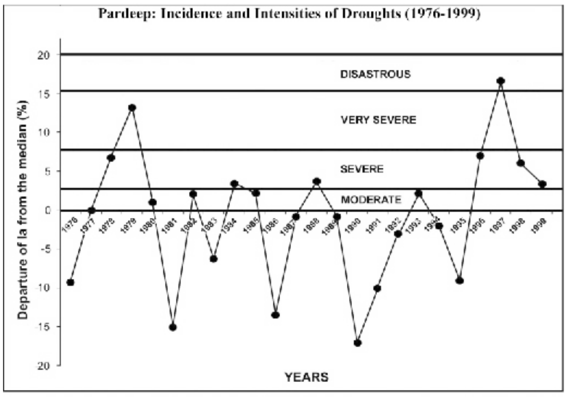

Fig. 2

been attempted using the scheme illustrated by Subrahmanyam and Subrahmaniam (1965). Based on the this scheme, the droughts that occurred in Orissa at all the representative stations during 1976-1999 were categorized and presented in Table 2.

Table 2
General Scheme of Drought Categorization

Departure of Ia from the Median	Drought category
Less than ½	Moderate
Between ½ and	Severe
Between and 2	Very severe
More than 2	Disastrous

Based on the above scheme, droughts that occurred in Orissa state during 1976-1999 were categorized and presented in the Table.3.

From Table 3, it can be inferred that Orissa has experienced 11 years of drought between 1976 and 1999 in most of parts of the state except in areas of Titlagarh and Bhawanipatna where the number of droughts that occurred were 8 and 7, respectively. The Table 3, further reveals that Chandbali,

Table 3
Orissa: Incidence of total Number of Droughts and their Intensities (1976-1999)

Sr. no	Representative Stations	Category of the drought based on the intensity				Total droughts
		Disastrous	Very Severe	severe	Moderate	
1	Bhubaneswar	--	8	1	2	11
2	Cuttack	1	1	4	5	11
3	Puri	--	--	8	3	11
4	Gopalpur	--	4	5	2	11
5	Chandbali	1	2	6	2	11
6	Jharsuguda	--	2	3	6	11
7	Baripada	--	4	4	3	11
8	Keonjhar	1	2	4	4	11
9	Paradeep	1	1	4	5	11
10	Balasore	--	3	3	5	11
11	Sambalpur	1	--	1	9	11
12	Titlagarh	1	2	3	2	8
13	Bhawanipatna	1	--	2	4	7
14	Bolangir	--	--	1	10	11
15	Phulbani	1	3	4	3	11

Keonjhar, Paradeep, Sambalpur, Titlagarh, Bhawanipatna and Phulbani have experienced disastrous nature of droughts one each during the study period. Out of 11 droughts experienced by Bhubaneswar, Puri and Sambalpur, 8 are of very severe, 8 are of severe and 9 are of moderate type respectively.

Drought Proneness

The vulnerability of a region for a particular intensity of drought is also a common phenomenon. Among the climatic types, the moist categories namely perhumid, humid and moist sub humid indicate drought tolerance. While the dry climates namely dry sub humid, semi arid and arid are more prone to drought. Permanent and continuous drought conditions may lead to desertification (Subrahmanyam and Hema Malini, 1978). Hence, it is essential to identify drought-prone areas which are more frequently vulnerable to droughts.

Jameson (1932) coined a term *'index of liability'* which indicates the ratio of the number of drought days to the total number of days examined. Earlier, studies on drought proneness were made by Blanford (1868) and Eliot (1909) using rainfall variability. However, Subrahmanyam and Sastry (1968, 1969a, 1969b), Hema Malini (1979) reported that water balance parameters are better and more realistic than rainfall figures in the study of droughts.

Drought proneness can be calculated by taking the number of droughts that occurred in each drought category under consideration. Percentage ratio of the number of drought years to the total number of years examined provides the overall drought proneness of the area. Similarly percentage ratio of number of years of drought of each category to the total number of drought years will give proneness to each category of drought.

Table 4
Orissa : Drought Proneness (values are in percentages)

Representative Station	Overall	Disastrous	Very severe	Severe	Moderate
Bhubaneswar	47.8	0	72.7	9.1	18.2
Cuttack	47.8	9.1	9.1	36.4	45.5
Puri	47.8	0	0	72.7	27.3
Gopalpur	47.8	0	36.4	45.5	18.2
Chandbali	47.8	9.1	18.2	54.5	18.2
Jharsuguda	47.8	0	18.2	27.3	54.5
Baripada	47.8	0	36.4	36.4	27.3
Keonjhar	47.8	9.1	18.2	36.4	36.4
Paradeep	47.8	9.1	9.1	36.4	45.5
Balasore	47.8	0	27.3	27.3	45.5
Sambalpur	47.8	9.1	0	9.1	81.8
Titlagarh	50.0	12.5	25	37.5	25
Bhawanipatna	56.3	11.1	0	22.2	44.4
Bolangir	47.8	0	0	9.1	90.9
Phulbani	47.8	9.1	27.3	36.4	27.3

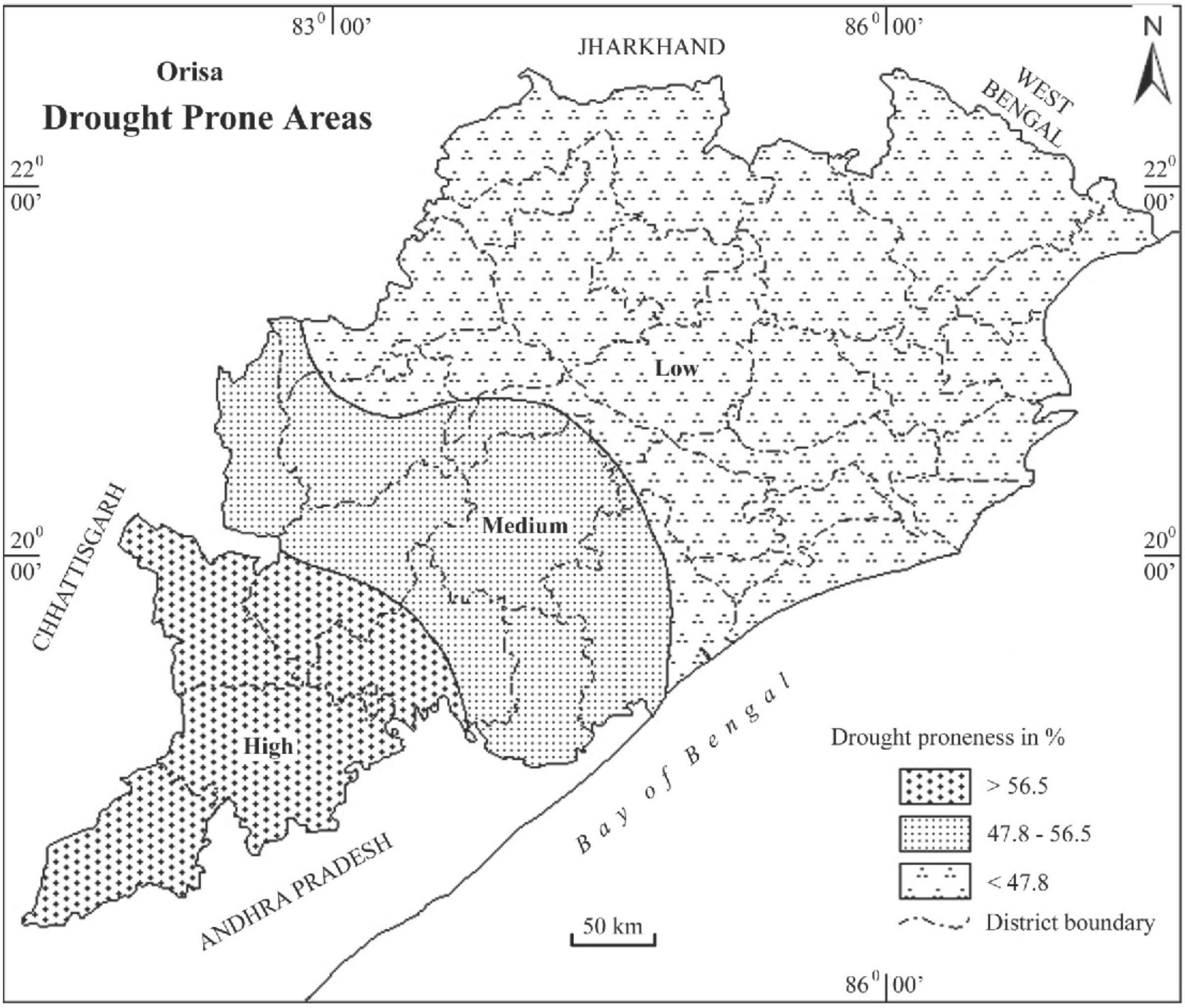

Fig. 3

The overall as well as category-wise drought proneness of the 15 representative stations of Orissa state was computed (Table 4) and spatially represented in Fig 3.

The analysis shows that all the representative stations of the state are prone to droughts. Bhawanipatna indicates the highest drought proneness of 56.3 per cent followed by Titlagarh with 50 per cent. The remaining stations show the drought proneness of 47.8 per cent.

The study reveals that the eight stations, namely, Cuttack, Chandbali, Keonjhar, Paradeep, Sambalpur, Titlagarh, Bhawanipatna and Phulbani are prone to disastrous droughts and the remaining seven stations namely Bhubaneswar, Gopalpur, Puri, Jharsuguda, Baripada, Balasore and Bolangir have not experienced any disastrous nature of droughts during the study period. Titlagarh has indicated maximum proneness to disastrous nature of droughts with 12.5 per cent followed by Bhawanipatna (11.1 per cent). The very severe drought proneness of varying intensity is observed in the entire state except at Puri, Sambalpur, Bhawanipatna and Bolangir stations. The maximum proneness of very severe droughts was observed at Bhubaneswar with 72.7 per cent proneness.

The proneness to severe droughts has

been observed at all the stations. Puri recorded the highest proneness of 72.7 per cent in this category (Table.4). Bolangir, Sambalpur and Bhubaneswar have shown low tendency towards severe nature of droughts. The proneness to moderate drought has also been observed in all the stations of Orissa state. However, the proneness ranges from 18.2 percent to 90.9 per cent. Bolangir and Sambalpur recorded very high proneness to moderate droughts with 90.9 per cent and 81.8 per cent values respectively (Table. 4).

From the above analysis it may be inferred that drought impact is more at Bhawanipatna and Titlagarh. Bhawanipatna shows the greatest tendency towards disastrous, severe and moderate types of droughts. Very severe droughts have not occurred at this station during the period under investigation. Titlagarh is another station which indicated maximum proneness towards disastrous droughts (12.5 Per cent) followed by severe droughts with 37.5 per cent of proneness (Table.4). Five stations namely Cuttack, Chandbali, Keonjhar, Titlagarh and Phulbani are prone to all types of droughts (Table 4). The analysis shows that even though the state has a significant rainfall potential, yet drought is a recurring phenomenon especially in the southwestern parts of the state (Fig.3).

Decennial Frequency of Droughts

The decennial frequencies of droughts, i.e., the number of years of droughts that occurred in the consecutive decades in any region indicate the trend of drought incidence. Table 5 shows the decennial frequency of droughts in different stations of Orissa state and Fig.4 illustrates the decennial frequency at Phulbani, a representative station.

All the representative stations have experienced more number of droughts in the decade 1980-1989 when compared to 1970-1979 and 1990-1999 decades (Table 5). There was a decrease in the number of drought years in 1990-99 than 1980-89 except Bhubaneswar where the number of drought years remained unchanged and Bolangir which experienced 100 per cent increase (Table 5). The analysis indicated that 1980-1989 was the decade mostly under the impact of droughts.

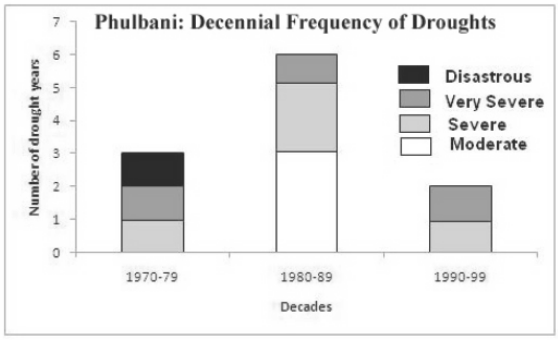

Fig. 4

Table 5
Orissa: Decennial Frequency in the Incidence of Droughts

Representative Station	1976 – 1979	1980 – 1989	1990 – 1999
Bhubaneswar	1	5	5
Cuttack	4	4	3
Puri	3	5	3
Gopalpur	2	5	4
Chandbali	2	6	3
Jharsuguda	3	6	2
Baripada	2	5	4
Keonjhar	3	6	2
Paradeep	2	5	4
Balasore	1	6	4
Sambalpur	4	3	4
Titlagarh	3	2	3
Bhawanipatna	4	2	1
Bolangir	2	3	6
Phulbani	3	6	2
Total	**39**	**69**	**50**

Duration and Severities of drought spell

The duration and severity of drought is another aspect of drought analysis with immense practical significance in hydrological and agricultural planning. The severity of the drought may not be uniform throughout its spell. Hence, the severity indices for individual droughts at different stations of a region help in objective categorization of droughts. Duration combined with intensity of a drought spell determines the severity or its ultimate effect on water shortage and economic situation (Subrahmanyam and Sastry, 1969). Therefore, the study of duration and severity of drought spells helps in understanding the nature of drought pattern in detail.

The adverse effect of severe and disastrous droughts of short duration is less than that of the moderate drought of prolonged duration. Hence, not only intensity but also the duration aspect of droughts requires proper assessment. Foley (1957) identified the drought periods in Australia from monthly rainfall deficiency. The duration and the intensity were determined by using cumulative deviation technique. Later in India, Subrahmanyam and Sastri (1968, 1969a, 1969b), Hema Malini (1979, 1981, 1984 and 1996) used the same technique but with a slight modification wherein instead of rainfall departures, water deficit was taken into consideration in the analysis of droughts.

Cumulative deviations for the individual significant drought episodes have been calculated by taking deviations of monthly water deficit from the climatic normal and expressed as ratios of the normal annual water need in units of thousandths. These units were cumulated from an arbitrary origin (zero) and plotted against successive months. The cumulative mass diagrams of the monthly water deficiency departures at selected stations for sequential drought spells were prepared. The core period of drought is then shown by the steepest part of the rise in the mass curve (Fig.5). The severity indices were caculated during the period of rise in gradients of the curve. The categorization of the drought based on this concept is shown in Table 6.

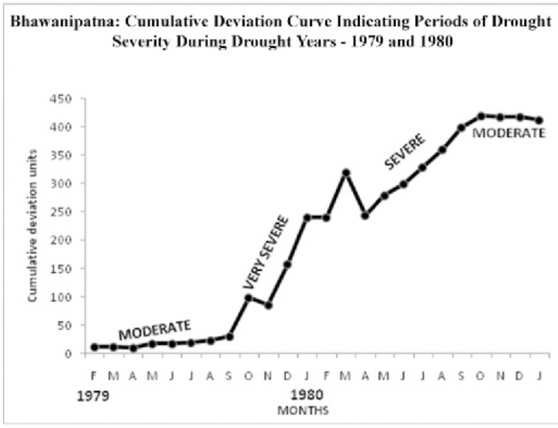

Fig. 5

Table 6
General Scheme of Drought Categorization Based on Severity Indices

Severity Indices %	Drought Category	Symbol
> 41	Disastrous	D
31 – 40	Very severe	VS
21 – 30	Severe	S
< 20	Moderate	M

This categorization of droughts based on their severity indices is very helpful for delineation of droughts prone areas more objectively besides being useful towards scientific planning of suitable cropping patterns of a particular region. In the present study, sequential drought years were identified for fifteen representative tations in Orissa state, which revealed that most drought spells were confined to the pre-monsoon and post-monsoon periods. However, occurrence of droughts during the monsoon season was also not uncommon. The study also revealed that the droughts of mild, harsh and acute categories were of very common occurrence, while chronic drought occurred occasionally. However, it was found that the state is liable to

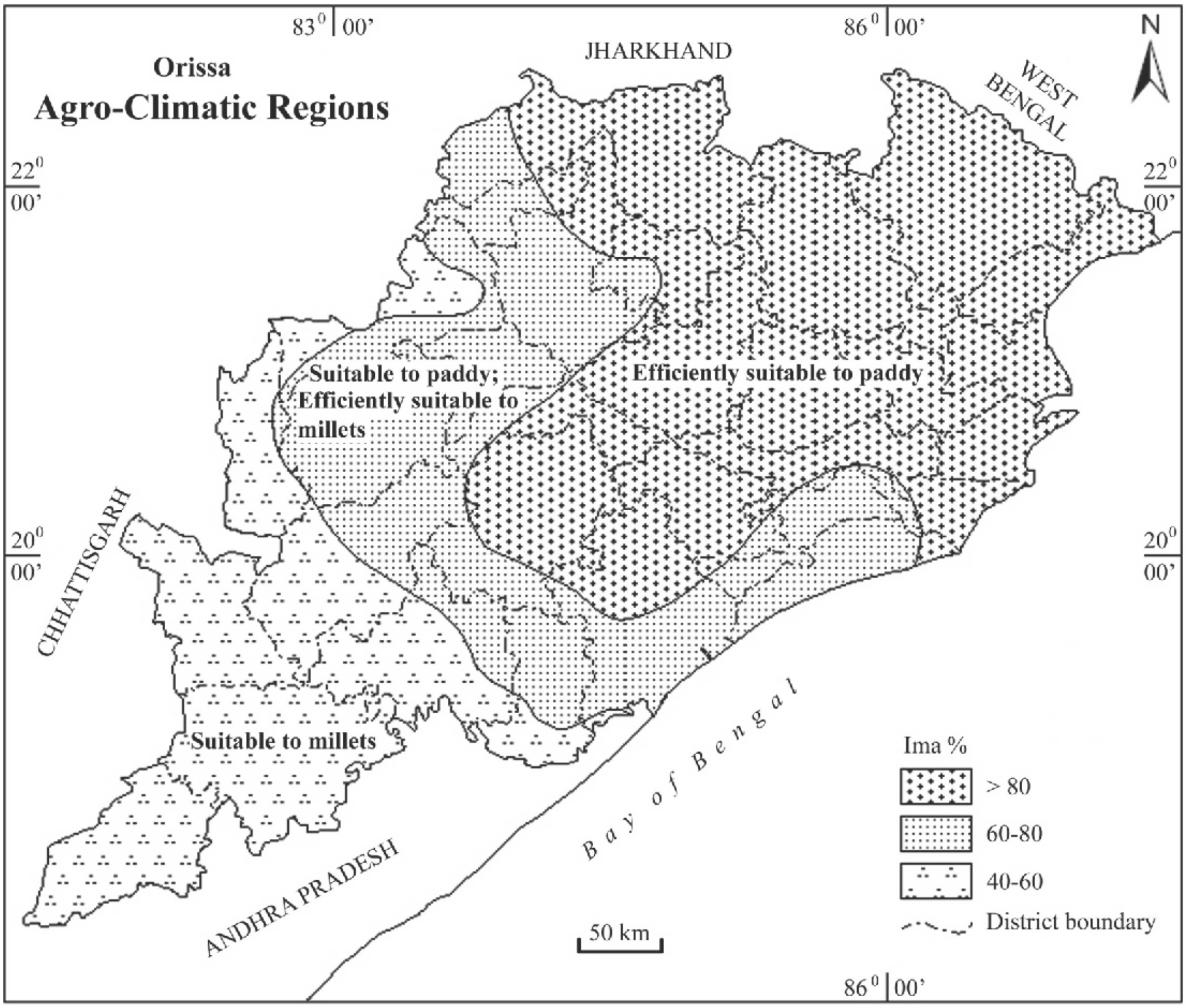

Fig. 6

drought conditions of various severities in both the crop seasons of *kharif* and *rabi*.

Agro-Climatic Zones

The book-keeping procedure of Thornthwaite and Mather (1955) which has a multivariate application in scientific studies also acts as a tool to delineate agro climatic regions. The actual evapotranspiration (AE), which is one of the derived parameters of water balance, represents the amount of water that actually evaporated and transpired to the atmosphere. The percentage ratio of AE to PE (Potential Evapotranspiration) provides an index namely Index of Moisture Adequacy (Ima), which varies with the total availability of moisture and therefore is the best index to estimate the agricultural potentiality of the region. The high Ima rates indicate high potentiality to agriculture and low values indicate poor potentiality. Thus, Index of moisture adequacy is a useful parameter to delineate the agro-climatic zones of any region as it suggests suitability of crops in a particular area.

According to the concept of Moisture Adequacy (Subrahmanyam *et al.,* 1963), when Ima values are between 60 per cent and 100 per cent, paddy cultivation can be carried out even in the absence of supplemental irrigation. On the other hand, in areas where Ima values are between 60 per cent and 80 per cent, paddy cultivation is uneconomical without supplemental irrigation. However these areas are efficiently suitable for millet cultivation. In the areas where Ima values are between 40% and 60%, only millets can be grown successfully, whereas in the areas with 20 per cent and 40 per cent of Ima, the choice of crops is highly limited to drought resistant crops that can withstand water scarce conditions. Lastly, areas with less than 20 per cent of Ima are not at all suitable for any type of crop cultivation. However, livestock rearing can be suggested as an alternative to crop cultivation.

Based on this assumption, moisture adequacy indices for all the representative stations of Orissa state were computed and presented in the Table 7.

The moisture adequacies of Orissa state as a whole range between 59 per cent and 85 per cent. The maximum crop potentiality lies along the coastal areas and it decreases towards southwestern interior parts. However, the entire state can be recognised into three distinct agro-climatic zones namely; (1) efficiently suitable to paddy, (2) suitable to paddy but efficiently suitable to millets, and (3) suitable to millets (Fig.6).

The agro-climatic analysis based on average moisture adequacy conditions clearly indicates that most of the agricultural area of Orissa state is suitable for paddy and millet cultivation where the moisture adequacy indices ranges between 59 per cent and 85 per cent. Higher Ima values ranging from 80 per cent to 85 per cent prevail in the northeastern part of the state comprising the eastern part of the Northern Plateau and northern part of the Eastern Coastal Plains. Balasore station, situated here records the highest Ima value of 85 per cent in the state. The moisture adequacy gradually declines towards the southwestern part of the State where it is less than 60 per cent. Kalahandi district, represented by Bhawanipatna, situated in the southwestern

Table 7
Orissa: Moisture Adequacy Indices and Crop Suitability

Sr. no	Representative Stations	Ima %	Crop Suitability
1	Balasore	85.24	Efficiently suitable to Paddy
2	Baripada	85.09	Efficiently suitable to Paddy
3	Chandbali	84.57	Efficiently suitable to Paddy
4	Keonjhar	83.15	Efficiently suitable to Paddy
5	Paradeep	82.44	Efficiently suitable to Paddy
6	Bhubaneswar	81.27	Efficiently suitable to Paddy
7	Cuttack	80.65	Efficiently suitable to Paddy
8	Phulbani	79.43	Suitable to paddy but efficiently suitable to millets
9	Puri	77.29	Suitable to paddy but efficiently suitable to millets
10	Gopalpur	75.48	Suitable to paddy but efficiently suitable to millets
11	Jharsuguda	71.15	Suitable to paddy but efficiently suitable to millets
12	Sambalpur	68.02	Suitable to paddy but efficiently suitable to millets
13	Bolangir	65.77	Suitable to paddy but efficiently suitable to millets
14	Titlagarh	63.72	Suitable to paddy but efficiently suitable to millets
15	Bhawanipatna	59.28	Suitable to millets

part shows only 59 per cent of Ima which is the lowest among all the districts under consideration.

The northeastern part of the state where Ima values are more than 80 per cent comes under paddy zone. The northwestern and the central parts of the state are suitable to paddy but efficiently suitable to millets with the Ima values ranging between 63 per cent and 79 per cent. On the other hand, the southwestern part with less than 60 per cent of Ima values comes under millet zone(Fig. 6).

Paddy yields vs. Drought

From the records of the Agriculture department it was found that paddy is the most dominant crop grown in all the districts of the State as it is the staple food crop. Agro-climatic regionalization of the state has clearly shown that except the northeastern districts of the state, all other areas are not climatically suitable to paddy cultivation. Yet paddy cultivation occupies the maximum area as compared to millets, oilseeds and pulses which can withstand water scarcity conditions. Hence, to examine whether climatic adversities such as drought has any impact on the paddy yields; yearly yields of paddy have been correlated with the years of drought incidence.

In the present study, an attempt has been made to estimate the impact of droughts on the paddy yield for six districts of Orissa namely Cuttack, Ganjam, Mayurbhanj, Keonjhar, Balasore and Phulbani. The average (normal) yields of paddy for 24 years (1976-1999) have been correlated with the yields of drought years. It was observed that in the moderate and severe droughts years, the variation in the yield was not significant. Hence, to get a better understanding the impact of drought on crop yields, drought years of very severe and disastrous nature were examined. Puri and Bolangir districts which have not experienced any very severe and disastrous droughts during the study period were excluded. Standard deviation technique was employed to assess the intensity of drought impact on the paddy yield. For measuring the departures, the average value of paddy yield for twenty four year period was considered as the normal and used as the basis of reference. The intensity of impact on an annual basis has been attempted using the scheme illustrated in Table 8.

Table 8
Orissa: Intensity of Drought Impact on Paddy Yield (Yields in quintals per hectare)

Departure of paddy yield from the normal	Intensity of drought impact
Less than ½ σ	Low
Between ½ σ and σ	Medium
More than σ	High

The analysis based on the above scheme (Table 8) is presented in Table 9.

It was observed from Table 9 that in Cuttack district the severe drought occurred in 1979 affected the paddy yield, which decreased to 12.73 Q/hec from the normal yield of 19.60 Q/hec. Similarly Ganjam district experienced severe droughts in 1979 and 1996 during which the paddy yields were lower than normal. The other stations also experienced lower than normal paddy yields during the years of severe drought as shown in Table 9. On the whole, high impact of drought was observed in four districts namely Ganjam, Keonjhar, Mayurbhanj and Balasore and low impact of drought was observed in the districts, namely, Cuttack and Phulbani. However, drought impact on paddy yield was moderate in Phulbani district in the year 1996.

Conclusion

The study revealed that droughts are a recurrent phenomenon in Orissa as 11 out 24 years of climatic data indicated drought

Table 9
Orissa: Drought vs. Paddy Yields (Quintals per Hectare)

District	**Year**	**Paddy Yield**		**Deviation**	**Intensity of drought impact**
		Normal	**For the Year**		
Cuttack	1979	**19.60**	12.73	-6.87	High
	1996		18.62	-0.98	Low
Ganjam	1979	**21.26**	16.53	-4.73	High
	1996		13.10	-8.16	High
Mayurbhanj	1979	**16.27**	8.62	-7.65	High
	1996		12.44	-3.83	High
Keonjhar	1979	**13.43**	10.59	-2.84	High
	1996		8.08	-5.35	High
Balasore	1979	**16.03**	13.65	-2.38	High
	1996		10.00	-6.03	High
Phulbani	1978	**16.86**	16.50	-0.36	Low
	1979		8.82	-8.04	High
	1996		15.00	-1.86	Moderate

conditions almost all over the state. The drought intensity is more in the southwestern parts of the state as compared to the northern and coastal areas. Out of the three decades of data analyzed, the 1980-89 period recorded maximum number of droughts in the state. Based on the agro-climatic analysis, it can be inferred that paddy yield had decreased in the drought years in Orissa state since paddy requires more water and hence cannot withstand drought conditions. In the absence of supplemental irrigation, the paddy crop is likely to fail. Even in irrigated areas, though the crop could survive yet the yields would be low due to lower moisture adequacy levels that prevail in the state. Hence, it may be suggested that the drought prone areas of the state should prefer the cultivation of millets, pulses and drought resistant crops, which can be grown even in water scarcity conditions. In the irrigated areas these would give more yields when compared to paddy.

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