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Drought investigations and crop water need in Kalahandi district in Orissa

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Abstract
Kalahandi district of Orissa, India is known for drought and water scarcity problems. The agricultural system of the district is dominated by rainfed rice cultivation. The knowledge of the probable period of onset and withdrawal of monsoon and the intervening critical dry spells is important for timely seedbed preparation, selection of crop varieties and contingent planning for supplemental irrigation etc., to derive maximum advantage of monsoon rains for rainfed cropping. Drought frequency, duration, dates of onset and withdrawal of monsoon and intervening critical dry spells have been assessed using hydro-meteorological data. The analysis revealed that the northern parts of the district experience drought with an average frequency of once in every 4-5 years and in the southern parts the drought recur after every 5-7 years. The probability distribution of annual rainfall indicates that the probabilities of occurrence of 75% of its normal rainfall vary from 0.72 to 0.88, and the ranges vary from 800-900 to 2000-2100 mm. This witnesses that the distribution of rainfall is crucial for agricultural system in the district.

The water requirements for different kharif season crops have been estimated and the irrigation requirement for the critical dry spells have been worked out to plan for alternate supplemental irrigation. There is a vast scope for development and exploitation of surface and ground water in Kalahandi. A planned development and exploitation of groundwater may not only contribute as a sustainable source of water for supplemental irrigation but also for tackling the situation during drought.

INTRODUCTION

The district Kalahandi is situated adjoining to the Chhattisgarh region in eastern Madhya Pradesh which is known as "Dhan Ka Katora" (a bowl of paddy) i.e. a well known rice producing region. The location of Kalahandi district is shown in Fig. 1. The agricultural activities of the district are dominated by rainfed rice and rice-based cropping system. The rice-based rainfed cropping is relatively more sensitive to water stress mainly due to intervening dry spells in monsoon season. Paddy alone constitute about 39% of the gross cropped area of the district. The other major crops like maize, greengram, mung, kutki etc. are also grown during kharif season. Onset and length of monsoon govern the entire paddy cultivation in Kalahandi. The selection of crop varieties and time for seedbed preparation depends on the onset of monsoon. Thus, the onset, termination, and distribution of rains during monsoon season play very significant role in the success of agricultural crops in this region. The long dry spells occur within the rainy season and cause misfortune for agriculture and normal life pattern of the region. Scanty, erratic and fluctuative distribution of rainfall in Kalahandi, Nuapada, Balangir and Koraput districts of

Orissa cause crop failures leaving behind devastating effect on economy and populace in the region (Ghose Dastidar, 1997; Dutt, 1986; Sahoo, 1993). Owing to unstable crop yields and non-availability of other employment opportunities, there is large-scale migration of poor people to other districts of the state and Raipur district in Madhya Pradesh. In Normal years, the migration percentage varies from 30 to 40% and in drought year of 1996, this percentage has been around 70-80% (Times of India, October 1996). The district is economically backward and rural in character as only 6.9 per cent of its population live in towns and the percent literacy of the districts is 31.08 as against the state average of 49.09 percent.

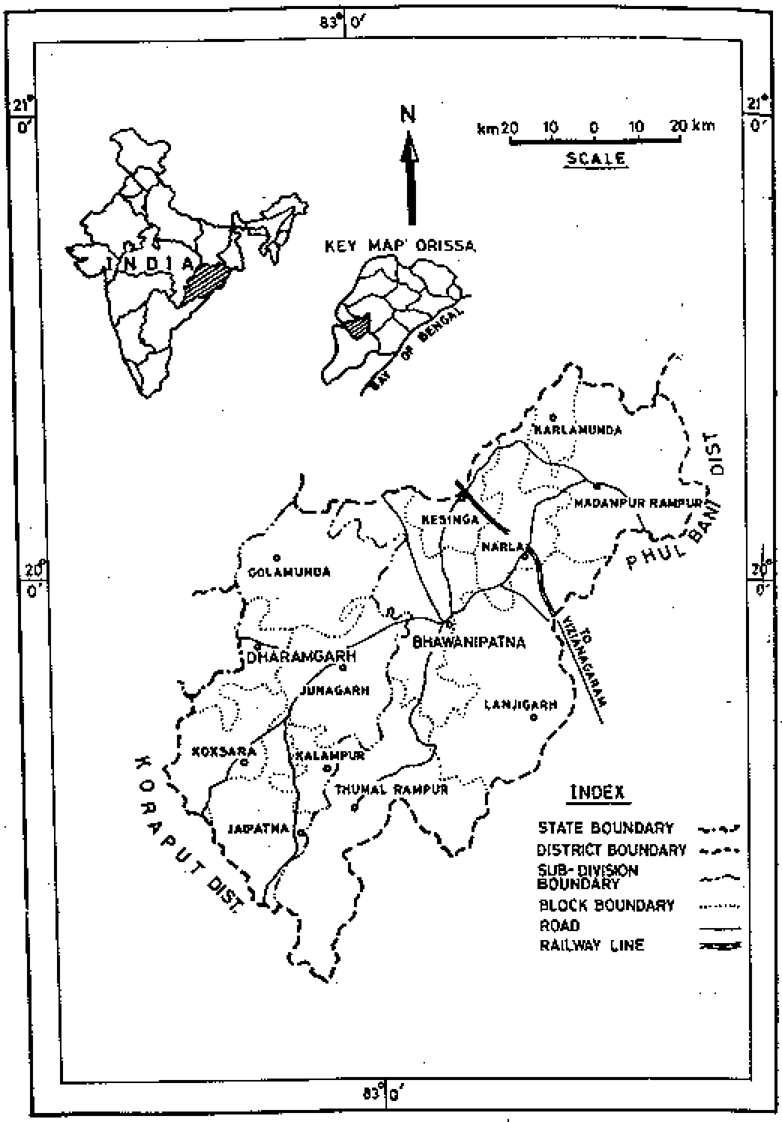

Figure 1. Location map of Kalahandi district.

Lack of irrigation facility is a major constraint in this district. Only 10.02 per cent of the cropped area was irrigated in kharif in 1996-97. Minor (flow and lift) irrigation projects and private sources form the major source of irrigation. Therefore, planning of supplemental irrigation for crops is important to lessen the impact of water stress during drought. There is no criterion available in the literature for supplemental irrigation planning based on critical dry spells and critical crop growth stages (Verma and Sarma,1989). The Critical dry spells are those dry spells, which exceed certain limiting duration identified to be critical to the crop. Of late, more emphasis is being given to store excess runoff in tanks for supplemental irrigation to crops. Hence, there is a need to contemplate suitable criteria for planning of supplemental irrigation to crops for increasing and stabilizing crop yields during non-drought conditions, and minimizing crop damages during drought. The present study is aimed to study hydrological and agricultural aspects of drought based on the analysis of rainfall, evapotranspiration, ground water table, soil characteristics, crop and its critical stages. The study is further aimed at planning of supplementary irrigation requirement for rainfed crops to reduce water stress during critical dry spells in Kalahandi.

GENERAL FEATURES

Kalahandi district may be broadly divided into two distinct physiographic regions, the plain land and the hill tracts. The plain land constitutes the river valleys with isolated hillocks in between and covers about 50 per cent of the total geographical area of the district. The entire hilly regions are covered with dense forests. Kalahandi district is noted for its rich forests covering nearly 30.34 per cent of its total geographical area. Timber and Bamboo are the major forest produce of the district. The other important produces from forests include Tendu leaf, Sabai grass and Mahua-flower.

The climate of Kalahandi district is hot, moist and sub-humid and is known to be of extreme type. It is characterized by a very hot dry summer and a cold winter. May is the hottest and December is the coldest month of the year with mean daily maximum and minimum temperatures of 41^0 C - 28^0 C and 28^0 C-13^0 C respectively. The south-west monsoon is the single largest contributor of monsoon rains.

The soils in the district can be classified into 5 categories, viz. red soil, red and yellow soil, red and black soil, black soil and alluvial soil. Red soil is the predominant among these and occurs in about 48 percent area of the district.

ANALYSIS

Drought implies a deficiency of rainfall of sufficient magnitude over a prolonged duration so as to interfere with some phases of regional economic activities. India Meteorological Department (IMD) prescribe an area/region to be considered drought affected if it receives seasonal total rainfall less than 75% of its normal value (Appa Rao, 1986). The rainfall records of 31 years (1966-96) for different parts of the Kalahandi district were analyzed to study the magnitude and frequency of drought in terms of rainfall deficiency, probability distribution and dry spell analysis etc.

Table 1. Blockwise rainfall distribution and drought years in Kalahandi (1966-996).

Sl. No	Name of the block	Mean annual rainfall (mm)	C.V. (%)	S.D.	Range of rainfall at 75% Probability level (mm)	probability of occurrence equivalent to 75% of normal (in %)	Drought years	Average drought frequency	Longest spell of Consecutive Drought years	Years with more than 25% deficiency in monsoon rains
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	Bhawani-patna	1445.6	27.68	37.42	1100-1200	85 (1084)	68,74,75,87, 88,89,96	4	3	66,68,74,75, 81,87,96
2	Kesinga	1371.0	34.38	43.30	1000-1100	75 (1028)	68,74,75,79, 87,88,89,96	4	3	74,75,87,88, 96
3	Lanjigarh	1185.4	42.36	48.67	800-900	74 (889)	74,79,81,82, 84,87,88	4	3	74,81,82,84, 87,88
4	Karlamunda	1238.5	25.76	29.47	900-1000	78 (929)	72,73,74,83, 87,96	5	3	72,74,83,87, 96
5	Narla	1349.8	24.28	29.67	900-1000	67 (1012)	70,71,73,74, 75,77,87,96	4	3	70,71,73,74, 77,87,88,96
6	M.Rampur	1523.4	24.51	36.47	1200-1300	80 (1142)	74,83,87,88, 96	6	2	74,83,87,88, 96
7	Th.Rampur	2670.2	31.56	85.24	2000-2100	81 (2003)	74,75,76,80, 83,88	5	3	68,74,75,76, 78,80,83,88
8	Dharamgarh	1223.7	22.20	27.62	1000-1100	78 (918)	74,83,86,88, 89,96	5	2	74,83,88,89,96
9	Junagarh	1308.0	25.57	33.75	1000-1100	72 (981)	74,79,86,87, 88,89,92	4	4	74,86,87,88, 89,96
10	Jaipatna	1272.4	36.38	45.28	900-1000	80 (954)	74,82,83,85, 86,87,88,89	4	5	74,81,82,83, 85,86,87,88
11	Golamunda	1111.2	32.24	36.40	900-1000	77 (833)	70,74,79,80, 82,96	5	2	70,71,74,79,80, 82,96
12	Kalampur	1554.7	19.09	29.90	1300-1400	86 (1166)	74,80,86,88	8	1	74,80,86,88
13	Koksara	1586.7	23.42	35.22	1300-1400	87 (1190)	68,74,79,82	8	1	68,74,81,82,83, 95

Note: Rainfall values equivalent to 75% of normal are shown in parenthesis in column (6).

Rainfall departure

The normal rainfall of the district is in the order of about 1378.2 mm. Southwest monsoon contributes about 91% of the average annual rainfall that occurs during June to September in the district (Ghose Dastidar, 1997). In order to identify the drought years and the extent of deficit of seasonal/annual rainfall, the departure analysis has been carried out. A year/season is considered as drought year if the total amount of annual/seasonal rainfall over an area is deficient by more than 25% of its normal value (Appa Rao, 1986). The drought years have been identified and presented in column (7) in Table 1. The longest duration of drought persistent (i.e. maximum numbers of consecutive drought years) is shown in column (9) in Table 1. Mean seasonal rainfall was computed as the arithmetic average of rainfall during June to September, over the period of record. A simple approach to delineate good or bad monsoon years was considered as suggested by Banerjee and Raman (1976), i e., a year to be a bad monsoon year if in more than two-third number of meteorological stations the seasonal rainfall is deficient by more than 25%. For the period from 1966 to 1996, the years during which various blocks of the district Kalahandi experienced seasonal drought are identified and given in column (10) in the Table 1.

Probability distribution of annual rainfall

Probability analysis of annual rainfall is important to predict the relative frequency of occurrence in different group interval of annual rainfall with reasonable accuracy. The probability distribution curves have been drawn by plotting cumulative probability against the various range-groups of annual rainfall at their corresponding midpoint. The graphs of probability distribution of annual rainfall for few blocks in Kalahandi district are shown in Fig. 3. The blockwise average range of annual rainfall at 75% probability level is presented in column (5) in Table 1. The percentage probability of occurrence of 75% of mean annual rainfall has been worked out to delineate the drought proneness of various blocks of the district Kalahandi. An area can be considered as drought prone if the probability of occurrence of 75% of normal rainfall is less than 80% (CWC,1982: Ramakrishna 1986). Percentage probability of occurrence of rainfall equivalent to the 75% of normal is presented in column (6) in Table 1.

Onset and withdrawal of effective monsoon

The date of onset of effective monsoon (EMO) can be defined as the date of commencement of a 7-day spell satisfying the following criteria (Varma and Sarma, 1989; Ashok Raj, 1979; Sahoo, 1993):
First day's rain in 7-days spell is not less than average daily evapotranspiration (ET).

At least four out of seven days are rainy days with not less than 2.5 mm of rain each day.

The total rain during the 7-day spell is not less than (5ET+10) mm.

Using above definition the daily rainfall record from 1966-96 were analysed to identify the date of EMO in respective years. The mean date and standard Deviation (σ) of onset of effective monsoon was calculated as follows:

$$D_m = \sum_{i=1}^{n} \frac{X_i}{n} \quad (1)$$

$$\sigma = \left[\frac{\sum_{i=1}^{n} \left\{ X_i - \left(\sum_{i=1}^{n} \frac{X_i}{n} \right) \right\}^2}{n} \right]^{1/2} \quad (2)$$

Where, D_m is mean date of effective monsoon; X_i = date of onset of effective monsoon in ith year, (i=1,2,...n); n = total number of years for which rainfall data is being analysed; (σ = Standard deviation of date of onset of effective monsoon from its mean date.

Median date of EMO was obtained as the median value of X_i (i=1,2,..n). The earliest and latest probable date of EMO is considered as (D_m-σ) and (D_m+σ) respectively.

Critical dry spell (CDS)

Occurrence of critical dry spells depend upon the rainfall pattern, crop-soil complex of the region under consideration (Ashok Raj,1979; Verma and Sarma 1989; Sahoo, 1993). Normally, a dry spell is defined as the interval of dry days (none of the day have rainfall more than 2.5 mm) between two consecutive wet spells. After the onset of effective monsoon, a wet spell can be defined as a rainy day with rainfall equal to or more than 5ET, Or; a spell of two consecutive rainy days with rainfall totaling at least 5ET, Or; a 7-day period having at least 3 or 4 rainy days with a total rainfall not less than 5ET.

The intervening period of dry days between any two consecutive wet spells is considered as dry spell. Accordingly, the dry spells after the date of onset of effective monsoon were identified for each year of record from 1966 to 96. Similarly, depending on the crop variety and crop duration all the dry spells during crop growing season are identified. If the duration of these dry spells exceeds certain limiting period when the moisture stress is experienced by crops (under rainfed conditions), then the dry spell is called as 'critical dry spell'. Since paddy is the principal crop of the district Kalahandi and the most parts of the district have red and red-mixed soils (i.e. light soil). The rooting system of paddy is inherently incapable of efficiently using moisture from deeper layers, which explains, why paddy is so extraordinarily susceptible to short drought period of 10-15 days (Sharma and Nayak, 1990). On the basis of crop-soil combination the minimum length of a dry spell is considered as 10-days that becomes critical to the crop. Thus, the critical dry spells are identified in the similar manner for all the 31 years of record.

Table 2. Average dates of onset and withdrawal of effective monsoon based on mean in different blocks of Kalahandi

Sl. No	Name of the block	Mean date of onset of mon-soon	Stan-dard devia-tion of onset (days)	Mean date of with-drawal of mon-soon	First CDS		Second CDS		Third CDS	
					Probable period of comencement	Av-er-age Length in days	Probable period of comencement	Average Length in days	Probable period of comencement	Average Length in days
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	Bhawanipatna	18 June	18	20 Sept.	July-II-week	14	Aug-I-weeK	16	Sep-I-week	22
2	Kesinga	20 June	22	19 Sept.	July-I- week	16	Aug-II- week	15	Aug-IV-week	19
3	Lanjigarh	17 June	14	18 Sept.	July-I- week	15	Aug-I-weeK	17	Aug-III-week	21
4	Karlamunda	21 June	13	23 Sept.	July-I- week	19	July-IV- week	20	Aug-IV-week	16
5	Narla	15 June	15	25 Sept.	July-II- week	16	Aug-II-week	18	Aug-IV-week	17
6	M.Rampur	19 June	19	20 Sept.	July-I- week	18	Aug-I- week	21	Aug-IV-week	22
7	Th.Rampur	14 June	15	22 Sept.	July-II- week	13	Aug-III-week	14	Sep-II- week	14
8	Dharamgarh	16 June	19	18 Sept.	July-I- week	21	Aug-I- week	15	Aug-III-week	18
9	Junagarh	17 June	12	16 Sept.	July-II- week	17	Aug-II- week	18	Aug-IV-week	15
10	Jaipatna	15 June	15	20 Sept.	July-II- week	16	Aug-II- week	22	Aug-IV-week	15
11	Golamunda	16 June	13	13 Sept.	July-I- week	21	July-IV-week	15	Aug-IV-week	17
12	Kalampur	14 June	14	16 Sept.	July-I- week	15	Aug-II- week	16	Sep-I- week	16
13	Koksara	14 June	15	19 Sept.	July-II- week	14	Aug-I- week	18	Aug-IV-week	20

For calculating the duration of CDS, an appropriate approach is to divide the crop growth period into some important growth phases according to water demand as evapotranspiration of crop varies according to growth stages. For paddy crop the critical stages for water demand are (i) tillering and (ii) flowering while for maize crop the critical stages are (i) early vegetative stage and (ii) tasselling and silking stage, the later being the most critical (Hiler, 1974; Waldren, 1982). In order to predict probable period of CDS the Median dates of beginning of 1st, 2nd and 3rd CDSs for crop growing season were computed. The corresponding week of the month to which median date belongs, has been taken as the probable period of commencement of critical dry spells. The probable period of commencement of critical dry spells and their duration are presented in the Table 2.

Estimation of crop evapotranspiration and irrigation requirement

The potential reference crop evapotranspiration (ET_p, mm/day) was estimated for 52 standard weeks using modified Penman (1963) method. The ET_p estimates for Bhawanipatna station have been assumed, as the representative for all other blocks, as none of the other stations had required data. In order to account for the effect of crop characteristics on ET_p, the crop coefficients (K_c) for the selected crops were used and to get crop-evapotranspiration (ET_{crop}) as follows.

$$ET_{crop} = K_c \times ET_p \qquad (3)$$

The factors affecting the value of the crop coefficient (K_c) are mainly the crop characteristics, crop planting or sowing period, rate of crop development, length of growing season and climatic condition. The crop growing season has been divided in to four stages (i) initial stage, (ii) crop development stage, (iii) mid-season stage and (iv) late season or ripening stage. Using the guidelines suggested by Doorenbos and Pruitt (1977), the crop coefficient curves for selected major crops i.e. rice, maize, greengram, blackgram, minor millet and sesamum were developed. These crop coefficient curves were utilized to obtain K_c values for different growing phases of the above crops. Using equation 3, the consumptive use (ET_{crop}) for different time interval during the growing periods were estimated for selected crops.

Crop water needs may fully or partly be met by the rainfall. Not all the rainfall be effective, as part may be lost by surface runoff, deep percolation and evaporation etc. Rainfall for any period vary from year to year and therefore, rather than using mean rainfall data (saying roughly one year is drier, the next is wetter), a dependable level of rainfall may be used. Doorenbos and Pruitt (1977) suggested considering the probable rainfall that can be expected 3 out of the 4 years or 4 out of 5 years. With a dry soil surface and little or poor vegetative cover rain up to 8 mm/day may all be lost by evaporation; rains of 25 to 30 mm may be only 60% effective with a low percentage of vegetative cover (USDA, 1969; Doorenbos and Pruitt, 1977; Sahoo, 1993). In this study, the monthly rainfall at 80% probability level has been taken as dependable rainfall. As per the guidelines suggested by U.S. Department of Agriculture,(1969), monthly effective rainfall (ER) was computed using evapotranspiration/ precipitation ratio method (Doorenbos and Pruitt, 1977). Effective rainfall during the probable duration of critical dry spells (CDS) was estimated using interpolation technique.

The total water requirement (ET_{crop}) for different crops was estimated as given in Table 3. For first three critical dry spells, the crops water requirement (ET_{crop}) were worked out as given in Table 4. The irrigation requirement (IR) of crop has been obtained as the difference between crop water requirement (ET_{crop}) and the effective rainfall. Table 4 presents the irrigation requirements of selected crops for critical dry spell periods.

Table 3. Water Requirement for different crops in Kalahandi

Sl.No.	Crop	Crop duration	Sowing date	Water Requirement
1	Rice	95-100 days	June 18	587 mm
2	Maize	110 days	July 5	551 mm
3	Greengram (kharif)	70 days	June 15	297 mm
4	Greemgram (pre-rabi)	65 days	August 20	269 mm
5	Blackgram	85 days	June 25	358 mm
6	Sesamum	90 days	June 15	413 mm
7	Minor millet	65 days	June 20	283 mm

DISCUSSIONS

The long-term annual rainfall series from 1901-1996 for Bhawanipatna (Fig. 2) shows that the meteorological droughts had occurred in Kalahandi after every 5-6 years on an average. The deficiency of annual rainfall varied from 0-62% in the different blocks of Kalahandi. There had been many occasions (years), when one block had received more than its normal rainfall and during the same year another block had experienced severe rainfall deficiency. Out of the 31 years (1966-96) of rainfall records analysed for, there had been about 10 years during which at least 1/3 number of blocks of Kalahandi were affected by drought. The analysis indicate that more than 2/3 numbers of blocks had been affected by drought in the years 1974, 1987, 1988 and 1996. Also the seasonal rainfall analysis indicates that the years 1974, 1987, 1988 and 1996 had been the bad monsoon years for more than 1/2 number of blocks in Kalahandi. The summary of identified drought years is given in Table 1.

The mean annual rainfall in different blocks of Kalahandi varies from 1111.2 mm at Golamunda to 2670.2 mm at Th. Rampur (column 2 in Table 1). The probability distribution analysis of annual rainfall (Fig. 3) shows that the probability of occurrence of rainfall equivalent 75% of normal in different blocks of the district varies from 67% to 87%. The average value of probability of occurrence of rainfall equivalent to 75% of normal, for Kalahandi district is estimated in the order of about 79.5%. Which indicates that the area has good overall chances of receiving a moderate quantity of total annual rainfall for crop survival in kharif season. However, this area had been suffering from frequent failure of crops and severe water scarcity conditions. Thus, it is quite understandable that the distribution of rainfall in time and space, and intervening dry spells during cropping season are responsible for most crop loss events in Kalahandi.

The majority of the farmers in the district belong to illiterate backward class and they believe on traditional type of cropping pattern (paddy croping). Due to inherent characteristic of the rooting system, paddy is incapable of efficiently using moisture from deeper layers of soil and therefore paddy is so extraordinarily susceptible to short dry spells of 10-15 days. Thus, the traditional cropping system in the district is also responsible to some extent in aggravating moderate drought condition in to severe one. Therefore, effective changes in cropping pattern are necessary to reduce the extent of agricultural loses during drought.

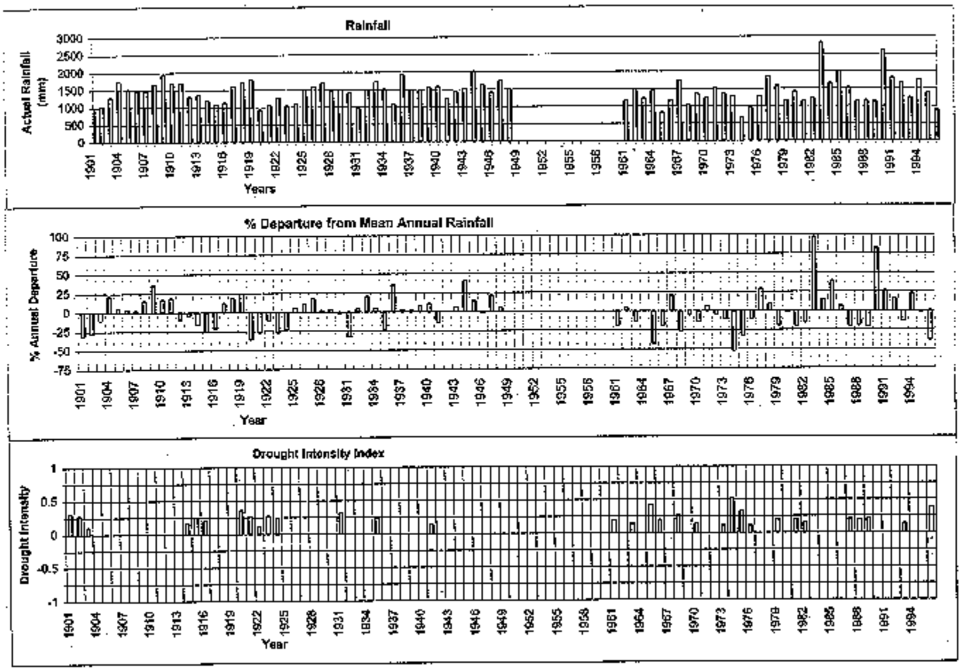

Figure 2. Annual rainfall, Percentage departure and drought intensity at Bhawanipatna.

The Central Ground Water Board, Bhubneshwar (1992-93) reported that the Kalahandi has adequate ground water potential and a significant quantity of this resource is unutilized and it was later supported by Sahoo (1993) also. Only 8% of the total replenishable groundwater is being used for irrigation at present. The estimates of ground water balance are summarised below:

1. Total replenishable ground water resource — 582493 'thousand' m^3/yr
2. Provision for domestic & industrial uses — 87377 'thousand' m^3/yr
3. Utilizable ground water for irrigation — 495116 'thousand' m^3/yr
4. Net ground water draft — 43245 'thousand' m^3/yr
5. Balance ground water resource — 451871 'thousand' m^3/yr

Percentage of balance ground water available for irrigation -- 91.26%

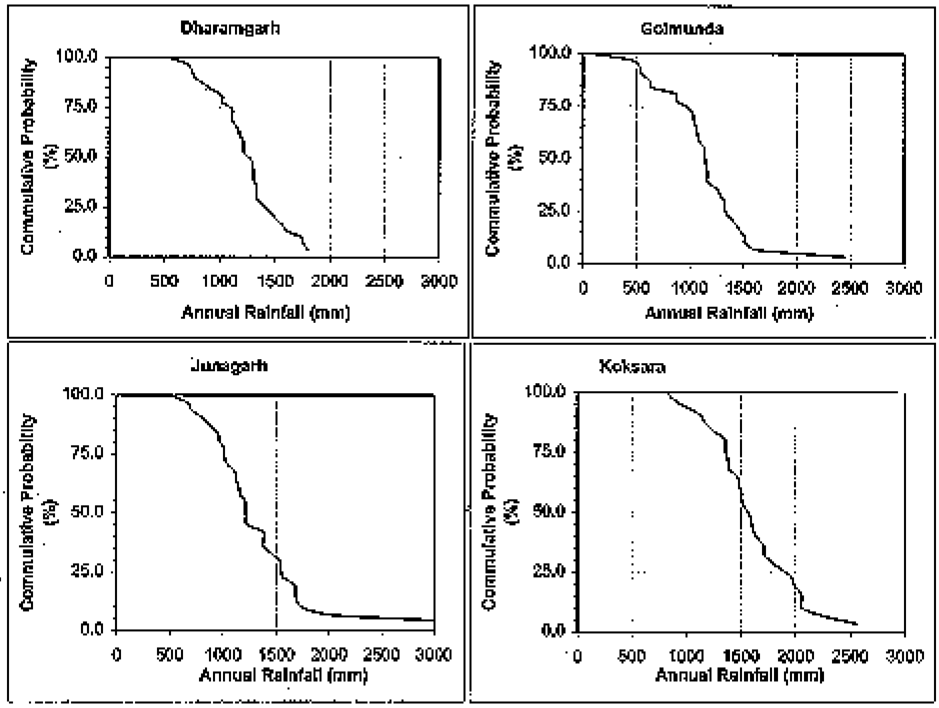

Figure 3. Probability distribution of annual rainfall in different blocks in Kalahandi.

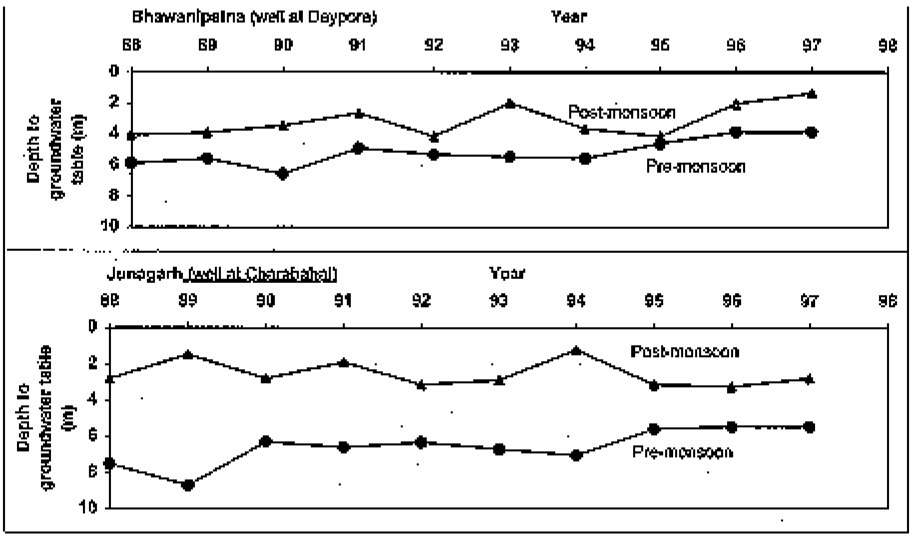

Figure 4. Ground water table fluctuation in different blocks in Kalahandi.

The available groundwater (dynamic storage) can be exploited as supplementary source to meet the important demands of the society during water scarcity or drought. Usually, the change in groundwater storage is a seasonal phenomenon. However, during the period of scarcity of rains or drought, more dependence comes on groundwater storage. The above estimates witness that there is enough scope for development of ground water resources both for irrigation as well as for domestic purposes. Also, the plots of depth to water table (Fig. 4) for last 10 years (1988-1997) show that the ground water table had not depleted much from the average position even during drought years. In other words, the water table was more or less static in all the thirteen blocks. According to information furnished by State Ground Water Dept. Orissa, the underground water bearing layers-the phreatic aquifer is quite extensive and fairly thick to facilitate storage and movement of water. Thus, all the above facts are witnessing to believe that the ground water may provide a sustainable source of water in this area.

The knowledge of mean date of arrival of monsoon is very useful for timely kharif operations to take maximum advantage of monsoon rains. From Table 2, it may be observed that the mean date of onset of effective monsoon (EMO) in different blocks of Kalahandi varies from June 14th to 21st with an average standard deviation of 15.7 days. The average length of monsoon period (based on mean) in different blocks varies from 91-102 days. Therefore, under rainfed condition in Kalahandi, farmer should adopt only such paddy varieties whose crop growth duration is not more than 100 days.

The average number of critical dry spells (CDS) during monsoon season was observed only two CDS per year. However, in some years there were more than two CDS. In 13 out of 31 years of rainfall records, there were more than two CDS. It was also observed that number of CDS in different blocks was not same during a year. The predictions about CDS are of great practical value in selecting suitable crops and their varieties to achieve required level of drought tolerance or to plan for supplemental irrigation at appropriate times of crop need. In order to prevent the crops from moisture stress and to achieve better production, it is essential to have provisions for supplemental irrigation for critical dry spell period.

The crop water requirement (Table 3) indicate that the amount of water required to grow rice (597 mm) and maize (551 mm) crops, is almost twice of that for greengram (kharif) (297 mm) and greengram (pre-rabi) (269 mm). Therefore, in case of delayed onset of monsoon the crops of greengram (kharif) and greengram (pre-rabi) may be more profitable as compare to the crops of rice and maize. Since, the rice crop is very sensitive to water stress and the intervening critical dry spells may cause great loss to it even during a normal year, the provisions of supplemental irrigation are must.

The irrigation requirements (IR) of selected crops were obtained as the difference between crop water requirement (ET_{crop}) and the effective rainfall (ER) for effective critical dry spell duration. The results of estimated irrigation requirements (IR) are given in Table 4. From Table 4, it can be observed that for the principal rice crop, the total irrigation requirement during first three critical dry spells (CDS) varies from a lowest value of 239.01 mm at Th.Rampur to a highest value of 327.27 mm at Karlamunda. It can also be seen that the maize crop has maximum irrigation requirement during the effective CDS in the order of 273.57 mm at M. Rampur and the lowest as 203.05 mm at Golamunda. It is also clear from the Table 4 that during CDSs, greengram (pre-rabi) crop needs only one irrigation during effective CDS. In order to insure full benefit of one-season crops in this region. Table 4 can provide broad guidelines for the supplemental irrigation planning in the district.

Table 4. Water requirement (ET_{crop}) and Irrigation requirement (IR) for selected major crops during effective critical dry spells in different blocks in Kalahandi.

Sl No	Name of the block	Water requirement (ET_{crop}) during effective Critical Dry Spells, (mm)							Irrigation requirement (IR) during effective Critical Dry Spells, (mm)						
		Rice	Maize	Green-gram (kharif)	Green-gram (pre-rabi)	Black-gram	Sesa mum	Minor millet	Rice	Maize	Green-gram (kharif)	Green-gram (pre-rabi)	Black-gram	Sesamum	Minor millet
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	Bhawani patna	299.98	247.68	150.68	38.59	215.97	239.17	116.32	207.48	167.18	92.18	14.59	125.11	128.67	75.32
2	Kesinga	295.19	233.42	148.96	31.00	234.95	244.32	130.04	165.19	111.26	51.06	--	111.47	114.32	43.04
3	Lanji-garh	319.0	241.22	194.55	23.91	256.10	302.23	149.06	222.0	144.22	95.55	--	159.10	185.43	62.06
4	Karla-munda	327.27	220.46	197.19	24.65	243.28	289.99	201.80	232.77	125.96	130.79	--	148.96	195.491	114.80
5	Narla	298.94	240.57	164.80	22.54	251.49	280.33	161.82	204.44	147.07	99.30	--	156.99	85.83	74.82
6	M.Ramp ur	253.93	273.57	188.19	38.59	228.86	301.41	185.56	249.93	158.47	101.19	10.59	113.86	206.91	98.56
7	Th.Ram pur	239.01	206.59	103.05	55.46	163.01	164.51	106.40	112.01	99.19	23.05	8.46	47.46	61.31	26.40
8	Dharam garh	325.12	225.04	212.23	16.53	249.56	263.54	179.12	214.36	134.04	121.23	--	158.56	172.54	110.12
9	Juna-garh	288.33	237.78	165.30	22.54	250.37	284.65	167.89	185.33	134.78	90.30	1.54	147.37	181.65	92.89
10	Jaipatna	307.24	254.30	179.77	22.54	262.84	299.69	167.50	217.24	164.30	110.77	--	172.84	209.69	98.50
11	Gola-munda	319.14	203.05	191.2	26.76	217.41	269.32	181.47	180.14	65.90	86.20	--	78.41	130.32	76.47
12	Kalam-pur	279.70	229.98	132.27	47.49	180.28	208.60	129.03	186.70	136.98	69.72	17.49	87.28	115.60	66.03
13	Koksara	303.16	235.52	167.79	33.11	251.14	269.55	173.47	195.16	130.06	93.79	--	143.14	161.55	103.47

CONCLUSIONS

The majority local farmers believe on traditional system of cropping. The traditional rice cropping system under rainfed conditions increases the risk of crop loss during drought.

Droughts of moderate to severe intensity reocur with average frequency of every 4 years in Bhawanipatna, Kesinga, Langigarh, Junagarh and Jaipatna blocks and every about 5 years in Karlamunda, Th. Rampur, Dharamgarh and Golamunda. The Kalampur and Koksara blocks had experienced minimum number of droughts (i.e. once in every 8) during the period from 1966-96. However, M.Rampur block had been facing drought after every 6 years.

The years 1974, 1987, 1988 and 1996 had been the bad monsoon years with seasonal rainfall deficiency in the order of 40-66% and had caused severe water stress and crop loss in more 2/3 number of blocks in Kalahandi.

The period between 14th June to 21st September is found as the average length for south-west monsoon season (about 99 days).

The intervening dry spells during cropping season had significant role in seasonal water scarcity problems and crop loss in Kalahandi. On an average the monsoon period incorporates two-to-three intervening critical dry spells.

The water requirement for any kharif season crop was found less than mean monsoon season rainfall in the district. However, there is a need for provisions of supplemental irrigation to meet the crop water requirement during the dry spell periods to lessen the impact of water stress to the crops.

There is enough scope for development and exploitation of ground water. A planned development and exploitation of available ground water may not only contribute as a sustainable source of water for supplemental irrigation but also for tackling the situation during drought.

RECOMMENDATIONS

The efforts are needed to promote crop diversification. The traditional rice cropping system, under rainfed conditions, need to be suitably substituted by low water dependent crops like pulses, oilseeds and horticulture crops.

In view of the average length of monsoon period and soil characteristics of this area, the farmers should be advised to adopt short duration paddy varieties (i.e. <100 days).

Both the surface and ground water resources are much underutilized. There is need to focus on alternative provisions for supplementary irrigation, through planned water resources development, to check the severe drought hardship in this region.

References

Anil Mahajan, 1991. Human Encounter with drought. P.K.Nayak and Anil Mahajan eds., Reliance Publishing House, New Delhi.

Appa Rao, G., 1986. Drought climatology, Jal Vigyan Samiksha, Publication of High Level Technical Committee on Horology, National Institute of Hydrology, Roorkee

Banerjee, A. K. and C. R. V. Raman, 1976. One hundred years of Southwest monsoon rainfall over India, Scientific Report No. 76/6, IMD, Pune, India.

Central Water Commission (CWC), 1982. Report on identification of drought prone areas for 99-districts, New Delhi.

Department of Economics & Statistics, 1998. Districts at a glance-1998, Orissa, Bhubaneswar.

Department of Revenue, Orissa, 1974. White Paper on natural calamities. Govt. of Orissa, December 2nd , 1974.

Department of Revenue, Orissa, 1976. White Paper on natural calamities. Govt. of Orissa, December 6th , 1976.

Dutt, D. K., 1986. Management of ground water under drought conditions, Jal Vigyan Samiksha, Publication of High Level Technical Committee on Horology, National Institute of Hydrology, Roorkee

Doorenbos, J. and W. Q. Pruitt , 1977. Crop water requirements. FAO Irrigation and Drainage Paper No. 24, FAO, Rome.

Ghose Dastidar, P.K., 1997. Prevention of drought in Orissa-some remedial measure. Souvenir of Workshop on Prevention of drought in Orissa, January 9-10, IIM&MS, Bhubaneswar.

Hiler, E. A., T. A. Howell, P. B. Iewis and R. P. Boos, 1974. Irrigation timing by the stress day index method. Trans. ASAE, Vol. 17, No. 2, 393-398 pp.

National Commission on Agriculture, 1976. Climate and agriculture, Part IV. Govt. of India, Ministry of Agriculture and Irrigation, New Delhi.

Penman, H.L., 1963. 'Vegetation and hydrology', Tech. Comm. No. 53, Commonwealth Bureau of Soils, Harpenden Engg. pp-125.

Sahoo, M. K., 1993. Analysis of drought phenomenon of pre-divided Kalahandi district of Orissa. M. Tech. Thesis, Dept. of Soil and Water Conservation Engineering, Orissa University of Agriculture and Technology, Bhubaneswar.

Sastry, P.S.N., 1986. Meteorological drought, Jal Vigyan Samiksha, Publication of High Level Technical Committee on Horology, National Institute of Hydrology, Roorkee

Sharma, S.D. and S. C. Nayak, 1990. Rainfall pattern in orissa and its storage needs for assured crop production, procedings of the workshop on research needs on land and water management for enhancing agricultural production in eastern region, Water Technology Center for Eastern Region, Bhubaneshwar, 4-5 Oct, 1990.

Sharma Devinder, 1997. Wet desert: Kalahandi's thirst for water continues. Times of India (daily news paper), Friday, June 27.

U.S. Department of Agriculture, 1969. Irrigation water requirement, Tech. Paper No. 21, Engg. Div. SCS 83p.

Verma, H. N. and P. B. S. Sarma, 1989. Critical dry spells and supplemental irrigation to rainfed crops. Jour. of Indian Society of Water Resources, vol 9, No 4, 12-16 pp.

Waldren, R. P., 1982. Corn. In crop water relations. Ed. by Tear, I.D. and Peet, M.M., John Wiley and sons, 187-206 pp.