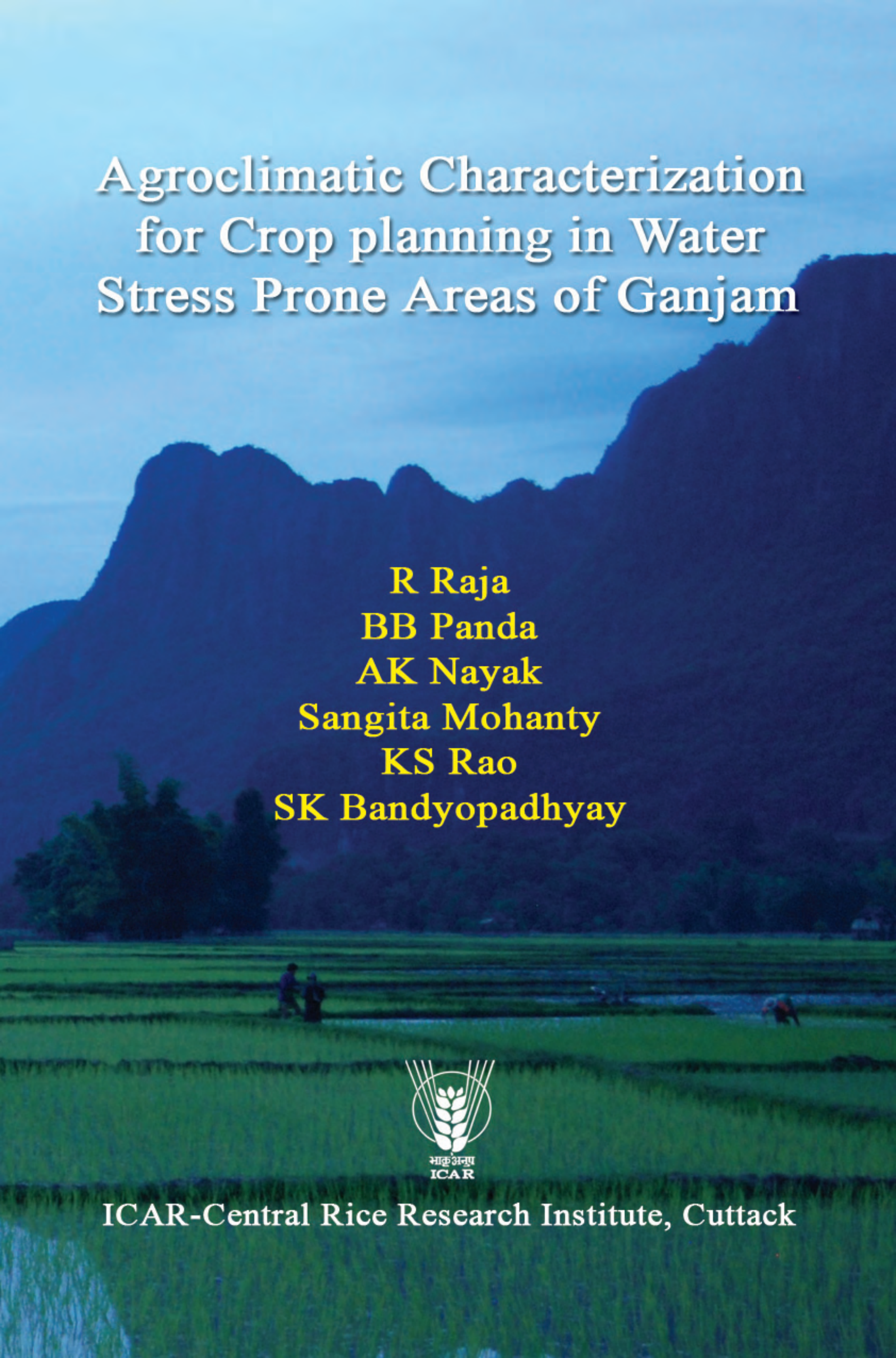

Agroclimatic Characterization for Crop planning in Water Stress Prone Areas of Ganjam

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2014

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Citation: Raja R, Panda BB, Nayak AK, Mohanty S, Rao KS and Bandyopadhyay SK (2014). **Agroclimatic characterization for crop planning in water stress prone areas of Ganjam**. ICAR-Central Rice Research Institute, Cuttack, India. p. 50

Published by:
Dr. Trilochan Mohapatra
Director, ICAR-Central Rice Research Institute, Cuttack (India)

Cover and layout: Mr. Sunil Kumar Sinha

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Laser typeset at the ICAR-Central Rice Research Institute, Cuttack (Odisha) 753006, India, and printed in India by the Print-Tech Offset Pvt. Ltd., Bhubaneswar (Odisha) 751024. Published by the Director, for the ICAR-Central Rice Research Institute, Cuttack (Odisha) 753006.

PREFACE

Rice is the staple food for more than 50% of world population and 85% of Indian population. The country has achieved a record rice production of 106.5 million tons during 2013-14 through the concerted efforts of agricultural scientists and rice farmers supported by government policies. However, to ensure food and nutrition for the ever-growing population in the face of declining resource base, falling factor productivity, increasing cost of production and adversities due to climate change, the efforts to increase rice production have to be sustained. Out of the total 44 million ha of rice area in the country, 18.8 million ha is under rainfed condition, of which 67% lies in the eastern India. Though farming practices in these regions have developed over years as a response to climatic risks, farmers are facing the challenge of the increase in extreme climatic events associated with climate change, such as increasing severity and frequency of floods and droughts.

Monsoon plays a vital role in success or failure of the rainfed rice in Eastern India. With advancement in science, now scientists are able to partly understand the performance of monsoon over years. To derive maximum and sustained yield, farmers should have proper knowledge of the agro climatic resources of the location including the prevailing weather and climatic conditions as well as the impact of the climatic variability on crop performance. In this context, analyses of historical agromet data of a location are a valuable tool in crop planning.

An attempt has been made in this bulletin to analyze the historical agromet data of Purusottampur and Khalikote blocks of Ganjam district. Based on the results, suitable crop management and contingency plans are formulated and presented. We believe that the information provided through tables and figures must be useful to planners, extension workers and other stakeholders to make the rainfed rice system productive.

We are thankful to various organizations such as the Central Research Institute for Dryland Agriculture, Hyderabad, India; India Meteorological Department, Pune, India; Directorate of Economics and Statistics as well as Directorate of Agriculture, Government of Odisha, Odisha, India, for sharing the historical archive of agrometeorological and crop statistical data.

We express our sincere thanks to Dr T. Mohapatra, Director, CRRI, Cuttack for his encouragement and inspiration. We are very much thankful to Dr. V.U.M. Rao, Project Coordinator (AICRPAM) and Mr. A.V.M.Subba Rao, Scientist Senior Scale (Agromet), CRIDA, Hyderabad for their guidance in agro-climatic analysis of the study area. We also thank the National Agricultural Innovation Project and World Bank Global Environmental Facility for funding the project "Strategies to enhance adaptive capacity to climate change in vulnerable regions" under which the study was taken up.

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Introduction

With the ever-increasing need for food, shelter and energy, maximizing the food grain production in a sustainable manner has become the most important aspect of agricultural research. Despite the rapid strides made in increasing the food grain production including rice around the world, agriculture still continues to depend on favourable climate especially in the semi-arid and sub-humid regions of India, where rainfall is highly variable and undependable. Though farming practices in these regions have developed over years as a response to such climatic risks, farmers are facing the challenge of the increase in extreme climatic events associated with climate change, such as increasing severity and frequency of floods and droughts. Any change in the current climate scenario would further deepen the risk to agricultural productivity.

Rice is unique among the major food crops in its ability to grow in a wide range of hydrological situations, soil types, and climates. Farmers in Eastern India prefer to grow rice over other crops during wet season (June to November) because rice is the only cereal that can grow in wetland conditions. Depending on the hydrology of where rice is grown, the major rice ecosystems are classified into rainfed uplands, rainfed lowlands and irrigated medium lands and occupy 16%, 39% and 45% of rice area in Eastern India, respectively. The rainfed rice ecosystem is characterized by diverse agro-climatic and socio-economic conditions. It covers areas with favourable as well as unfavourable environments, like drought, submergence/flood, adverse soils, etc., which are complex, variable and heterogeneous. Hence, to derive maximum and sustained yield from these areas, farmers should have access to proper knowledge of the agro climatic resources of the location/region including the prevailing weather and climatic conditions as well as the impact of the climatic variability on crop performance.

Weather, the day-to-day state of atmosphere, consists of short-term variation of energy and mass exchanges within the atmosphere and between the earth and the atmosphere. It results from processes attempting to equalize differences in the distribution of net radiant energy from the sun. Acting over an extended period of time, these exchange processes accumulate to become *Climate*. In simple terms, climate is the synthesis of weather at a given location over a period of about 30 years. Climate, therefore, refers to the characteristic condition of the atmosphere deduced from repeated observations over a long period. More than a statistical average, climate is an aggregate of environmental conditions involving heat, moisture and air motion. Any study of climate must consider extremes in addition to means, trends, fluctuations, probabilities and their variations in time and space (Kesava Rao *et al.*, 2006). The importance of climate assumes greater importance in rainfed regions where moisture regime during the cropping season is highly variable and is strongly dependent on the quantum and distribution of rainfall *vis-à-vis* the soil water holding capacity and water release characteristics. In addition, weather abnormalities such as cyclones, floods, droughts, hailstorms, frost, high winds and extreme temperatures will lead to natural disasters affecting agricultural productivity. A thorough understanding of the climatic conditions will help in devising suitable management practices for taking advantage of the favourable weather conditions and avoiding or minimizing risks due to adverse weather conditions.

Study area

Ganjam is the most backward coastal district of Odisha which is included as one of the 150 most disadvantaged districts in India by the Planning Commission. Ganjam district is broadly divided into two divisions, the coastal plains area in the east and hill and tablelands in the west. The Eastern Ghats runs along the western side of the district. The plain area lies between the Eastern Ghats and the Bay of Bengal. The plains are narrow because of the absence of big rivers. The coastal plains in the east contain more fertile and irrigated lands. The Bay of Bengal touches the eastern frontier of Ganjam district and its coast extends over 60 kilometres. The rivers like Rushikulya, Dhanei, Bahuda, GhodaHada, Harabhangi, and Loharkhandi, Baghua and Kharkhari are the prominent ones which govern the agriculture and power sectors of the district. The vast river basin of Rushikulya provides grand potential for exploration of ground water. The district has alluvial soil in its eastern part (coastal region) and laterite soil in the west (hilly table land) with small patches of black cotton soil at the centre and in the northeast. The forest of Ganjam district comes under the mix moist peninsular high and low level Sal forests, tropical moist and dry deciduous and tropical deciduous forest types.

Total geographical area of the district is about 8,71,000 ha and the area under different land uses for the year 2010-11 are presented in Table 1.

Agriculture is the main livelihood of the people, and partially supported by livestock. Based on land holdings, 69% of the farmers are marginal (having <1.0 ha), 20% are small (1-2 ha) and 11% are medium (having 2-

Table 1. Area under different land use categories in Ganjam

Categories of land use	Area (ha)
Forest	48,000
Land put to non-agricultural uses	79,000
Barren & uncultivable land	46,000
Permanent pastures and other grazing land	16,000
Land under misc. Tree crops & groves not included in net area sown	26,000
Cultivable waste	21,000
Old fallows	32,000
Current fallows	49,000
Net area sown	2,93,000
% of the geographical area	70.3%
Area not included under survey	2,61,000
Total geographical area of the district	8,71,000

(Source: Technical report on Establishment of an agency for reporting agricultural statistics (EARAS), 2009-10 & 2010-11, Directorate of Economics & Statistics, Odisha)

10 ha). Main *kharif* crop of the district is rice while vegetable, oil seeds and pulses are grown during the *rabi* season. Rice is cultivated in an area of about 2,52,000 ha of which upland rice occupies 39,000 ha while the medium land rice and low land rice occupies 1,12,000 ha and 1,01,000 ha, respectively. The average rice productivity (2009-10) in the district is 2023 kg ha^{-1}. Thus there is a scope for enhancing productivity and cropping intensity through technological interventions and integrated management practices.

As Ganjam district lies in close proximity to the seashore, it is mostly affected by cyclone and floods from two major rivers namely, Rusikulya and Badanadi. Floods are a perennial problem and are most unpredictable. Every year they come, leave the poor with less grain, less money and less hope. Flooding can occur at different times. When the flood occurs soon after sowing/planting, rice seedlings are destroyed. When the flood water recedes, there is not much time to prepare seedlings for the next crop through the traditional method. In case of mid-season or terminal floods also most often the entire crop gets damaged and in turn affects the

Rice crop damaged due to flood and drought in Purusottampur and Khalikote blocks of Ganjam

livelihood of people. Many-a-time, the district also faces drought due to vagaries of monsoon. The chronology of flood in Ganjam district is presented in Table 2. Recurrent natural calamities have been a major stumbling block in the path of socio-economic development of the farmers of this district.

The National Agricultural Innovation Project "*Strategies to enhance adaptive capacity to climate change in vulnerable regions*" funded by World Bank Global Environmental Facility was taken up by Central Rice Research Institute (CRRI), Cuttack in the flood prone areas *viz*., Pratapur, Badgaon, Gothiali, Hindolopalli and Mendhapalli villages of Purusottampur block and Badarampali, Komonda and Balia villages of Khallikote block of Ganjam district with an objective to enhance the adaptive capacity of the farmers and other stakeholders to the changing climate with development in agriculture and allied sectors. In this bulletin, agroclimatic analysis of Purusottampur and Khalikote blocks has been carried out and suitable crop management and contingency plans are formulated and presented.

Table 2. Chronology of flood in Ganjam district

Year	Month of Occurrence
1964	July-August
1980	September
1982	August-September
1984	June- September
1985	August-September
1990	May
1991	July-August
1992	June-August
1995	May- November
1999	July - August
2003	July-October
2006	July - August
2007	July, August and September
2008	June and September
2009	July
2010	August, December

Data and methods

The districts in Odisha are administratively divided into blocks. There are 22 blocks in Ganjam district. Agroclimatic analysis of Purusottampur and Khalikote blocks (Fig 1) was carried out on the basis of agromet data for the period 1982-2011. Daily precipitation data from rain gauge station of Purusottampur and Khalikote blocks were collected from Agromet Databank, Central Research Institute for Dryland Agriculture, Hyderabad, India. Daily data on maximum and minimum temperatures, relative humidity (both morning and afternoon), wind speed and evaporation of Gopalpur were collected from India Meteorological Department (IMD), Pune for the period of 1982-2008. Block level rice productivity for wet season (June to November) were obtained from the Directorate of Economics and Statistics, Odisha. Soil information published by NBSS&LUP (2000) was used. The soil resource and land slope map of the study area are presented in Fig 2.

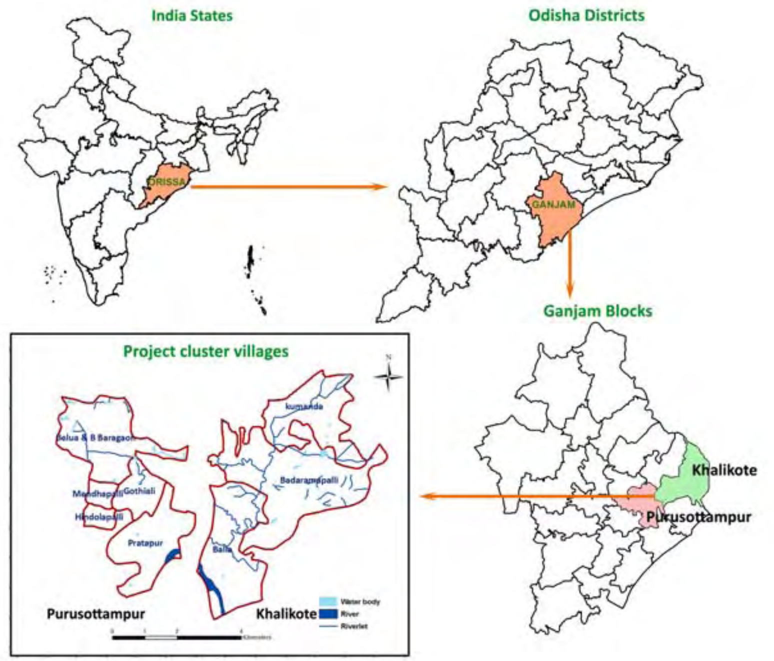

Fig 1. Study area map

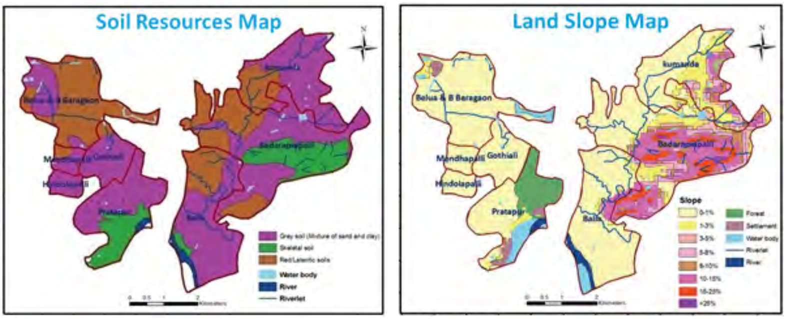

Fig 2. Soil resource and land slope map of the study area

Agroclimatic characteriza-tion of the target blocks was carried out following well-known and popular methods. Rainfall variability was studied following the method of IMD. Incomplete gamma and Markov-chain methods were used for studying rainfall probabilities. Modified FAO-Penman-Monteith method (Allen 1998) was used to estimate potential evapotranspiration. Plant extractable water was estimated from soil characteristics. Modified Thornthwaite and Mather (1955) method was used to compute water balances. Length of growing period (LGP), dry and wet spells during the crop growth period were calculated based on Index of Moisture Adequacy (IMA).

Standardized Precipitation Index (SPI), calculated at different time scales, e.g., 1- or 3-month SPI of a particular month, represents the deviation in total precipitation amounts for the same month and current plus previous two months, respectively. The 1- and 3-month SPI were computed for 168 rain gauge stations using monthly rainfall data of the wet season for the period of 1982–2008 by equation:

$$SPI_{ij} = (X_{ij} - \mu_{ij})/\sigma_{ij}$$

where, SPI_{ij} is the SPI of i^{th} month at j^{th} time-scale; X_{ij} is precipitation total for i^{th} month at j^{th} time-scale; μ_{ij} and σ_{ij} are long-term mean and standard deviation associated with i^{th} month at j^{th} time-scale.

Climatic conditions of the study area

Monthly climatic conditions of the study area are presented in Table 3. The study area is characterized by an equable temperature and higher relative humidity all through the year. May month is the hottest while December remains the coolest month. Winds are fairly strong particularly in summer and monsoon months.

Rainfall climatology of the target blocks

Annual and seasonal rainfall

Analysis of annual and seasonal rainfall of the target blocks was carried out using rainfall data from 1982 - 2011 and the results are presented in Fig 3 and 4. The year wise annual and seasonal rainfall received in Purusottampur and Khalikote blocks are presented in Annexure 1. June to September is considered as ‘southwest monsoon (SWM)’ season, October to December as ‘northeast monsoon (NEM)’ season, January and February as ‘winter’ and March to May as ‘summer’ season.

Table 3. Monthly climatic conditions of the study area

Month	Temperature (°C)		Relative humidity (%)		Wind speed (kmph)	Daily evaporation (mm)
	Max	Min	RH I	RH I		
January	27.7	17.3	80	72	6.0	3.8
February	29.5	20.0	78	75	6.7	4.2
March	31.1	23.1	82	80	8.4	4.9
April	31.6	25.2	86	82	10.9	5.1
May	32.8	26.8	83	80	11.6	5.7
June	32.5	27.0	82	82	8.8	4.8
July	31.6	26.3	85	85	8.0	4.4
August	31.5	26.1	85	85	8.1	4.0
September	32.3	25.9	84	83	6.6	4.5
October	31.9	23.9	82	76	5.4	5.1
November	30.3	20.2	79	69	6.1	4.4
December	28.4	17.2	78	68	6.0	4.1

(Source: Gopalpur IMD Station, Ganjam)

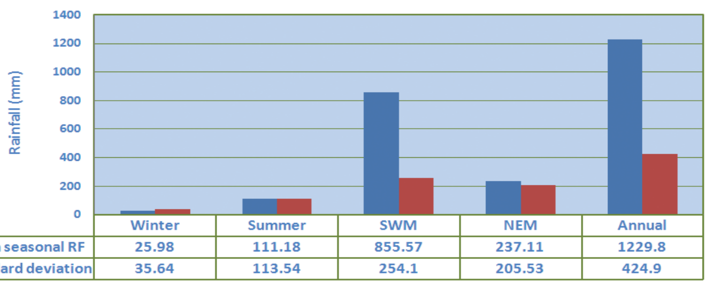

Fig 3. Mean annual and seasonal rainfall (mm) of Purusottampur

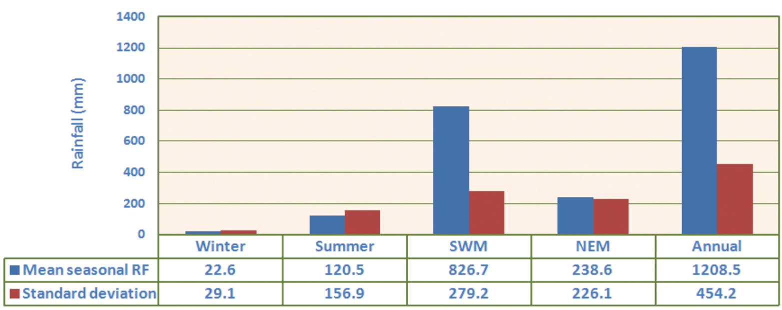

Fig 4. Mean annual and seasonal rainfall (mm) of Khalikote

The mean annual rainfall of Purusottampur block is 1230 ± 425 mm with a coefficient of variation (CV) of 34.5%. The Kahlikote block, which is situated near the Purusottampur is having slightly lesser annual rainfall of 1208 ± 454 mm with a coefficient of variation of 37.6%. Contribution of SWM and NEM rainfall to the annual is about 70% and 19% in Purusottampur and 68% and 20% in Khalikote, respectively. Contribution of NEM to the tune of 20% in both the blocks indicates the prolonged nature of rainfed crop-growing season. Analysis of standard deviation (SD) and coefficient of variation indicate a great year-to-year variability in rainfall. Rainfall variability in the NEM season is more than twice than that of the SWM season in both the blocks.

Based on the rainfall data of 29 years, extremes of rainfall in the SWM and NEM seasons were identified and presented in Table 4. There exists a great variation in the rainfall extremes in both the blocks. During the SWM season, Purusottampur recorded the highest rainfall of 1295 mm during 1989 while Khalikote recorded the highest SWM rainfall of 1325 mm during 2006. However, the same SWM rainfall could be as low as 309 mm at Purusottampur and 287 mm in Khalikote, respectively during the year 2000 indicating the magnitude of rainfall extremes in both the blocks. During the NEM season, the highest rainfall received is 771 mm in Purusottampur and 810 mm in Khalikote, respectively. Non occurrence of rainfall during NEM season in both the blocks in some years indicates the possibility of early cessation of monsoon and possible terminal moisture stress to the long duration rice varieties which is predominantly grown in rainfed lowland ecosystem.

As per the method of IMD, seasonal variability of rainfall was assessed based on the rainfall deviation from the normal (Table 5). Years were classified into four categories as *Excess* (>20%), *Normal* (19 to –19%), *Deficit* (–20 to –59%) and *Scanty* (less than –59%).

Table 4. Extreme rainfall characteristics of the study area

Rainfall	Purusottampur		Khalikote	
	Highest	Lowest	Highest	Lowest
Annual (mm)	2104.7 (1995)	423.0 (2000)	2118.0 (1986)	334.0 (2000)
Southwest monsoon (mm)	1295.2 (1989)	309.0 (2000)	1325.0 (2006)	287.0 (2000)
Northeast monsoon (mm)	771.0 (1986)	0.0 (2000)	810.0 (1986)	0.0 (2000)

**Figures in paranthesis indicate the year of occurrance*

Table 5. Variation in seasonal rainfall at the study area

Particulars	Number of years in rainfall category			
	Excess	Normal	Deficit	Scanty
Purusottampur				
Annual	7	14	7	1
Southwest monsoon	5	20	3	1
Northeast monsoon	10	4	8	7
Khalikote				
Annual	7	17	3	2
Southwest monsoon	5	18	4	2
Northeast monsoon	8	4	7	10

Table 5 shows that during the southwest monsoon season in both the blocks, rainfall was generally either in normal category or in excess/deficit category. Very rarely was the rainfall *scanty* during this season. During the NEM season, both the blocks have considerable number of years with excess/*scanty* rainfall indicating the chances of possible terminal floods in lowlying areas or terminal moisture stress situations in medium and upland areas.

Monthly rainfall

Information on the monthly rainfall for a location is helpful for crop planning, cultivar selection, run off estimation, determining crop water needs and for formulating rainwater management/ irrigation management strategies. The perusal of mean monthly rainfall of target blocks revealed that August is the wettest month in both the blocks followed by July, September and June in that order (Table 6). Albeit, highest rainfall is received during August, rainfall during July is associated with least variability indicating its consistency *vis-à-vis* other months. The year wise monthly rainfall received in Purusottampur and Khalikote blocks are presented in Annexure 2a and 2b.

Analysis of extreme values of monthly rainfall in the SWM season indicated that in certain years, rainfall could exceed more than twice the average for that month. In the other seasons, the variation could be much higher. Results of such analysis for both the blocks are shown in Fig 5 and 6. June to September has low variation compared to the average, and May and November show extreme variations, indicating the high risk associated with rainfall.

Table 6. Mean monthly rainfall of Purusottampur and Khalikote

Month	Purusottampur				Khalikote			
	RF (mm)	% of annual RF	SD	CV	RF (mm)	% of annual RF	SD	CV
January	8.2	0.7	17.6	215.4	6.7	0.6	12.7	190.4
February	17.8	1.4	33.1	185.9	16.0	1.3	28.5	178.2
March	16.0	1.3	25.0	156.1	22.5	1.9	35.2	156.3
April	22.7	1.8	30.2	133.2	26.3	2.2	28.8	109.3
May	72.5	5.9	114.1	157.4	71.7	5.9	137.4	191.8
June	154.6	12.6	92.4	59.8	133.9	11.1	83.3	62.2
July	244.4	19.9	110.6	45.3	233.6	19.3	107.4	46.0
August	264.2	21.5	126.0	47.7	279.5	23.1	144.5	51.7
September	192.4	15.6	115.2	59.9	179.8	14.9	120.9	67.2
October	159.7	13.0	147.0	92.0	163.4	13.5	160.5	98.2
November	70.6	5.7	100.5	142.3	67.3	5.6	106.6	158.4
December	6.8	0.6	17.7	261.3	7.9	0.7	22.1	279.2
Annual RF	1229.9	100	424.9	34.5	1208.5	100	454.2	37.6

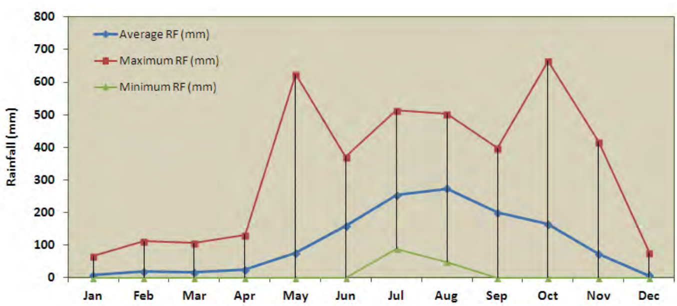

Fig 5. Monthly range of rainfall at Purusottampur

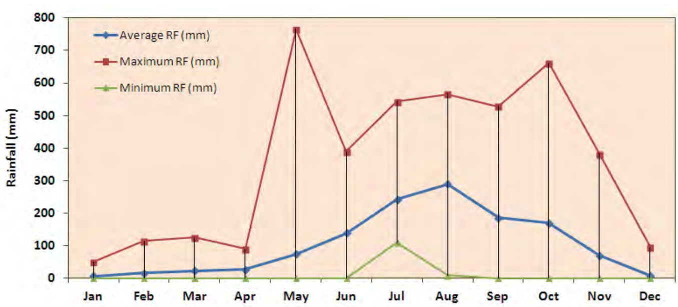

Fig 6. Monthly range of rainfall at Khalikote

Weekly rainfall

Commencement of growing season, length of growing season, choice of cropping systems, allocation of resources and inputs depend significantly on the weekly distribution of rainfall. Average distribution of rainfall on a weekly basis for the target blocks are presented in Fig 7 and 8. Considerable rainfall occurs (>20mm/week) in Purusottampur block in the period from 23 Meteorological Standard Week (MSW) (4-10 June) to 44 MSW (29 Oct – 4 Nov) indicating an average total growing period of 22 weeks (around 150 days). In case of Khalikote block considerable rainfall occurs in the period from 24 MSW (11-17 June) to 44 MSW (29 Oct - 4 Nov) indicating an average total growing period of 21 weeks (around 145 days).

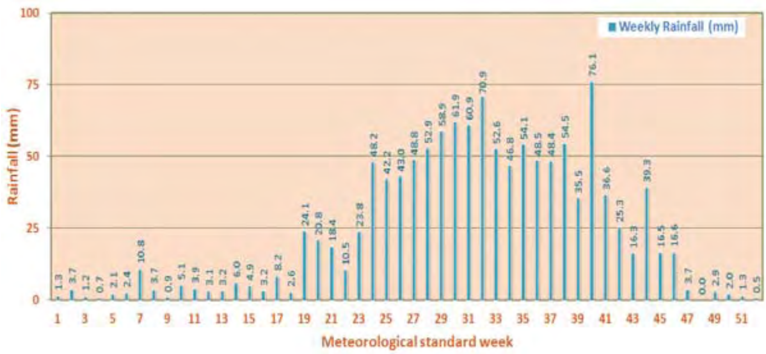

Fig 7. Mean weekly rainfall of Purusottampur

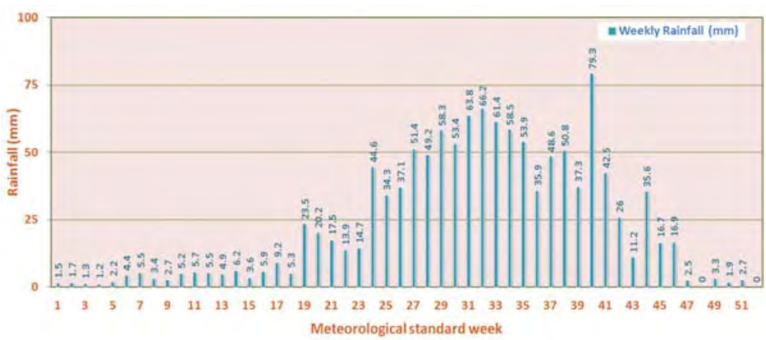

Fig 8. Mean weekly rainfall of Khalikote

Rainy days

Knowledge on the amount of rainfall and rainfall intensity helps in understanding the water balance components as well as the water harvesting potential at a location. India Meteorological Department has defined a rainy day as a day that receives at least 2.5 mm of rainfall. The mean annual and seasonal rainy days of both the blocks are presented in Fig 9 and 10 and Annexure 3. Both the blocks on an average recorded 40 and 9 rainy days during SWM and NEM, respectively.

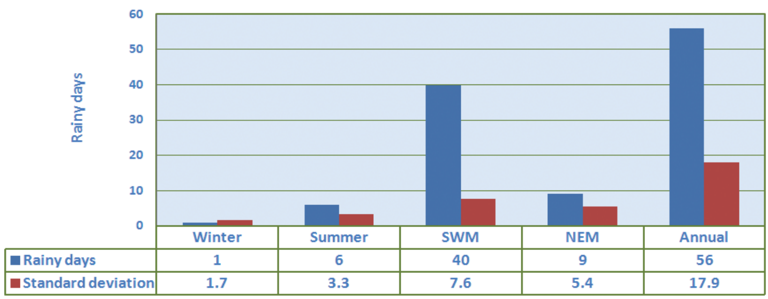

Fig 9. Mean annual and seasonal rainy days of Purusottampur

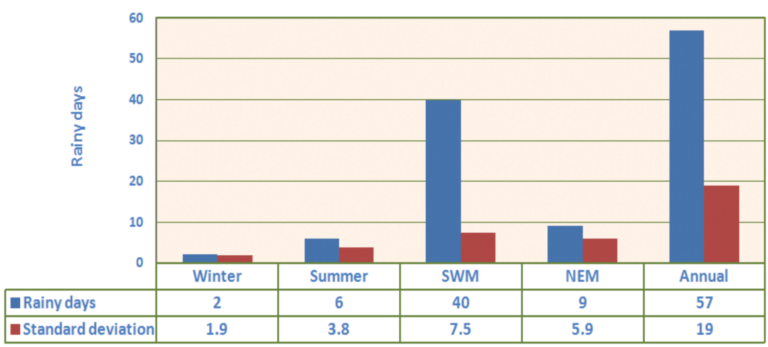

Fig 10. Mean annual and seasonal rainy days of Khalikote

Daily rainfall data of the target blocks are classified into four categories having days receiving rainfall of more than 2.5, 10, 25 and 50 mm and are presented in Table 7. The result revealed that there is not much difference in rainy days and rainfall intensities between the blocks during normal years. However, during drought years, there is a distinct difference between the blocks in terms of rainy days and rainfall intensities which needs attention while selecting the varieties for different rice growing ecologies.

Table 7. Average annual number of days with different rainfall intensities

Threshold rainfall per day (mm)	Purushottampur			Khalikote		
	Highest	Lowest	Average	Highest	Lowest	Average
> 2.5 to 10	38	8	22	32	13	23
> 10 to 25	26	8	19	34	7	19
> 25 to 50	16	3	11	18	1	11
> 50 to 75	8	1	3	8	0	3
> 75 to 100	3	0	1	4	0	1
> 100	5	0	1	3	0	1

Extreme rainfall characteristics of the study area

Heavy or very heavy rainfall events results in flash floods leading to soil erosion, crop damage and silting up of cultivable lands in lowlying areas. The details of the annual maximum heavy rainfall received in the target blocks are presented in Table 8.

Figure 11 and 12 depicts the monthly rainfall intensities observed at Purusottampur and Khalikote blocks. Occurrence of more than 100mm rainfall in a day in most of the monsoon months indicates the possibility of flood occurrence in lowlying areas in both the blocks.

Rainfall probabilities

Characterization of a location based on average rainfall can yield good results, provided the rainfall distribution is normal. Monthly rainfall that can be expected at different probability levels was computed based on incomplete gamma distribution model and presented in Table 9.

Weekly probable rainfall of Purusottampur and Khalikote are presented in Fig 13 and 14 and Annexure 4 and 5.

Agricultural operations are determined by the receipt of certain amount of rainfall at each stage. There are specific amounts of rainfall required for the activities like land preparation, sowing, transplanting, fertilizer application etc. Thus, estimation of probabilities with respect to a given amount of rainfall is useful for rainfed agricultural planning. Initial probability is the probability of receiving a certain amount of rainfall in a given week and is denoted by P (W). The interesting point to be noted is

Table 8. Annual maximum heavy rainfall received in Purusottampur and Khalikote

Date	Annual maximum heavy rainfall (mm) received at Purusottampur	Date	Annual maximum heavy rainfall (mm) received at Khalikote
24/07/1982	104	18/08/1982	105
24/07/1983	103	21/03/1983	125
27/07/1984	104	09/02/1984	61
25/06/1985	85	21/09/1985	100
11/03/1986	162	11/08/1986	108
07/06/1987	84	16/10/1987	90
19/09/1988	131	18/09/1988	97
13/06//1989	187	13/06/1989	130
11/03/1990	175	11/03/1990	164
21/09/1991	81	29/07//1991	145
18/06/1992	124	18/06/1992	122
10/11/1993	94	07/03/1993	89
18/08/1994	115	10/06/1994	96
05/10/1995	207	05/11/1995	227
21/08/1997	107	21/08//1997	125
24/07/1998	48	16/11/1998	69
06/10/1999	57	19/07/1999	30
07/10/2000	85	07/11/2000	68
06/12/2001	115	30/09/2001	105
13/10/2002	80	28/08/2002	61
10/07/2003	133	10/07/2003	165
08/04/2004	73	10/05/2004	130
09/09/2005	109	09/09/2005	144
07/03/2006	118	07/03/2006	245
27/09/2007	104	08/06/2007	118
10/07/2008	86	26/06/2008	92
14/07/2009	112	13/07/2009	110
08/06/2010	145	08/06/2010	205

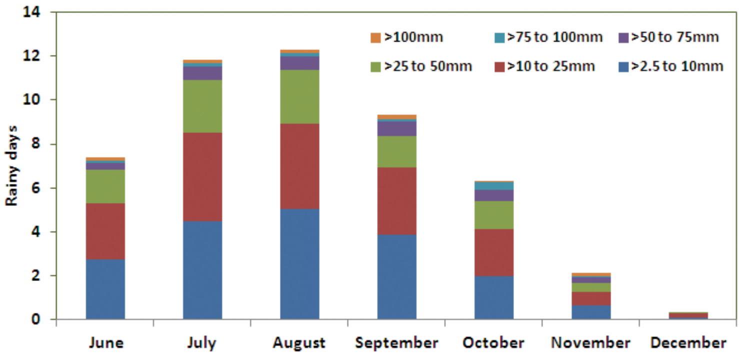

Fig 11. Monthly rainfall intensities at Purusottampur

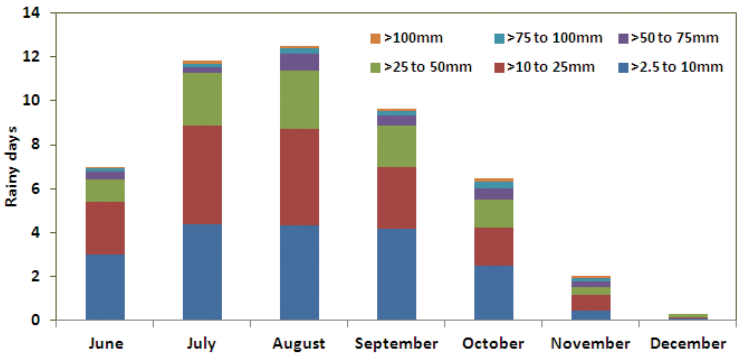

Fig 12. Monthly rainfall intensities at Khalikote

that the probability of getting a next week as a wet week, given the condition that the current week is a wet week can be estimated. These are called Conditional probabilities and denoted by P (W/W). Initial and conditional probabilities of receiving different amounts of rainfall at Purusottampur and Khalikote was computed following the method of Virmani *et al.* (1982) and the results are presented in figures 15 -18. This information will be of great practical use in planning of land preparation and sowing operations in the target areas.

Table 9. Monthly probable rainfall of Purusottampur and Khalikote blocks

Probability level (%)	10	20	30	40	50	60	70	80	90
Purusottampur									
January	22.0	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
February	92.2	37.5	19.0	2.0	0.0	0.0	0.0	0.0	0.0
March	58.0	37.5	22.5	13.0	9.3	5.0	0.0	0.0	0.0
April	59.0	47.0	29.0	25.0	17.0	5.0	3.0	0.0	0.0
May	133.0	104.0	75.0	50.0	40.3	28.0	19.0	5.0	0.0
June	296.0	230.3	210.0	187.0	166.3	149.8	117.3	77.8	51.0
July	370.0	318.1	293.0	264.0	252.7	248.0	196.5	183.5	126.2
August	387.0	361.0	338.0	288.0	238.7	229.0	215.0	174.0	118.0
September	374.0	313.0	242.5	208.0	191.5	166.0	136.5	113.5	68.0
October	373.0	278.0	202.0	173.0	132.1	116.0	64.0	42.0	31.0
November	252.0	108.5	81.0	35.0	30.5	9.0	0.0	0.0	0.0
December	25.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Khalikote									
January	25.0	16.5	9.0	0.0	0.0	0.0	0.0	0.0	0.0
February	63.0	38.0	25.0	5.0	0.0	0.0	0.0	0.0	0.0
March	82.5	52.5	27.0	19.0	10.0	5.0	0.0	0.0	0.0
April	68.0	58.8	45.5	21.0	15.5	12.0	7.0	0.0	0.0
May	129.0	95.5	68.0	36.0	34.5	29.0	17.0	8.0	0.0
June	261.0	201.0	164.0	126.0	125.5	123.0	101.0	70.0	52.0
July	341.0	290.5	254.0	248.0	226.0	206.0	189.0	152.0	139.0
August	447.0	428.5	312.0	307.0	279.5	224.0	212.0	183.0	132.0
September	346.0	274.5	231.0	221.0	190.0	143.0	125.0	91.3	66.0
October	433.0	282.0	239.0	166.0	123.0	77.0	54.0	25.3	0.0
November	343.0	105.0	58.0	43.0	30.5	14.0	0.0	0.0	0.0
December	27.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

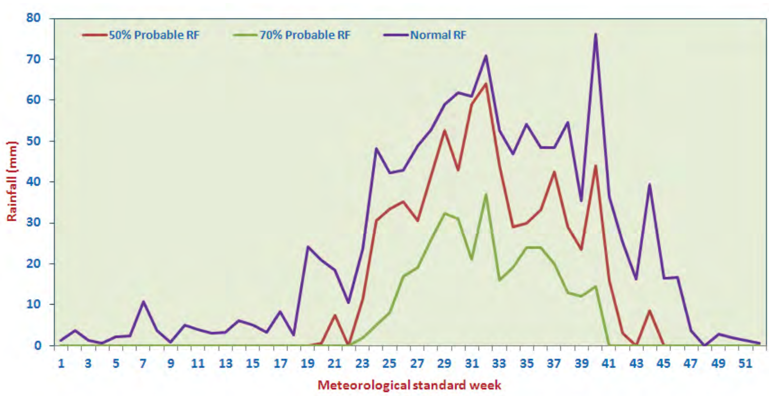

Fig 13. Average and probable weekly rainfall at Purusottampur

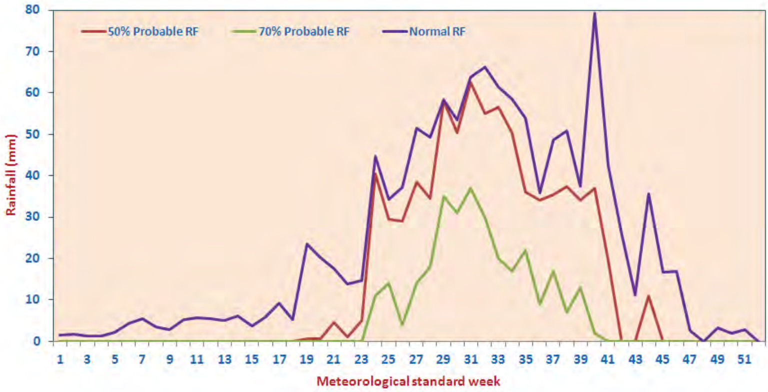

Fig 14. Average and probable weekly rainfall at Khalikote

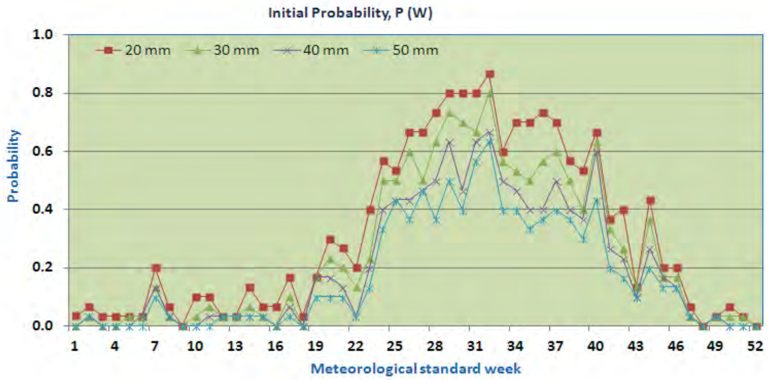

Fig 15. Initial probabilities of rainfall at Purusottampur

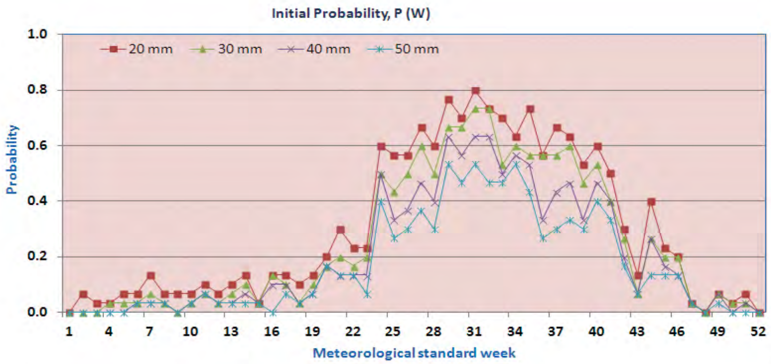

Fig 16. Initial probabilities of rainfall at Khalikote

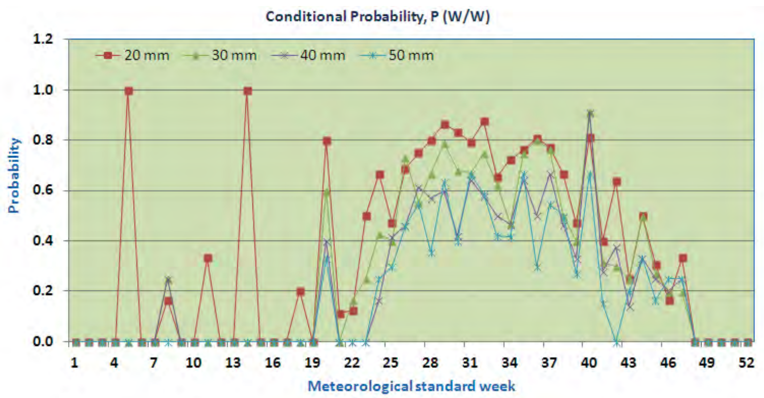

Fig 17. Conditional probabilities of rainfall at Purusottampur

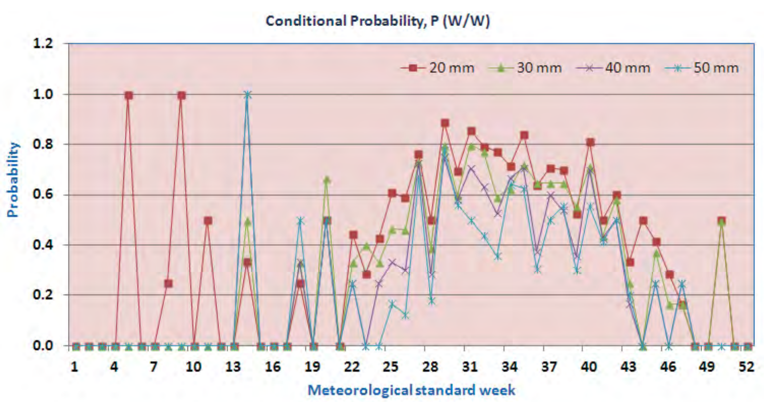

Fig 18. Conditional probabilities of rainfall at Khalikote

Consecutive wet weeks

It is the probability of getting two or three or four weeks as a wet week consecutively for a given amount of rainfall. The probabilities of wet spells of consecutive weeks is also an important parameter to assess the possibility of continuous wet weeks which may result in possible water logging/ flooding in low lying areas. The results are presented in Fig 19 and 20 and it is evident that from 25-40 MSW there is a potential chance for occurrence of more than 50 mm rainfall for 3-4 consecutive weeks.

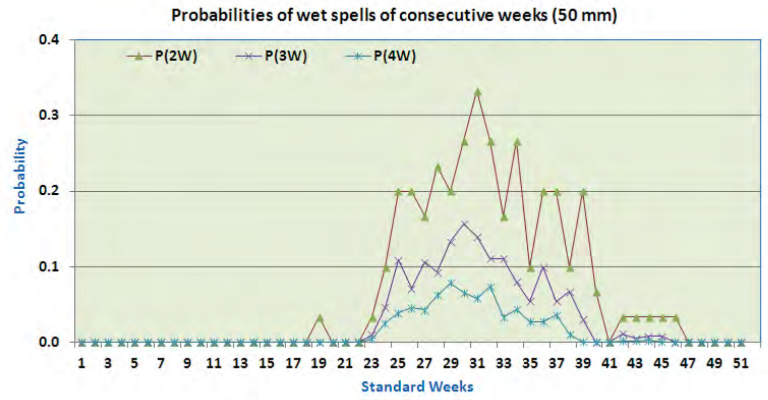

Fig 19. Probabilities of wet spells of consecutive weeks at Purusottampur

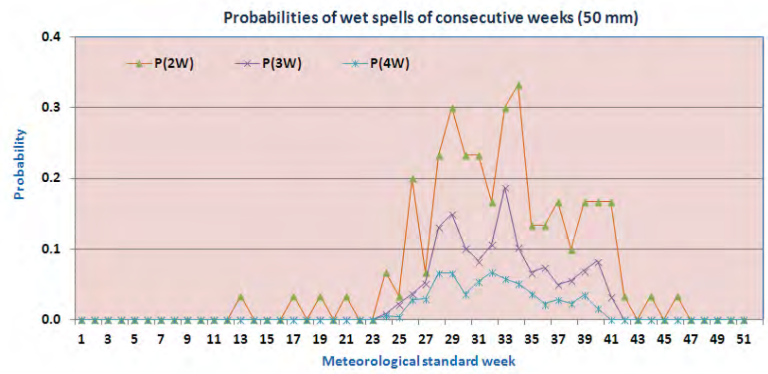

Fig 20. Probabilities of wet spells of consecutive weeks at Khalikote

Drought analysis

Drought, an abnormal climatic event, occurs when there is a prolonged absence or deficiency or poor distribution of precipitation compared with the normal pattern. It is the most complex and least understood of all natural hazards, affecting more people than any other hazard (Wilhite, 2000). Generally, large-scale spatiotemporal variability in timing and duration of drought impact hinders a universal definition of drought. However, Wilhite and Glantz (1985) have categorized drought into meteorological (lack of precipitation); hydrological (drying of surface water storage); agricultural (lack of root zone soil moisture) and socio-economic (lack of water supply for socio-economic purpose). In India, drought is a recurrent climatic phenomenon caused due to the country's peculiar physical and climatic characteristics and affects agricultural production and socioeconomic conditions. A recent analysis of the variation of the national Gross Domestic Product (GDP) and the monsoon has revealed that the impact of severe droughts on GDP has remained between 2 and 5% of GDP throughout (Gadgil *et al.*, 2007). Out of the total 45.5 million ha of rice area, 18.8 million ha is under rainfed condition (Anonymous, 2010). Because of its semi-aquatic phylogenetic origin and the diversity of rice ecosystems and growing conditions, current rice production systems rely on ample water supply and thus, are more vulnerable to drought stress than other cropping systems. Eastern India in particular, the success or failure of the rice crop in any year is closely linked to the behaviour of the monsoon rains during wet season (June to November) as 67% of the country's total rainfed rice area is concentrated in this region.

In agroclimatic analysis, meteorological and agricultural drought study is important. The frequencies of occurrence of different type of meteorological droughts (mild, moderate and severe) over a period of year would give insight for vulnerability of a particular location/region to drought on annual basis. Agricultural drought analysis would give idea about susceptibility of a region to drought on seasonal basis, i.e., main crop growing season.

Meteorological Drought

The meteorological drought situation of the target blocks were classified into 3 types based on the IMD criteria i.e., mild (0- 25% rainfall deficit from normal), moderate (26-50% rainfall deficit from normal) and severe (> 50% rainfall deficit from normal) and the results are presented in Table 10 and 11. The results revealed that Khalikote encountered more drought situation than Purusottampur block though the average annual rainfall of both the blocks are almost similar i.e. 1230mm and 1208mm for Purusottampur and Khalikote, respectively.

Table 10. Drought information of Purusottampur and Khalikote blocks

	Purusottampur		Khalikote	
Drought condition	No. of years	%	No. of years	%
No Drought	16	56	13	45
Mild Drought	11	38	13	45
Moderate Drought	1	3	1	3
Severe Drought	1	3	2	7
Total	29	-	29	-

Table 11. Meteorological drought situation of Purusottampur and Khalikote blocks

	Purusotampur			Khalikote		
Year	RF (mm)	deviation (%)	Drought condition	RF (mm)	deviation (%)	Drought condition
1982	918.4	-25.3	Mild	1032	-14.6	Mild
1983	1527.4	24.2	No Drought	1370	13.4	No Drought
1984	971.5	-21.0	Mild	920.5	-23.8	Mild
1985	1672.4	36.0	No Drought	1430	18.3	No Drought
1986	1751.0	42.4	No Drought	2118	75.3	No Drought
1987	1145.9	-6.8	Mild	1592	31.7	No Drought
1988	1318.8	7.2	No Drought	1144	-5.3	Mild
1989	1392.2	13.2	No Drought	1205	-0.3	Mild
1990	1937.2	57.5	No Drought	1855	53.5	No Drought
1991	1360.0	10.6	No Drought	1271	5.2	No Drought
1992	1505.0	22.4	No Drought	1090	-9.8	Mild
1993	1184.0	-3.7	Mild	1142	-5.5	Mild
1994	1162.5	-5.5	Mild	1130	-6.5	Mild
1995	2104.7	71.1	No Drought	1994	65.0	No Drought
1997	1108.0	-9.9	Mild	1409	16.6	No Drought
1998	663.8	-46.0	Moderate	500	-58.6	Severe
1999	942.5	-23.4	Mild	732	-39.4	Moderate
2000	423.0	-65.6	Severe	334	-72.4	Severe
2001	1355.0	10.2	No Drought	1391	15.1	No Drought
2002	951.0	-22.7	Mild	1089	-9.9	Mild
2003	1573.0	27.9	No Drought	1727	42.9	No Drought
2004	1139.0	-7.4	Mild	935	-22.6	Mild
2005	1249.0	1.6	No Drought	1298	7.4	No Drought
2006	1345.0	9.4	No Drought	1596	32.1	No Drought
2007	999.0	-18.8	Mild	1043	-13.7	Mild
2008	1262.0	2.6	No Drought	1134	-6.2	Mild
2009	1326.0	7.8	No Drought	1138	-5.8	Mild
2010	1636.0	33.0	No Drought	1587	31.3	No Drought
2011	972.0	-21.0	Mild	1047	-13.4	Mild

Agricultural Drought

Agricultural drought is defined as a period of four consecutive weeks (of severe meteorological drought) with a rainfall deficiency of more than 50 per cent of the long term average or with a weekly rainfall of 50mm or less during the period from mid-May to mid- October (the *Kharif* season) when 80 per cent of the country's total crop is planted, or six such consecutive weeks during the rest of the year. The results revealed that varying degree of agricultural drought situation prevailed in both the blocks in different years and the shortest being 4 weeks to the longest duration of 16 weeks (Table 12).

Table 12. Agricultural drought situation of Purusottampur and Khalikote blocks

	Purusottampur		Khalikote
Year	Drought Period (MSW)	Year	Drought Period (MSW)
1984	38-45	1982	38-41
1988	34-37	1987	37-40
1989	40-45	1988	41-46
1992	34-37	1989	40-45
1994	22-25	1994	41-46
1997	41-46	1998	31-42
1998	33-40	2000	22-25
2000	23-26		31-46
	33-45	2008	39-45
2004	32-35		40-45
2005	22-25	2009	30-33
2011	39-42		

Water balance

Availability of water in right quantity and in the right time and its management with suitable agronomic practices are essential for good crop growth and yield. To assess water availability to crops, soil moisture is to be taken into account and the net water available through soil moisture can be estimated using the water balance technique. The concept of water balance was first put forth by Thornthwaite (1948) and later modified by Thornthwaite and Mather (1955). The term water balance refers to the climatic balance obtained, by comparing the rainfall as income with evapotranspiration as loss or expenditure, soil being a medium for storing water during periods of excess rainfall and utilizing or releasing moisture during periods of deficit precipitation. The basic water balance equation is

$P = E + \Delta S + RO$

Where,

P is rainfall

E is the evapotranspiration

ΔS is the change in soil moisture storage

RO is the runoff

When the seasonal march of rainfall is compared with that of water need (PET or ETo) of a location, one obtains information on many aspects of water relations of the location like soil moisture storage, actual evapotranspiration, water deficit, water surplus and runoff. The concepts of PET and water balance have been extensively applied to studies such as climatic classification, aridity, droughts, crops and watersheds in India by many researchers (Ramakrishna et al. 2000; Kesava Rao et al. 2002; Kesava Rao et al. 2006; Wani et al. 2004).

Water balance study of the target blocks

Indices like Aridity index (Ia), Humidity Index (Ih) and Moisture Index (Im) are output of water balance analysis. These indices are useful in climatic classification and to find climatic type of a particular place. Occasional shifts in the annual water balance of a location may be of such magnitude that the climatic type of the location could be shifted by one or more categories in the dryer or wetter direction. Such shifts in climate, though temporary, are very important and this determines the potential of a region for agricultural development. Similarly knowledge on the length of growing period (LGP) of a region, especially in rainfed areas is a valuable tool in crop planning. The information about when the period of water surplus and deficit occurring in a season or year obtained through water balance analysis is also helpful to find ideal period for starting of crop season and stages, which may fall in deficit period. The variability in LGP and soil water balance of target blocks and the year to year shifts in climate type were analyzed. For this analysis, weather (maximum and minimum temperatures, morning and evening relative humidity, wind speed) recorded at Gopalpur, Ganjam from 1982 to 2008 were used along with the rainfall data of the target blocks. The daily weather data were converted into weekly data and analyzed using PENWBLGP FORTRAN Programme Version 1.0. The programme computes potential evapotranspiration (ET_0) using Penman-Monteith method and determines LGP based on Thornthwaite water balance method using following equations:

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where, ET_o = reference evapotranspiration (mm day^{-1}); Rn = net radiation at the crop surface (MJ m^{-2} day^{-1}); G = soil heat flux density (MJ m^{-1} day^{-1}); T = mean daily air temperature at 2 m height (°C); u_2 = wind speed at 2 m height (m s^{-1}); e_s = saturation vapour pressure (kPa); e_a = actual vapour pressure (kPa); e_s - e_a = saturation vapour pressure deficit (kPa); Δ= slope of vapour pressure curve (kPa °C^{-1}); γ= psychrometric constant (kPa °C^{-1})

The formula used for calculating the aritidy index, humidity index, moisture index and index of moisture adequacy are as follows:

Aridity Index (Ia) % = (Water deficit / PET) * 100

Humidity Index (Ih) % = (Water surplus / PET) * 100

Moisture Index (Im) % = Ih – Ia

Index of Moisture Adequacy (IMA) % = (AET / PET) * 100

Variability in soil water balance components

Water surplus and water deficit occur in different seasons at most places, both are significant to indicate the index of moisture availability, the one affecting positively and the other affecting negatively. Thornthwaite termed this as Moisture Index (Im) and it can be computed from the annual water balance parameters such as water surplus (WS), water deficit (WD) and PET.

Although a water surplus in one season cannot prevent water deficit in the other except as moisture, the surplus can be stored in soil, to some extent. Since water surplus means seasonal additions to subsoil moisture and groundwater, deep-rooted perennials may make partial use of subsoil moisture and will be less affected by drought. The results of the water balance analysis analysis of target blocks for excess, normal, deficit and scanty rainfall years are presented in Table 13. The results indicated that even during deficit rainfall years, there was a water surplus during the crop growing season indicating the opportunity for water harvesting and storage. The harvested water can be used for supplemental irrigation to mitigate the drought, extend crop growing season and irrigation for the *rabi* crops.

Year to year shift in climatic type at the study area

Moist climates have positive value of Im, while dry climates have negative values. As per the climatic classification of Thornthwaite and

Table 13. Annual water balance of the study area in different rainfall conditions

	PET (mm)	Rainfall (mm)	Water surplus (mm)	Water deficit (mm)	Humidity index (%)	Aridity index (%)	Moisture index (%)
Purusottampur							
Excess rainfall year (1995)	1399	2105	1252	573	89.5	41.0	48.5
Normal rainfall year (2006)	1394	1345	507	558	36.4	40.0	-3.7
Deficit rainfall year (2007)	1394	999	389	763	27.9	54.7	-26.8
Scanty rainfall year (2000)	1348	423	21	907	1.6	67.3	-65.7
Khalikote							
Excess rainfall year (1995)	1397	1994	1075	505	77.0	36.1	40.8
Normal rainfall year (1988)	1473	1144	392	666	26.6	45.2	-18.6
Deficit rainfall year (2004)	1333	935	314	675	23.6	50.6	-27.1
Scanty rainfall year (2000)	1344	334	2	986	0.1	73.4	-73.2

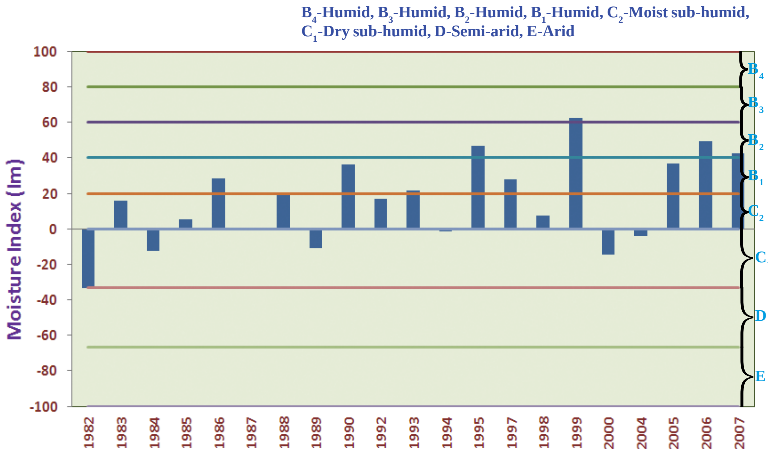

Fig 21. Yearly shifts in climatic types at Purusottampur

Mather (1955), if the value of Im is between 0 and –33.3, the climate is called ‘dry sub-humid’ and if it is between –33.3 and –66.6, it is called ‘semi-arid’. Arid climates occur when Im is less than –66.6. As per this classification, it can be seen from Fig 21 that the climate type of Purusottampur mostly varied among dry sub-humid (C_1: I_m value of -33.3 to 0), moist sub-humid (C_2: I_m value of 0 to 20) and humid (B_1: I_m value of 20 to 40). However, it also swung to Humid (B_2: I_m value of 40 to 60), Humid (B_3: I_m value of 60 to 80), as well as semi-arid (D: I_m value of -33.3 to -66.7) on few occasions. In case of Khalikote, the climate type varied among dry sub-humid (C_1: I_m value of -33.3 to 0), moist sub-humid (C_2: I_m value of 0 to 20) and humid (B_1: I_m value of 20 to 40). However, it also swung to Humid (B_2: I_m value of 40 to 60) as well as semi-arid (D: I_m value of -33.3 to -66.7) and arid (E: Im value less than –66.6) on few occasions (Fig 22).

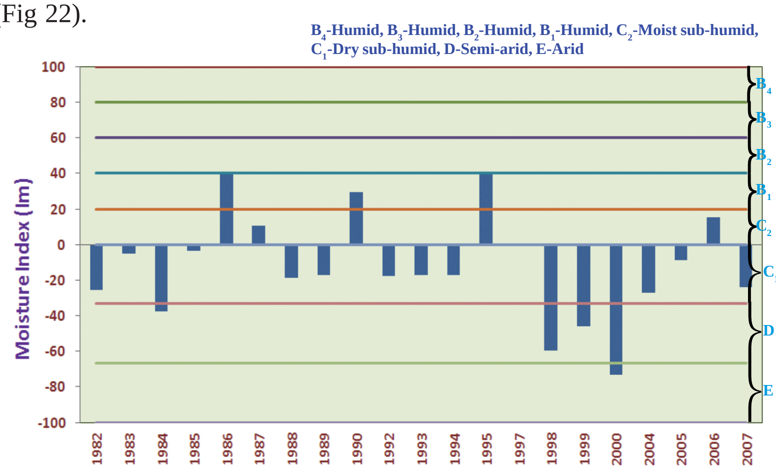

Fig 22. Yearly shifts in climatic types at Khalikote

Extreme event water balance analysis

Changes in the rainfall amount and distribution make considerable changes in the water balance of a location. Based on the water balances of 30 years, dry, normal and wet years were identified at the target blocks and the variability in water balance components are presented in Fig 23 to 26.

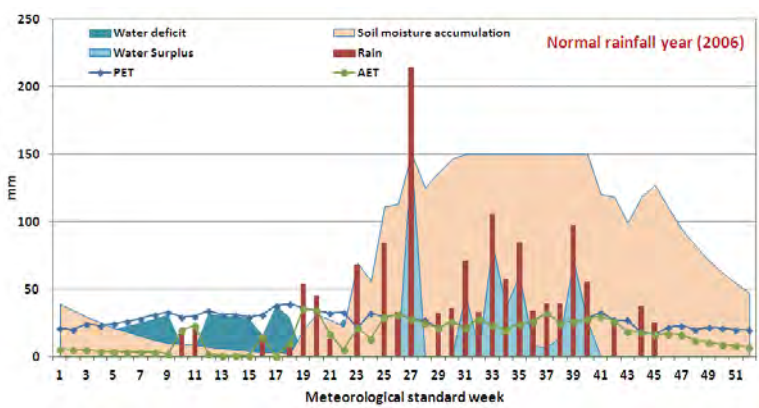

Fig 23. Water balance at Purusottampur during normal rainfall year

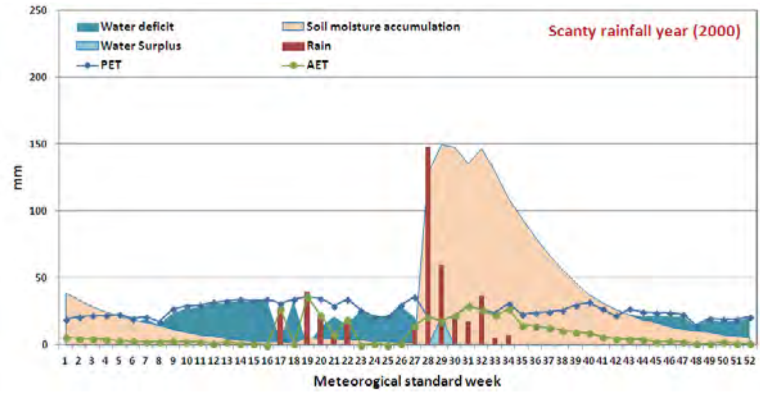

Fig 24. Water balance at Purusottampur during scanty rainfall year

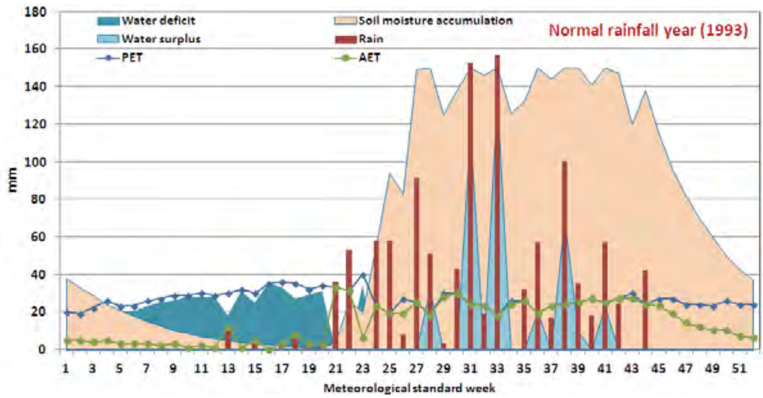

Fig 25. Water balance at Khalikote during normal rainfall year

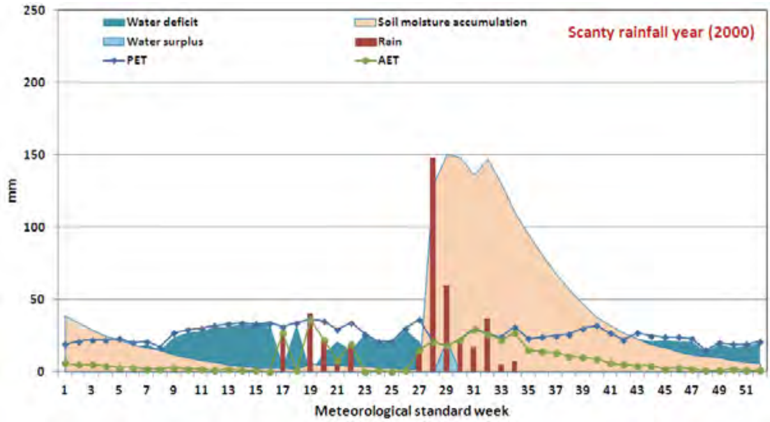

Fig 26. Water balance at Khalikote during scanty rainfall year

Variability in length of growing period

Knowledge on the date of onset of rains will help to plan the agricultural operations better, particularly, land preparation and sowing. The ‘length of the rainy season’ is the duration between the onset and end of agriculturally significant rains. The length of growing period (LGP) is defined as the length of the rainy season. This includes the period of soil moisture storage at the end of the rainy season, the post rainy season and winter rainfall, which can all meet the crop water needs. Therefore, the LGP depends not only on the rainfall distribution but also on the type of soil, soil depth, water retention and release characteristics of the soil. Several methods were used to estimate the LGP using rainfall (Ashok Raj 1979; Sivakumar et al. 1993). The National Bureau of Soil Survey and Land Use Planning (Velayutham et al. 1999) estimated LGP using the PET and rainfall.

Using the water balance, week-wise index of moisture adequacy (IMA) was computed, which is defined as the ratio of the actual evapotranspiration to the potential evapotranspiration expressed as a percentage. The beginning and end of the growing season was identified based on the IMA. The growing season begins when the IMA is above 50% consecutively for at least two weeks, starting from the middle of May. The end of the season was identified when the IMA falls below 25% for two consecutive weeks, when seen backwards starting from the end of December.

Using the beginning and end of the crop growing season, the LGP was estimated. The average LGP of Purusottampur and Khalikote is 196 days.

Table 14. Variability at the beginning and end of growing period

Particulars	Purusottampur	Khalikote
Beginning of season		
Normal	23 MSW	24 MSW
Assured	25 MSW	25 MSW
Standard Deviation (Days)	17	16
End of season		
Normal	4 MSW	2 MSW
Assured	52 MSW	52 MSW
Standard Deviation (Days)	33	38

**** For soils having 150mm water holding capacity***

The standard devistion of almost 3 weeks at the beginning and 5 weeks at the end of the season indicates the extend of variability involved in the distribution of rainfall in the crop growing period in both the blocks (Table 14).

Dry and wet spells

High variability in the distribution of rainfall in the crop-growing period results in dry and wet spells of varying durations. Dry and wet spells during the crop-growing season have been defined based on the Index of Moisture Adequacy (IMA). When the rainfall and the soil moisture contribution put together cannot satisfy even 25% of the crop requirement, the period is termed as 'very dry'. If the IMA is between 76 and 99%, crops in general do not suffer from water stress. Some of the 'wet' weeks are with heavy rainfall leading to accumulation of runoff for water harvesting and also soil erosion. Dry and wet spells during the crop growing season have been defined based on IMA and classified into very dry (0 to 25), dry (26 to 50), semi-moist (51 to 75), moist (76 to 99) and wet (100). Dry and wet spells during the crop growing season of target blocks revealed that there is variation in both the beginning and ending of the season; however, the end is more variable compared to the start. The variability in dry and wet spells of Purusottampur and Khalikote is depicted in Fig 27 and 28.

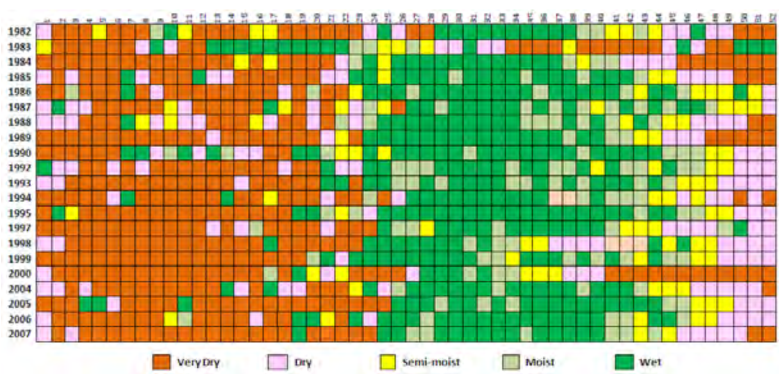

Fig 27. Variability in dry and wet spells of Purusottampur

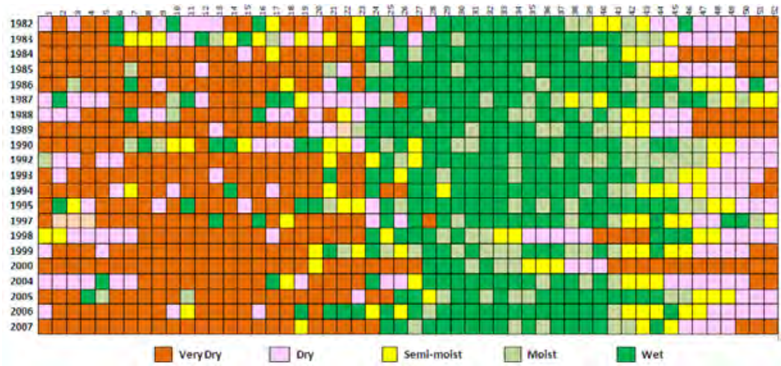

Fig 28. Variability in dry and wet spells of Khalikote

Normal date of onset of southwest monsoon over the target blocks is 10th June and the crop growing period extends up to December. Probability of occurrence of dry and wet spells in the crop-growing period starting from the 23 MSW (4-10th June) to 52 MSW (24-31st December) on a weekly basis was computed and shown in Fig 29. A week having more than 30% chances of being dry to very dry is shown in orange and having more than 50% chance of being wet is shown in green. Figure 30 shows that the probability of occurrence of dry spells increases from 46th MSW (12-18th November) in both the blocks. This indicates that the rice crop in its reproductive stage may encounter greater risk of dry spells in both the blocks. Hence, one has to select rice varieties of suitable duration according to the land situation i.e., uplands, medium lands, shallow low lands and semi-deep low lands to avoid the terminal moisture stress situation in deficit rainfall years.

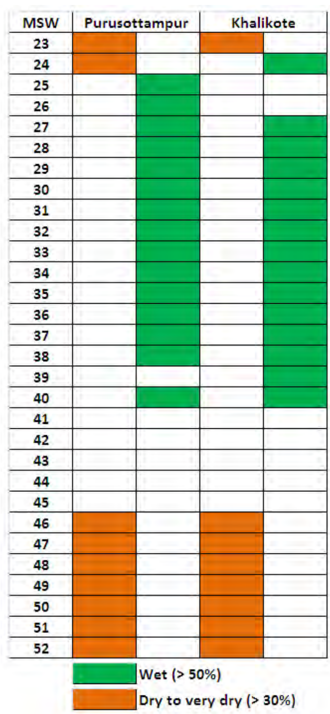

Fig 29. Percent probability of occurrence of dry and wet spells in Purusottampur and Khalikote

Standardized precipitation index

Standardized precipitation index can detect drought or wetness over different periods at multiple time scales and is produced by standardizing the probability of observed precipitation for any duration. The applicability of SPI varies with time scale because the 1-month SPI reflects short-term conditions and its application can be related closely to soil moisture; the 3-month SPI provides a seasonal estimation of precipitation (Ji & Peters 2003). SPI, calculated at different time scales, e.g. 1- or 3-month SPI of a particular month, represents the deviation in total precipitation amounts for the same month and current plus previous 2 months, respectively. Positive SPI values indicate greater than mean precipitation and negative SPI values indicate less than mean precipitation. If the 1-month SPI for August is -2.00, then the precipitation is much less than normal and when it is +1.00, then the precipitation for the same month is substantially above normal. Using SPI thresholds, the dryness or wetness of a location is categorized into severely wet (>2.0), very wet (>1.5 to 2.0), moderately wet (>1.0 to 1.5), near normal (1.0 to -1.0), moderately dry (<–1.0 to –1.5), severely dry (<–1.5 to –2.0) and extremely dry (< –2.0).

Many studies have demonstrated that a 3-month SPI provides an indication of the seasonal anomaly in precipitation, and thereby, this index is considered as an agricultural drought indicator (McKee et al. 1993; Hayes et al. 1999; Patel et al. 2007). However, in the case of semi-aquatic crops like rice, which are grown in upland, shallow lowland and lowland situations during wet season, a dry period of 7–15 days could affect the

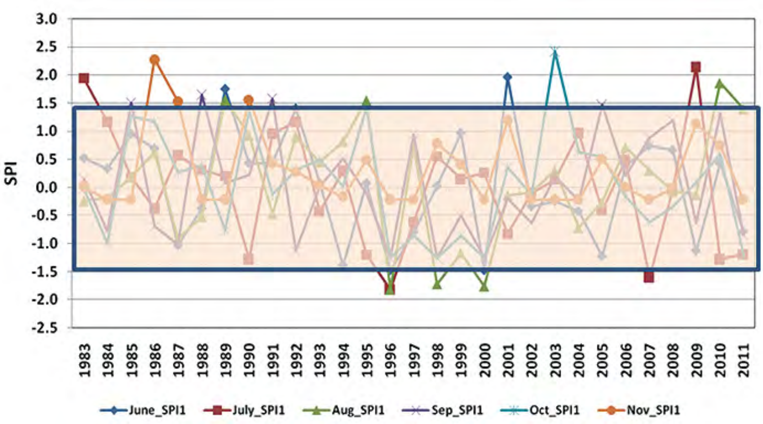

Fig 30. Temporal variation of monthly SPI in Purusottampur

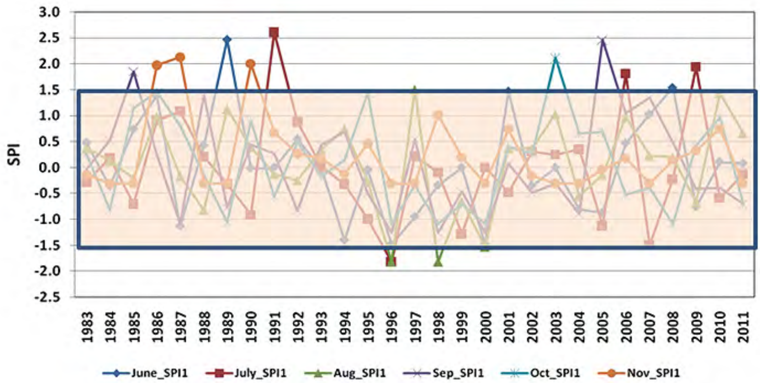

Fig 31. Temporal variation of monthly SPI in Khalikote

yield due to moisture stress. Hence, a shorter time scale (1-month SPI) may capture drought events more precisely as an increase in SPI time scales decreases the frequency of dry periods (Patel et al. 2007; Raja et al., 2014). The 1-month SPI of *Kharif* season months over the years indicated the occurrence of both wet spell and dry spell during these months in Purusottampur and Khalikote blocks (Fig 30 adn 31). This indicates the possibility of occurrence of excess or deficit moisture stress at early, mid and later stages of the crop growth during *kharif* season.

Relationship between rainfall and rice yield

The rice area, production and productivity of Purusottampur and Khalikote blocks are presented in Table 15 and 16. The relationships between crop yield and rainfall for the months of June, July, August, September, October, November and December/ SWM season/ NEM season have been worked out through correlation analysis. A correlation matrix table has been prepared for both Purusottampur and Khalikote blocks and shown in Table 17. The results revealed that production and yields are better related to seasonal rainfall than individual months. There is no specific trend between rainfall and area coverage. This may due to the fact that 70 and 54 per cent of area is under irrigated condition in Purusottampur and Khalikote blocks, respectively. However, paddy production and yield in Purusottampur block recorded significant relationship with SWM rainfall.

Table 15. Area (A), production (P) and productivity (Y) of paddy in Purusottampur block

Year	Kharif Paddy			Summer Paddy			Total Paddy		
	A (ha)	P (q)	Y(q/ha)	A (ha)	P (q)	Y(q/ha)	A (ha)	P (q)	Y(q/ha)
1981-82	13152	255388	19.42	39	210	5.38	13191	255598	19.38
1982-83	12939	236898	18.31	3	28	9.33	12942	236926	18.31
1983-84	15703	463082	29.49	6	120	20.00	15709	463202	29.49
1984-85	13526	240977	17.82	3	84	28.00	13529	241061	17.82
1985-86	14695	530554	36.10	0	0	0	14695	530554	36.10
1986-87	14042	399925	28.48	2	50	25.00	14044	399975	28.48
1987-88	13077	250771	19.18	77	1458	18.94	13154	252229	19.18
1988-89	15117	354757	23.47	86	1523	17.71	15203	356280	23.43
1989-90	13727	599221	43.65	13	312	24.00	13740	599533	43.63
1990-91	12467	74278	5.96	16	388	24.25	12483	74666	5.98
1991-92	14182	730964	51.54	12	390	32.50	14194	731354	51.53
1992-93	14504	483424	33.33	13	138	10.62	14517	483562	33.31
1993-94	15197	590177	38.84	59	1317	22.32	15256	591494	38.77
1994-95	13187	396722	30.08	22	160	7.27	13209	396882	30.05
1995-96	14964	318338	21.27	0	0	0.00	14964	318338	21.27
1996-97	13070	156109	11.94	5	79	15.80	13075	156188	11.95
1997-98	13360	318550	23.84	0	0	0.00	13360	318550	23.84
1998-99	14502	307628	21.21	4	72	18.00	14506	307700	21.21
1999-00	14889	33274	2.23	12	96	8.00	14901	33370	2.24
2000-01	15340	524575	34.20	2	32	16.00	15342	524607	34.19
2001-02	14290	465180	32.55	0	0	0.00	14290	465180	32.55
2002-03	13811	195059	14.12	0	0	0.00	13811	195059	14.12
2003-04	15424	92747	6.01	0	0	0.00	15424	92747	6.01
2004-05	13586	437959	32.24	6	186	31.00	13592	438145	32.24
2005-06	14971	419503	28.02	0	0	37.01	14971	419503	28.02
2006-07	13105	424504	32.39	1	50	49.74	13106	424554	32.39
2007-08	12326	400573	32.50	0	0	0.00	12326	400573	32.50
2008-09	15495	464030	29.95	0	0	0	15495	464030	29.95
2009-10	15330	561199	36.61	0	0	0	15330	561199	36.61
2010-11	14726	311850	21.18	0	0	0	14726	311850	21.18

Table 16. Area (A), Production (P) and Productivity (Y) of paddy in Khalikote block

Year	Kharif Paddy			Summer Paddy			Total Paddy		
	A (ha)	P (q)	Y(q/ha)	A (ha)	P (q)	Y(q/ha)	A (ha)	P (q)	Y(q/ha)
1981-82	16623	167291	10.06	6	11	1.83	16629	167302	10.06
1982-83	19111	106851	5.59	34	220	6.47	19145	107071	5.59
1983-84	17904	362864	20.27	57	856	15.02	17961	363720	20.25
1984-85	11993	69062	5.76	0	0	0	11993	69062	5.76
1985-86	12852	248391	19.33	5	84	16.80	12857	248475	19.33
1986-87	17393	288661	16.60	93	2498	26.86	17486	291159	16.65
1987-88	18101	320799	17.72	299	7888	26.38	18400	328687	17.86
1988-89	17320	352918	20.38	202	2026	10.03	17522	354944	20.26
1989-90	20515	603880	29.44	19	530	27.89	20534	604410	29.43
1990-91	12732	296018	23.25	259	5442	21.01	12991	301460	23.21
1991-92	15022	521997	34.75	216	7268	33.65	15238	529265	34.73
1992-93	16371	391090	23.89	246	5599	22.76	16617	396689	23.87
1993-94	16387	509680	31.10	149	4547	30.52	16536	514227	31.10
1994-95	11933	358460	30.04	10	206	20.60	11943	358666	30.03
1995-96	15448	437213	28.30	51	881	17.27	15499	438094	28.27
1996-97	12630	166503	13.18	9	114	12.67	12639	166617	13.18
1997-98	12963	263209	20.30	35	960	27.43	12998	264169	20.32
1998-99	18753	668508	35.65	115	2444	21.25	18868	670952	35.56
1999-00	15368	107268	6.98	94	2024	21.53	15462	109292	7.07
2000-01	17848	299967	16.81	48	580	12.08	17896	300547	16.79
2001-02	16089	473778	29.45	29	835	28.79	16118	474613	29.45
2002-03	16646	235706	14.16	5	98	19.56	16651	235804	14.16
2003-04	18714	268181	14.33	55	1363	24.78	18769	269544	14.36
2004-05	17000	165757	9.75	71	1566	22.06	17071	167323	9.80
2005-06	13586	243064	17.89	10	419	41.90	13596	243483	17.91
2006-07	20577	497458	24.18	0	0	0	20577	497458	24.18
2007-08	13640	305625	22.41	53	702	13.24	13693	306327	22.37
2008-09	11026	135719	12.31	0	0	0	11026	135719	12.31
2009-10	16156	402801	24.93	80	1884	23.55	16236	404685	24.93
2010-11	14346	444950	31.02	0	0	0	14346	444950	31.02

Table 17. Relationship between rainfall and paddy acreage/ production/ productivity in Purusottampur and Khalikote blocks

Particulars	Monthly RF						Seasonal RF		Annual
	June	July	Aug	Sept	Oct	Nov	SWM	NEM	rainfall
Purusottampur									
Area	0.09	0.28	-0.17	0.14	0.27	-0.08	0.20	0.16	0.22
Production	0.24	0.29	0.13	0.29	-0.21	-0.10	0.56*	-0.22	0.09
Productivity	0.24	0.25	0.16	0.28	-0.25	-0.11	0.55*	-0.26	0.05
Khalikote									
Area	0.20	0.28	0.04	-0.46	0.04	0.09	0.09	0.06	0.03
Production	0.25	0.31	-0.03	-0.21	-0.08	0.12	0.40	0.00	0.08
Productivity	0.13	0.23	-0.01	-0.05	-0.03	0.12	0.38	0.04	0.13

* Significant at P=0.05

Crop planning

The soil water balance, LGP and its variability determine suitability of crops and cropping systems at a selected location. Considerable variability has been observed in these parameters over years for Purusottampur and Khalikote blocks. This necessitates all the ingenuity while selecting the crop and variety which suits for a particular land situation. Based on the agro-climatic analysis of the target blocks, the following rice based cropping system is recommended for different land situations.

Uplands

In rainfed uplands, short duration rice varieties having around 100 days duration *viz.*, Anjali, Annada, Vandana, Heera and Sahbhagidhan should be grown during the wet season in order to avoid the possible terminal moisture stress/ drought situation.

If moisture availability is there due to extended monsoon rains, Horsegram (Urmi/ local) can be grown as a sequence crop or as a relay crop.

To minimize the risk of complete crop failure during the wet season, inter cropping of red gram can be taken up with rice crop. For this, rice and red gram can be grown in 4:1 row ratio.

In the foothills, groundnut can be grown for seed purpose and this will enhance groundnut seed availability for the subsequent dry season.

Medium lands

Short duration rice varieties like Naveen can be grown instead of medium duration rice varieties like Swarna in rainfed medium lands and this may help the farmers getting an early harvest and escape from the possibility of terminal moisture stress to the rice crop. This will also facilitate in timely sowing of subsequent pulse/ oil seed crop during the dry season using residual soil moisture.

After harvest of rice crop in medium lands, the following cropping sequences can be taken up using the residual soil moisture.

Rice– Groundnut

Rice – Rapeseed/Toria

If water is available for providing supplemental irrigation at critical crop growth stages, then the following crops can be grown after rice:

Rice– Sunflower

Rice-Sesame

Rice-Maize

Rice-Vegetables

Low land

Both the blocks have greater chance for water surpluses during the rainy season, thus offer opportunity for water harvesting and supplemental irrigation to mitigate dry spells for an extended growing season. On creation of water resources, farmers can grow groundnut/ sunflower/ vegetables viz., chilies, brinjal, tomato, etc during the dry season.

In rainfed lowlands, black gram is a better crop for *pyra* cropping using residual soil moisture whereas, greengram is a better option as a seqnence crop after harvest of rice.

On delayed or late sown condition upon availability of water for supplemental irrigation at critical growth stages, cultivation of sunflower, sesame, maize, melons or vegetables after rice will be more remunerative.

Contingency plan for rice under aberrant weather situations

A. Early Drought

In case of early drought in the month of June and July due to delayed monsoon, the farmers either are unable to sow the crop or the sown crop is damaged. Early medium duration varieties (105-120 days) like Naveen, Satabdi, Lalat**,** Annada, Chandan, Sahbhagi Dhan, etc. can be transplanted using 15 days old seedlings up to September first week with basal application of 40:40:40 kg N, P_2O_5 and K_2O for better establishment in rainfed shallow lowlands.

If receipt of rainfall is delayed upto August end, early maturing rice varieties (90-105 days) like Vandana, Kalinga III, Anjali, Sahbhagidhan, Khandagiri, Parijat can be grown in rainfed shallow lowlands by direct seeding upto end of August with basal application of 30 kg P_2O_5 and 30 kg K_2O for better establishment. Initial Nitrogen fertilizer dose @ 30 kg ha^{-1} should be applied 7-15 days after sowing.

In medium lowlands, where direct seeding is not feasible, farmers are advised to take up either transplanting of the available aged seedlings (upto 60 days old) of long duration varieties *viz.*, Gayatri, Sarala, Varshadhan, etc. or transplanting of clonal seedlings from the surviving rice crop in the neighboring fields at closer spacing (15 x 10 cm) with basal application of 40:40:40 kg N, P_2O_5 and K_2O. In above situations, it is advisable to raise the bund height and plug the holes in the bunds to arrest the seepage loss and keep the fields weed free.

In uplands, if rice crop is not yet sown or damaged due to drought, farmers should take up short duration low water requiring crops like cowpea (Utkalmanika), blackgram (T-9, Sarala, PU 19, 30), green gram (K851), Horsegram (Urmi) and Sesamum (Kanak, Kalika, Uma, Usha).

B. Mid/ Late Season Drought

In-situ rain water conservation measures such as plugging the holes can be adopted in the field bunds to arrest the seepage loss and keep the fields weed free.

Supplemental/ life saving irrigation can be provided if water is available in rainwater harvesting structures.

If the crop is completely damaged, rice fallow pulses (black gram/ lathyrus) or toria may be an option after receipt of sufficient late season rains.

C. Early Flood

In flood prone areas, where crop is completely damaged due to flooding, replanting with aged seedlings (upto 40 days old) of Swarna *sub-1*, Pooja and Swarna in rainfed shallow low lands and Varshadhan, Durga, Sarala and Hanseswari in semi-deep and deep low lands upto end of August is recommended.

Otherwise, where crop was partially damaged due to flood, gap filling with aged seedlings or clonal tillers and apply Nitrogen @ 20 kg ha^{-1} immediately after receding of the flood water may can help in rapid emergence of new leaves and tillers.

D. Mid/ Late Season Flood

In areas where the rice crop is completely damaged due to mid/ late season flooding (September- October) in rainfed shallow low lands, plug the holes in the field bunds and remove weeds to retain moisture in the field. In the second week of October, if the soil moisture is optimum (Slight sticky condition) broadcast black gram seeds. If the soil moisture is not sufficient enough, plough the land to fine tilth and then go for line sowing of black gram.

In case of partial damage to rice crop due to flood, apply Nitrogen @ 15 kg ha^{-1} immediately after receding of the flood water.

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Annexure 1. Annual and seasonal rainfall received during 1982- 2011 at Purusottampur and Khalikote

Year	Purusottampur					Khalikote				
	Annual RF (mm)	SWM RF (mm)	NEM RF (mm)	Winter RF (mm)	Summer RF (mm)	Annual RF (mm)	SWM RF (mm)	NEM RF (mm)	Winter RF (mm)	Summer RF (mm)
1982	918.4	746.9	66.5	19	86	1032	759.5	80.5	45	147
1983	1527.4	1098	172.2	92.2	165	1370	850	178	114	228
1984	971.5	880	31	2	58.5	920.5	845.5	28	0	47
1985	1672.4	1137.9	351.5	101	82	1430	989	353	42	46
1986	1751	865.5	771	43	71.5	2118	1209	810	54	45
1987	1145.9	591.9	421	18	115	1592	676	661	25	230
1988	1318.8	965.3	187	99	67.5	1144	888	101	63	92
1989	1392.2	1295.2	50	0	47	1205	1160	5	0	40
1990	1937.2	903	632	111.3	290.9	1855	813	641	80	321
1991	1360	1106	201	0	53	1271	1096	154	12	9
1992	1505	1115	236	31	123	1090	785	257	21	27
1993	1184	846	237	0	101	1142	882	141	0	119
1994	1162.5	911.5	144	28	79	1130	864.5	160	16	89.5
1995	2104.7	958.7	476	38	632	1994	599	507	40	848
1997	1108	911	92	5	100	1409	1114	173	9	113
1998	663.8	499.8	127	0	37	500	333	151	0	16
1999	942.5	747.5	120	0	75	732	531	83	9	109
2000	423	309	0	0	114	334	287	0	0	47
2001	1355	924	374	0	57	1391	940	299	0	152
2002	951	702	116	0	133	1089	793	178	0	118
2003	1573	872	701	0	0	1727	970	704	53	0
2004	1139	781	226	0	132	935	585	239	35	76
2005	1249	833	301	59	56	1298	957	266	50	25
2006	1345	1027	141	0	177	1596	1325	100	0	171
2007	999	885	64	0	50	1043	946	73	0	24
2008	1262	1008	119	47	88	1134	983	39	0	112
2009	1326	932	325	0	69	1138	803	253	0	82
2010	1636	1028	419	66	123	1587	996	484	2	105
2011	972	787	12	20	153	1047	822	40	9	176
Mean	1229.8	855.57	237.11	25.98	111.18	1208.5	826.7	238.6	22.6	120.5
SD	424.9	254.10	205.53	35.64	113.54	454.2	279.2	226.1	29.1	156.9
CV	34.5	29.70	86.68	137.16	102.12	37.6	33.8	94.8	128.5	130.2

Annexure 2a. Monthly rainfall received during 1982-2011 at Purusottampur

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1982	0.0	19.0	66.0	20.0	0.0	51.0	295.2	239.3	161.4	32.2	34.3	0.0
1983	0.0	92.2	33.0	83.0	49.0	196.2	482.3	217.0	202.5	129.2	31.0	12.0
1984	0.0	2.0	0.0	40.0	18.5	177.5	370.0	223.0	109.5	31.0	0.0	0.0
1985	22.0	79.0	58.0	5.0	19.0	241.5	251.4	271.0	374.0	351.5	0.0	0.0
1986	20.0	23.0	8.5	9.0	54.0	213.5	196.5	338.0	117.5	330.0	416.0	25.0
1987	18.0	0.0	22.5	55.0	37.5	69.5	295.0	144.0	83.4	169.0	252.0	0.0
1988	0.0	99.0	15.0	29.0	23.5	117.3	266.0	185.0	397.0	187.0	0.0	0.0
1989	0.0	0.0	10.0	0.0	37.0	342.2	254.0	504.0	195.0	50.0	0.0	0.0
1990	0.0	111.3	105.9	25.0	160.0	187.0	119.0	387.0	210.0	373.0	259.0	0.0
1991	0.0	0.0	27.0	26.0	0.0	188.0	341.0	191.0	386.0	116.0	81.0	4.0
1992	22.0	9.0	0.0	0.0	123.0	296.0	370.0	381.0	68.0	173.0	63.0	0.0
1993	0.0	0.0	0.0	21.0	80.0	155.0	192.0	311.0	188.0	202.0	35.0	0.0
1994	0.0	28.0	5.0	54.0	20.0	37.0	264.0	368.0	242.5	135.0	9.0	0.0
1995	38.0	0.0	5.0	4.0	623.0	154.0	126.2	502.5	176.0	388.0	88.0	0.0
1997	0.0	5.0	13.0	59.0	28.0	86.0	175.0	354.0	296.0	42.0	0.0	50.0
1998	0.0	0.0	0.0	37.0	0.0	149.8	293.0	57.0	0.0	0.0	127.0	0.0
1999	0.0	0.0	0.0	0.0	75.0	244.0	249.0	118.0	136.5	42.0	78.0	0.0
2000	0.0	0.0	0.0	27.0	87.0	0.0	260.0	49.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	10.0	4.0	43.0	372.0	157.0	229.0	166.0	181.0	193.0	0.0
2002	0.0	0.0	0.0	0.0	133.0	120.0	223.0	236.0	123.0	116.0	0.0	0.0
2003	0.0	0.0	0.0	0.0	0.0	127.0	248.0	289.0	208.0	666.0	0.0	35.0
2004	0.0	0.0	0.0	132.0	0.0	113.0	343.0	163.0	162.0	226.0	0.0	0.0
2005	59.0	0.0	43.0	3.0	10.0	54.0	194.0	215.0	370.0	211.0	90.0	0.0
2006	0.0	0.0	42.0	14.0	121.0	182.0	286.0	350.0	209.0	111.0	30.0	0.0
2007	0.0	0.0	0.0	0.0	50.0	219.0	89.0	288.0	289.0	64.0	0.0	0.0
2008	0.0	47.0	17.0	0.0	71.0	210.0	230.0	238.0	330.0	91.0	28.0	0.0
2009	0.0	0.0	0.0	0.0	69.0	62.0	515.0	231.0	124.0	143.0	182.0	0.0
2010	66.0	0.0	0.0	0.0	123.0	187.0	119.0	375.0	347.0	219.0	123.0	77.0
2011	0.0	20.0	0.0	33.0	120.0	87.0	127.0	471.0	102.0	12.0	0.0	0.0

Annexure 2b. Monthly rainfall received during 1982-2011 at Khalikote

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1982	4.0	41.0	82.5	58.5	6.0	105.0	141.0	423.0	90.5	22.5	58.0	0.0
1983	0.0	114.0	125.0	68.0	35.0	164.0	206.0	309.0	171.0	164.0	14.0	0.0
1984	0.0	0.0	0.0	37.0	10.0	100.5	248.0	266.0	231.0	28.0	0.0	0.0
1985	17.0	25.0	10.0	0.0	36.0	187.0	171.0	212.0	419.0	353.0	0.0	0.0
1986	22.0	32.0	5.0	0.0	40.0	253.0	321.0	436.0	199.0	440.0	343.0	27.0
1987	25.0	0.0	82.0	81.0	67.0	52.0	341.0	217.0	66.0	272.0	382.0	7.0
1988	0.0	63.0	19.0	61.0	12.0	160.0	250.0	132.0	346.0	101.0	0.0	0.0
1989	0.0	0.0	10.0	0.0	30.0	389.0	202.0	471.0	98.0	5.0	0.0	0.0
1990	0.0	80.0	111.0	73.0	137.0	125.0	155.0	312.0	221.0	292.0	349.0	0.0
1991	12.0	0.0	2.0	7.0	0.0	126.0	544.0	224.0	202.0	54.0	100.0	0.0
1992	16.0	5.0	0.0	9.0	18.0	170.0	318.0	205.0	92.0	205.0	52.0	0.0
1993	0.0	0.0	11.0	14.0	94.0	124.0	232.0	305.0	221.0	99.0	42.0	0.0
1994	0.0	16.0	10.0	45.5	34.0	30.5	202.0	381.0	251.0	145.0	15.0	0.0
1995	40.0	0.0	71.0	12.0	765.0	123.0	149.0	202.0	125.0	433.0	74.0	0.0
1997	3.0	6.0	34.0	50.0	29.0	63.0	251.0	566.0	234.0	77.0	0.0	96.0
1998	0.0	0.0	0.0	16.0	0.0	102.0	222.0	9.0	0.0	0.0	151.0	0.0
1999	9.0	0.0	0.0	0.0	109.0	126.0	126.0	152.0	127.0	39.0	44.0	0.0
2000	0.0	0.0	0.0	11.0	36.0	0.0	230.0	57.0	0.0	0.0	0.0	0.0
2001	0.0	0.0	28.0	40.0	84.0	261.0	189.0	309.0	181.0	189.0	110.0	0.0
2002	0.0	0.0	0.0	21.0	97.0	101.0	259.0	307.0	126.0	166.0	12.0	0.0
2003	0.0	53.0	0.0	0.0	0.0	126.0	254.0	447.0	143.0	662.0	0.0	42.0
2004	0.0	35.0	0.0	59.0	17.0	72.0	263.0	164.0	86.0	239.0	0.0	0.0
2005	50.0	0.0	25.0	0.0	0.0	68.0	139.0	222.0	528.0	244.0	22.0	0.0
2006	0.0	0.0	27.0	15.0	129.0	163.0	430.0	434.0	298.0	57.0	43.0	0.0
2007	0.0	0.0	0.0	0.0	24.0	215.0	109.0	283.0	339.0	73.0	0.0	0.0
2008	0.0	0.0	23.0	21.0	68.0	269.0	211.0	276.0	227.0	0.0	39.0	0.0
2009	0.0	0.0	0.0	0.0	82.0	75.0	447.0	149.0	132.0	194.0	59.0	0.0
2010	2.0	0.0	0.0	0.0	105.0	134.0	180.0	548.0	134.0	308.0	111.0	65.0
2011	0.0	9.0	0.0	90.0	86.0	132.0	219.0	366.0	105.0	40.0	0.0	0.0

Annexure 3. Annual and seasonal rainy day details of Purusottampur and Khalikote (1982-2011)

Year	Purusottampur					Khalikote				
	Annual	SWM	NEM	Winter	Summer	Annual	SWM	NEM	Winter	Summer
1982	45	33	5	2	5	54	34	4	6	10
1983	76	49	13	6	8	67	47	9	4	7
1984	51	44	3	0	4	51	45	1	0	5
1985	71	52	12	4	3	61	43	14	2	2
1986	69	44	15	3	7	77	55	15	3	4
1987	60	35	12	1	12	70	37	18	2	13
1988	62	50	4	2	6	62	50	4	2	6
1989	49	44	2	0	3	52	46	1	0	5
1990	80	43	16	5	16	77	39	17	7	14
1991	67	49	14	0	4	53	43	7	2	1
1992	58	43	7	3	5	49	33	9	2	5
1993	54	37	11	0	6	64	44	11	0	9
1994	63	45	9	3	6	64	45	8	3	8
1995	67	41	13	3	10	76	41	17	4	14
1997	51	36	5	1	9	56	38	8	2	8
1998	35	24	8	0	3	30	22	6	0	2
1999	59	46	6	0	7	58	42	9	1	6
2000	21	15	0	0	6	25	18	0	0	7
2001	60	42	14	0	4	62	43	14	0	5
2002	49	39	4	0	6	54	39	8	0	7
2003	53	39	14	0	0	64	43	18	3	0
2004	54	39	8	0	7	50	38	5	1	6
2005	64	40	18	2	4	64	46	15	2	1
2006	64	47	8	0	9	58	45	5	0	8
2007	48	42	4	0	2	47	42	4	0	1
2008	51	43	4	1	3	51	46	2	0	3
2009	49	38	9	0	2	46	38	6	0	2
2010	64	39	21	1	3	66	41	20	0	5
2011	43	35	2	2	4	41	34	2	2	3
Mean	56	40	9	1	6	57	40	9	2	6
SD	17.9	7.6	5.4	1.7	3.3	19.0	7.5	5.9	1.9	3.8
CV	263.0	18.7	59.5	126.1	58.7	264.1	18.4	66.6	113.3	65.7

Annexure 4. Weekly rainfall probability analysis for crop planning – Purusottampur

MSW	10%	20%	30%	40%	50%	60%	70%	80%	90%
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	5.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	60.0	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	22.0	14.5	5.0	0.0	0.0	0.0	0.0	0.0	0.0
11	23.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	10.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	25.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	17.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	18.0	3.5	3.0	0.0	0.0	0.0	0.0	0.0	0.0
17	37.0	20.5	8.0	1.0	0.0	0.0	0.0	0.0	0.0
18	13.0	6.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0
19	54.0	25.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
20	45.0	29.5	12.5	5.0	0.5	0.0	0.0	0.0	0.0
21	47.0	27.0	17.0	12.0	7.5	3.0	0.0	0.0	0.0
22	31.0	22.0	15.0	1.0	0.0	0.0	0.0	0.0	0.0
23	70.5	43.0	23.0	20.0	11.5	9.0	2.0	0.0	0.0
24	134.0	97.0	60.0	34.0	30.5	19.0	5.0	1.0	0.0
25	113.0	83.0	59.0	51.0	33.5	18.0	8.0	5.5	0.0
26	105.0	73.0	60.0	46.0	35.3	31.0	17.0	0.0	0.0
27	110.0	84.0	66.0	53.0	30.5	22.2	19.0	15.0	3.0
28	94.7	85.0	62.0	45.0	41.5	36.0	26.0	19.0	6.0
29	123.0	106.0	73.5	56.0	52.5	47.0	32.3	29.5	19.0
30	156.0	130.5	111.0	61.0	43.0	37.0	31.0	26.0	19.0
31	109.0	91.5	83.0	70.0	59.0	43.0	21.0	18.5	15.0
32	142.0	107.5	93.0	79.0	64.0	58.0	37.0	28.5	14.0
33	153.0	107.0	68.0	57.5	44.0	37.0	16.0	6.0	4.0
34	76.0	69.5	55.0	41.0	29.0	23.0	19.0	6.0	1.0
35	133.0	77.5	56.0	36.0	29.8	26.0	24.0	5.5	0.0

Contd....

MSW	10%	20%	30%	40%	50%	60%	70%	80%	90%
36	84.0	76.3	70.0	38.0	33.2	29.0	24.0	17.5	4.5
37	125.0	85.0	64.5	51.0	42.5	33.0	20.0	13.1	0.0
38	155.5	92.5	83.0	41.0	29.0	17.0	13.0	7.5	0.0
39	109.0	80.5	63.0	41.0	23.5	16.0	12.0	1.0	0.0
40	239.0	143.5	109.0	61.0	44.0	40.0	14.5	0.0	0.0
41	148.0	77.5	42.0	21.0	16.0	11.0	0.0	0.0	0.0
42	74.0	44.0	28.0	22.0	3.0	0.0	0.0	0.0	0.0
43	76.0	12.0	7.0	2.0	0.0	0.0	0.0	0.0	0.0
44	116.0	79.0	47.0	25.0	8.5	0.0	0.0	0.0	0.0
45	79.0	17.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	68.0	23.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
47	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Annexure 5.Weekly rainfall probability analysis for crop planning - Khalikote

MSW	10%	20%	30%	40%	50%	60%	70%	80%	90%
1	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	25.0	8.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0
8	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	12.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	19.0	10.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
11	25.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	10.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	26.0	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	21.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	12.0	5.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
16	40.0	10.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
17	21.0	16.3	9.0	2.0	0.0	0.0	0.0	0.0	0.0
18	20.0	10.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0
19	34.0	9.5	6.0	2.0	0.5	0.0	0.0	0.0	0.0
20	52.0	15.0	7.0	3.0	0.5	0.0	0.0	0.0	0.0
21	68.0	32.0	23.0	11.0	4.5	2.0	0.0	0.0	0.0
22	64.0	28.0	15.0	5.0	1.0	0.0	0.0	0.0	0.0
23	43.0	29.0	14.0	10.0	5.0	3.0	0.0	0.0	0.0
24	89.0	72.0	62.0	57.0	40.5	23.0	11.0	0.0	0.0
25	98.0	57.0	55.0	36.0	29.5	19.0	14.0	2.3	0.0
26	101.0	71.5	57.0	34.0	29.0	9.0	4.0	0.5	0.0
27	87.0	56.5	52.0	43.0	38.5	32.0	14.0	0.0	0.0
28	126.0	78.0	51.0	44.0	34.5	26.0	18.0	14.0	0.0
29	116.0	97.0	76.0	66.0	58.0	45.0	35.0	21.5	14.0
30	113.0	92.0	69.0	65.0	50.5	43.0	31.0	12.5	3.0
31	116.0	110.0	98.0	77.0	62.5	45.0	37.0	28.0	15.0
32	140.0	103.5	82.0	66.0	55.0	44.0	30.0	18.5	11.0
33	151.0	141.0	104.0	69.0	56.5	37.0	20.0	10.0	6.0
34	122.0	96.5	89.0	70.0	50.5	21.0	17.0	7.5	2.0
35	118.0	107.5	66.0	52.0	36.0	25.0	22.0	8.0	0.0

Contd....

MSW	10%	20%	30%	40%	50%	60%	70%	80%	90%
36	75.0	63.0	55.0	36.0	34.0	16.0	9.0	7.0	4.0
37	141.0	106.5	54.0	48.0	35.5	27.0	17.0	12.5	0.0
38	117.0	104.0	79.0	45.0	37.5	30.0	7.0	2.5	0.0
39	109.0	81.5	55.0	38.0	34.0	19.0	13.0	6.5	0.0
40	239.0	173.0	118.0	58.0	37.0	23.0	2.0	0.0	0.0
41	117.0	92.0	57.0	27.0	19.5	13.0	0.0	0.0	0.0
42	92.0	39.5	24.0	8.0	0.0	0.0	0.0	0.0	0.0
43	24.0	7.5	4.0	0.0	0.0	0.0	0.0	0.0	0.0
44	139.0	45.0	28.0	22.0	11.0	5.0	0.0	0.0	0.0
45	71.0	30.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
46	58.0	27.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0
47	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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