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Climate and soil characterisation of different blocks of Dhenkanal district of Odisha for cultivation of winter pulses in rice fallow condition

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Abstract
The present study has been undertaken to characterise climate and soil of each block of Dhenkanal district of odisha for assessing the suitability of cultivation of winter pulses in rice fallow condition. Daily rainfall and temperature data of 23 years (1995 to 2017) of Dhenkanal district have been collected to estimate amount of rainfall, rainy day, spatial and temporal variability of rainfall, initial and conditional probabilities of dry and wet week and mean monthly, seasonal and weekly temperature using 'Weather Cock' software. The district receives 77% of its total annual rainfall of 1367mm through SW monsoon and 155mm in post-monsoon (October-December) with 91% variability. soil texture was analysed by Bouyoucos hydrometer and the soil type were decided by using the textural triangle. Most of the blocks of the district had sandy loam to sandy clay loam textured soil with medium land with 100-150 mm/m available water holding capacity in the rice-fallow area, favours the cultivation of short duration(65-70days) variety of winter pulses like green gram and black gram. Minor irrigation is required for winter pulses in Parajang and Kanakadahad block during 48-49 SMW because there is early withdrawal of moisture and less availability of post-monsoon rainfall.

Keywords: climate, soil, rice-fallow, pulses, SMW

Introduction
After harvest of rainy season rice, farmers often leave the land fallow during post monsoon season which can be effectively utilized by cultivating *rabi* pulses like green gram, black gram in the residual soil moisture condition. For this purpose the soil and climate are to be properly characterised for better establishment of rabi pulses in rice fallow condition. Out of 12.2 lakh ha rice-fallow of Odisha, Dhenkanal district is having 0.28 lakh ha area under rice-fallow. The region receives 77% of the annual rainfall from south-west monsoon (June-September), but rainfall during winter/post-rainy season is important to grow second crop during the post rainy season (After wet season rice) either supplemental irrigations required or available to carry-over residual moisture which should be effectively utilized. In the region the mean date of onset of effective monsoon was found to be 17th June and southwest monsoon generally ends on 10th October.

Material and Method
The study has been conducted for Dhenkanal district of Odisha which is located between 85°58´E to 86°20´E longitude and 20°29´N to 21°11´N latitudes comes under Mid Central Table Land Zone of Odisha having 8 number of blocks namely Bhuban, Dhenkanal sadar, Gondia, Kamakhyanagar, Hindol, Kanakadaahad, Parajang, Odapada. All the weather data like morning and evening relative humidity (RH_1, RH_2), bright sunshine hours (BSH), wind speed (WS) and evaporation (E) has been collected from the Department of Agricultural Meteorology, OUAT, BBSR for the period 1995-2017 (23 years). Block wise rainfall data of Dhenkanal has been obtained from SRC site of Govt. of Odisha for the same period.

Fig 1: District map of Dhenkanal

Rainfall characterisation

Mean value of Annual, seasonal, monthly and weekly rain fall and rainy day and normal daily rainfall were found out by analysing rainfall block wise over a period of 23 years. Block wise daily rainfall data were collected from Special Relief Commissioner (SRC), Odisha. In this study the software, 'Weather Cock' was used for weather data analysis.

Spatial and temporal variability of rainfall

Mean annual, seasonal, monthly, weekly and daily rainfall and rainy day and variability of rainfall were found out by analysing rainfall block wise over a period of 23 years by processing daily rainfall data using Weather cock. "Rainy Day.exe" module was used to analyse the rainfall data. Standard deviation (SD) and Co-efficient of variance (CV) were calculated by using statistical equation.

Rainfall probability

The amount of rainfall at three probability levels i.e. 90%, 75% and 50% were computed for each standard week through fitting 'Incomplete Gamma Distribution model' by using block wise weekly rainfall data as input. Weekly rainfall probabilities for post-monsoon (Oct-Dec) period were calculated through the module "Incomplete Gamma Probabilities.exe".

Markov chain probability model for dry and wet spell analysis

In this study, weekly rainfall values have been computed from daily data series and were used for estimation of initial, conditional probabilities and consecutive dry and wet spell analysis based on 'Markov chain probability model' as described by (Pandarinath 1991) [5]. In this method 20 mm considered as the threshold value. Initial, conditional probabilities and consecutive dry and wet spell analysis for 52 SMWs are made by using equations from 1-10.

Initial probability

$$P(D) = F(D)/N \quad \text{(Eq. 1)}$$

$$P(W) = F(W)/N \quad \text{(Eq. 2)}$$

Where,
P(D) = probability of the week being dry,
F(D) = frequency of dry weeks,
P(W) = probability of the week being wet,
F(W) = frequency of wet weeks,
N = total number of years of data being used.

Conditional probabilities

$$P(DD) = F(DD)/F(D) \quad \text{(Eq. 3)}$$

$$P(WW) = F(WW)/F(W) \quad \text{(Eq. 4)}$$

$$P(WD) = 1 - P(DD) \quad \text{(Eq. 5)}$$

$$P(DW) = 1 - P(WW) \quad \text{(Eq.6)}$$

Where,
P(DD) = probability of a week being dry preceded by another dry week,
F(DD) = frequency of dry week preceded by another dry week,
P(WW) = probability of a week being wet preceded by another wet week,
F(WW) = frequency of a wet week preceded by another wet week,
P(WD) = probability of a wet week preceded by a dry week,
P(DW) = probability of a dry week preceded by a wet week.

Consecutive dry and wet week probabilities

$$P(2D) = P(DW1) \times P(DDW2) \quad \text{(Eq. 7)}$$

$P(3D) = P(DW1)\times P(DDW2)\times P(DDW3)$ (Eq. 8)
$P(2W) = P(WW1)\times P(WWW2)$ (Eq. 9)
$P(3W) = P(WW1)\times P(WWW2)\times P(WWW3)$ (Eq. 10)

Where,
P(2D) = probability of 2 consecutive dry weeks starting with the week,
P(DW1) = probability of the first week being dry,
P(DDW2) = probability of the second week being dry, given the preceding week being dry,
P(3D) = probability of 3 consecutive dry weeks starting with the week,
P(DDW3) = probability of the third week being dry, given the preceding week dry,
P(2W) = probability of 2 consecutive dry weeks starting with the week,
P(WW1) = probability of the first week being wet,
P(WWW2) = probability of the second week being wet, given the preceding week being wet,
P(3W) = probability of 3 consecutive wet weeks starting with the week
P(WWW3) = probability of the third week being wet, given the preceding week wet.

Analysis of air temperature

Normal temperature

Seasonal, monthly, weekly normal temperatures (T_{max} and T_{min}) were calculated by using the software "Weather Cock" (WC). The input data file comprised of daily T_{max} and T_{min} over the period of given years which were taken from NASA power software. The module of WC named as "Normal.exe" is used to derive seasonal and monthly normal temperature and the annual temperature is derived by computing the total monthly normal temperature.

Soil characterisation

Soil physical properties is characterised by the soil profile, land type and also textural analysis of eight blocks of Dhenkanal. soil type and soil texture plays a vital role in deciding the type and variety of crop to be grown in that area, textural analysis is done for determine the % sand, % slit and % clay by Bouyoucos hydrometer and the soil type were decided by using the textural triangle which needed for determining the available water holding capacity (AWHC).

Result and Discussion

Climatic characterisation

Mean annual rainfall for Dhenkanal district was 1367 mm (Table 1), while average number of rainy days were 64. Variability of annual rainfall among the all blocks of Dhenkanal district varied from 18% to 25% except Gondia block while CV of annual rainy days varied from 12% to 17% (Table 2) except Kankadahad. Present results confirm the results of (Pasupalak 2015) [6] for the Puri district. Mean seasonal rainfall (1055 mm) and rainy days (50 days) were highest in SW monsoon followed by post-monsoon. As a whole Dhenkanal received 77% of the mean annual rainfall during SW monsoon (Fig 2) and 8% during post-monsoon period which creates a better climatic condition of pulse production in the residual soil moisture after the harverst of *kharif* paddy in the fallow land but the post-monsoon rain fall was scanty for Kankadahada and Parajang (Fig 3) so pulses can cultivated in rice fallow land with the better utilisation of moisture or with assured irrigation. Maximum monthly rainfall (335 mm) occurred in July and rainy days (15) occurred in July and August. Lowest rain fall and rainy day occurred in the month of December. June, July, August, September and October together received 80% of the annual rainfall. Subash and Das, (2004) reported that monthly rainfall variability was low (<15%) in the months of June-September because of high rainfall. The CV was 60-140% from 24-41 week which was less than the weekly threshold limit (150%). There after it was gradually increasing in 42-52 week which was optimum for *rabi*pulses in rice-fallow condition. At 75%and 50%probability Dhenkanal received 12 mm and 40 mm post-monsoon rainfall, which is good amount of rainfall for pulse production in rice fallow condition. Hindol block received maximum amount of post-monsoon rainfall at 50% of probability (55 mm), while the minimum was received by Kankadahad (31mm) followed by Parajang (35mm) (Manikandani *et al.*, 2014).

Table 1: Block wise mean annual rainfall (mm) of Dhenkanal district

Blocks	Mean	STDEV	CV%
Bhuban	1314	279	21
Dhenkanal sadar	1432	322	22
Gondia	1321	351	27
Hindol	1607	403	25
Kamakhya Nagar	1378	336	24
Kankadahad	1441	266	18
Odapada	1264	283	22
Parjang	1175	276	23
District mean	1367	315	23

Table 2: Block wise mean annual rainy day of Dhenkanal district

Blocks	Mean	STDEV	CV%
Bhuban	62	11	17
Dhenkanal sadar	68	10	14
Gondia	61	10	17
Hindol	71	11	15
Kamakhya Nagar	65	8	12
Kankadahad	66	13	19
Odapada	60	10	17
Parjang	58	9	16
District mean	64	10	16

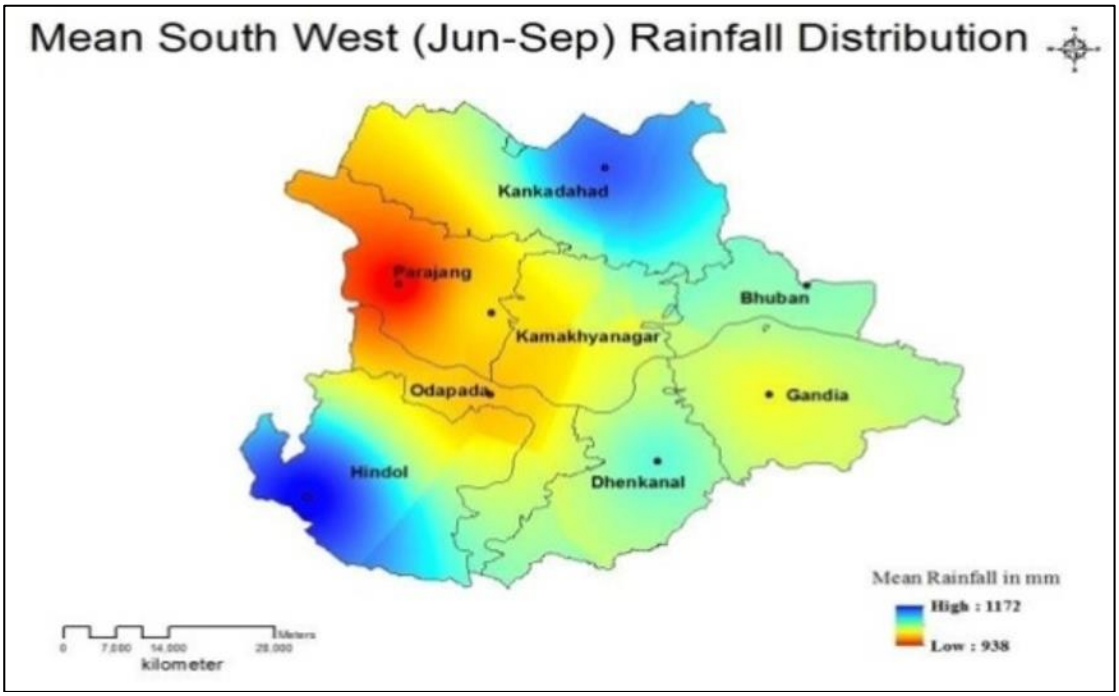

Fig 2: Mean south-west (june-Sep) rainfall distribution

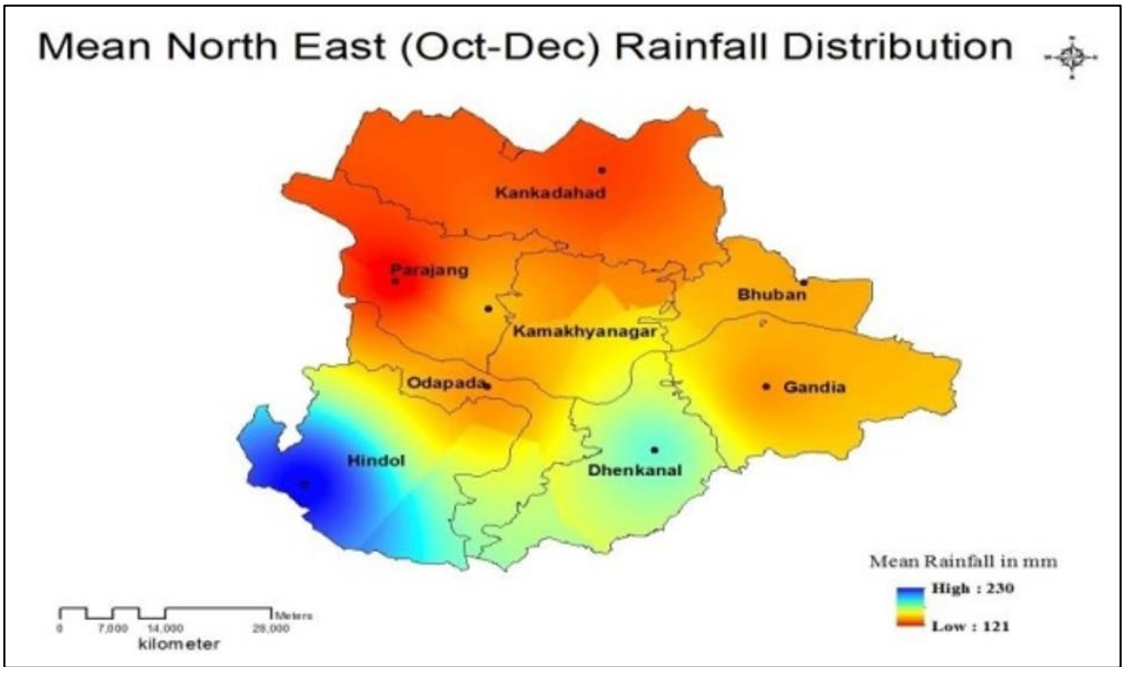

Fig 3: Mean North-East (Oct-Dec) rainfall distribution

Probability of occurrence of two to three consecutive dry weeks was >90% from week 1 to 15 and also from week 45 to 52SMW at rainfall limit of 20 mm so sowing of *rabi* pulses should be done before 45 SMW. Probability of occurrence of two consecutive wet weeks was >50% from week 25 to 37. The range of probability of wet week in these weeks varied from 50%to 75% so kharif rice transplanting was done from 26 SMW (Chand *et al.*, 2011) [1]. The average annual maximum temperature of Dhenkanal district was 30.6^{0}C, while minimum temperature was 22.1^{0}C. The months with high temperature were April and May, after which it decreased in SW monsoon period (June to September) and became lowest in the month of December. The mean seasonal maximum temperature was highest during summer (35^{0}C) and lowest in post-monsoon (27.8^{0}C). Minimum temperature was highest during SW monsoon (25.3^{0}C). The maximum and minimum temperature in post monsoon season was 27.8^{0}C and 18.9^{0}C (Fig 4) which was optimum for rabi pulses cultivation in Dhenkanal district (Johansen *et al*., 1994) [2].

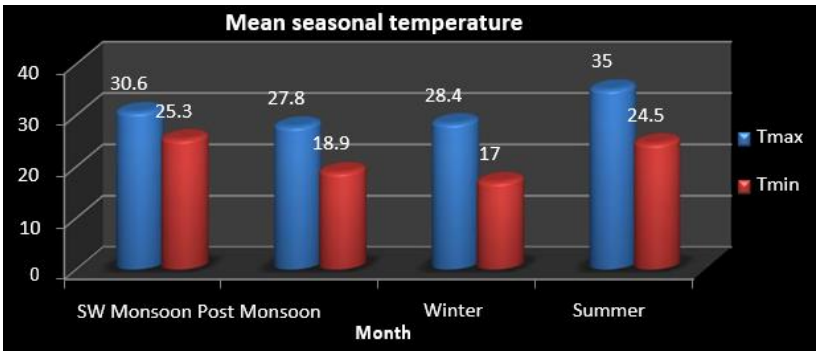

Fig 4: Mean seasonal maximum and minimum temperature of Dhenkanal district

Soil characterisation

Table 3: Block wise soil textural analysis and AWHC of Dhenkanal district

Blocks	Texture	Sand%	Slit%	Clay%	AWHC(mm/m)
Bhuban	Sandy loam	73	11	16	100
Dhenkanal sadar	Sandy clay loam	66	10	24	150
Gondia	Sandy loam	71	12	17	100
Hindol	sandyloam	73	11	16	100
Kamakhyanagar	sandy clayloam	64	11	25	150
Kankadahad	Sandy loam	70	12	18	100
Odapada	Sandy loam	71	13	16	100
Parjang	Sandy loam	70	14	16	100

Most of the blocks of Dhenkanal district had sandy loam textured soil (100mm/m AWHC) but in Dhenkanal sadar and Kamakhyanagar there was sandy clay loam soil (150mm/m) (Table 3) so the district had high potential for the growth of *rabi* pulses. Most of the blocks had high medium land coverage, but in Dhenkanal sadar and Kankadahad there was high low land coverage. Relay cropping is done particularly in rain fed low lands where excess moisture at the time of rice harvest does not permit tillage operation. Sequential cropping after harvesting of rice and land preparation is, however, practised in medium lands (Kushwana and Ali, 1992) [3].

Summery and Conclusion

The rainfall regime of the Dhenkanal district is characterised by an average annual amount of rainfall of 1367 mm with 64 numbers of rainy days. The district receives around 77% of its annual rainfall during SW monsoon and 155 mm mean rainfall during the post-monsoon period. Two blocks namely Kankadahad and Parajang have experienced less (<130 mm) amount of post-monsoon rainfall, while two blocks namely Dhenkanal sadar and Hindol have received more (>170 mm). The mean maximum and minimum temperature is 27.8ºC and 18.9ºC, respectively during post-monsoon. Maximum blocks have sandy loam and sandy clay loam textured soil having 100mm/m and 150mm/m AWHC respectively, which creates better edaphic and climatic condition for cultivation of short duration green gram and black gram by zero till method in medium land condition or *paira* method in low land condition This study further shows that minimal irrigation is required for *rabi* pulses in Parajang and kanakadahad during 48-49 SMW because there is early withdrawal of moisture and less availability of post-monsoon rainfall.

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