

Characterization of Climatic Normal and Water Balance of Ranchi

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Abstract

Daily weather parameters of 52 years (1956 to 2007) at Ranchi was considered to analyse the long-term climatic normal on weekly, monthly, seasonal and annual basis. May is found as the hottest month with monthly mean temperature of 29.8 C while January is the coldest month with monthly mean temperature of 15.5 C. July receives the highest average monthly rainfall amounts 357.9 mm distributed in average 16.9 rainy followed by August (318.8 mm in 16.7 rainy days). Maximum solar radiation (22.9 MJ/m² per day) is received during May which is associated with highest average temperature, moderate high wind speed and sun shine hours and relatively low average relative humidity. Summer season contributes substantial amount of rainfall (104.5 mm) which accounts for 7.5% to the annual rainfall with 46% coefficient of variation which is useful for the land preparation. Southwest monsoon contributes 82% of annual rainfall with 21% variability in average 55 rainy days. A large amount of cumulative surplus water (737 mm) occurs during June to September corresponds no need of supplementary irrigation for rice crop. **Key words :** Weekly climatic normal, Monthly climatic normal, Seasonal climatic normal, annual climatic normal, Water balance.

Long term series of weather data is essential for the characterization of climatic condition of a locality which has immense value for long term agricultural planning, adaptation of location specific new agricultural technologies and animal and human comfort. Better understanding of the climatic conditions will help in devising suitable management practices for increasing agricultural production. According to Vairavan et al. (1) the climatological data of a location becomes important to provide necessary information to minimize the risk. Crop productivity of a region is largely determined by its climate and prevailing weather condition. Information about pattern and magnitude of rainfall, temperature, intensity of solar radiation, water availability periods requires necessary attention for judicious crop planning and management. Water balance provides an estimate of water availability in relation to potential evapotranspiration (PET) and rainfall. Availability of water in right quantity and in right time and its management with suitable agronomic practices is essential for good crop growth and yield (2). Sahu (3) studied the annual and seasonal variability of climate in South Saurashtra agro-climatic zone by using daily historical weather

data. Singh and Singh (4) conducted a study on climatological parameters and its variation at Bikramganj, Bihar. They collected data of maximum and minimum temperature, relative humidity, rainfall and number of rainy days, wind velocity, potential evaporation and sunshine hours for 25 years and studied the weather parameters on weekly basis. In this paper, annual, seasonal, monthly and weekly variability of all weather parameters and water deficit and water surplus period based on climatic water balance were studied using 52 years weather data (1956—2007) for Kanke, Ranchi, which is close to the Tropic of Cancer at 23°17' N latitude, 83°19' E longitude and altitude of 625 meter above msl. Ranchi comes under the agro-climatic zone of eastern plateau and hills region. The soils of the region are shallow and medium in depth and the topography is undulating with a slope of 1 to 10%

Methods

The daily weather data such as air temperature (minimum and maximum), relative humidity (RH I RH II), rainfall, rainy days, pan evaporation, wind speed

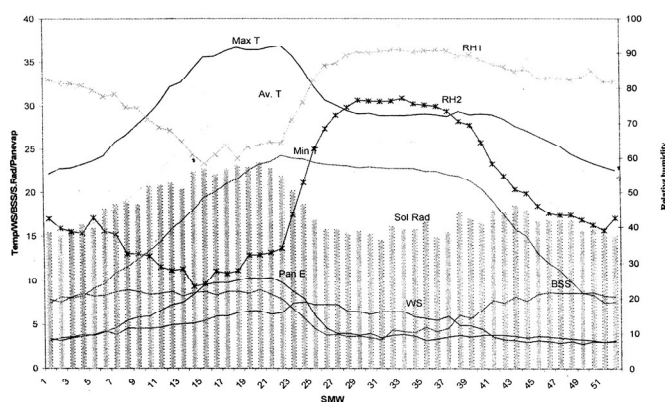


Figure 1. Weekly weather parameters at Ranchi.

and bright sun shine hours (BSS), from 1956 to 2007 recorded at Agro meteorological observatory, at BAU Kanke, Ranchi were transformed into standard meteorological weekly (SMW) means and totals. Based on IMD standards the year was divided into four seasons as summer (week 10 to 22), monsoon (week 23 to 39), post-monsoon (week 40 to 49) and winter (week 50 to 9). To study the annual, seasonal, monthly and weekly climatic behavior, statistical properties like mean, standard deviation (SD) and coefficient of variation (CV%) were derived. Potential evapotranspiration and incoming solar radiation were calculated on weekly, monthly and annual basis by using Penmen-Monteith FAO method.

Results and Discussion

To characterise the climatic normal of Kanke,

the basic statistical parameters (maximum, minimum), Standard deviation and CV of different climatic elements were computed and presented below.

Weekly Climatic Normal

Long-term weekly means of maximum, minimum and average temperature were calculated and presented in Figure 1. Rise in temperature starts from the smw, 2 attained highest value in the smw 22 (28 May-3 June) i.e. 36.9, 24.3 and 30.6 C respectively and lowest in smw 1 (1—7 January) i.e. 22.2, 7.5 and 14 C respectively. The weekly mean rainfall variation at Kanke shows that it had four peaks (Fig. 2). It is evident that from week, 42 to 22 the weekly rainfall was below 15 mm and three was a quantum jump in rainfall amount during smw 23 (4—10 June) and a value of

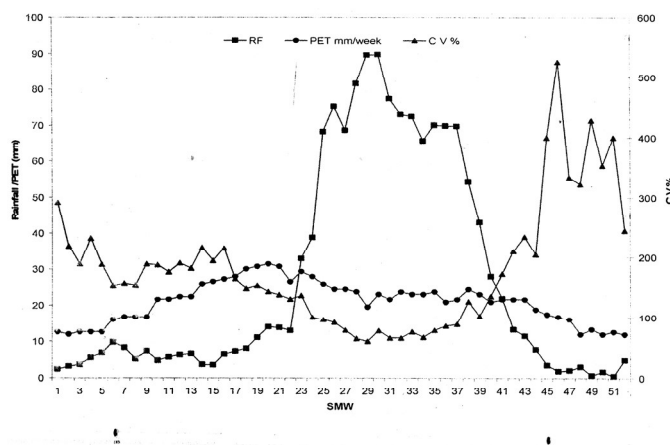


Figure 2. Weekly rainfall pattern with CV% and PET at Ranchi.

Table 1. Average monthly weather parameters at Ranchi.

Months	Rain (mm)	Rainy days	Temperature (C)			Relative humidity (%)			Wind speed (Km/h)	Sun shine hour	Solar radiation (MJ/m ² /day)	PET mm/day	Evaporation (mm/day)
			Max	Min	Average	RH I	RH-II	Average					
Jan	17.1	1.7	22.9	8.1	15.5	81	40	61	3.5	8.1	15.7	1.8	3.6
Feb	30.0	2.5	25.6	10.7	18.2	77	37	57	4.3	8.7	18.5	2.4	4.8
Mar	27.3	2.4	30.6	14.8	22.7	69	30	50	4.8	8.5	20.7	3.1	6.7
Apr	24.8	2.1	35.4	19.6	27.5	61	26	43	5.7	8.7	22.5	3.8	9.3
May	53.1	4.2	36.6	23	29.8	63	32	47	6.4	8.6	22.9	4.4	10.3
Jun	213.4	10.2	33.7	23.7	28.7	78	55	66	7.3	5.4	18.1	3.4	7.8
Jul	357.9	16.9	29.4	23	26.2	89	75	82	6.6	4	15.9	3.5	4
Aug	318.8	16.7	29	22.9	26.0	91	76	84	6.3	4.1	15.7	3.3	3.6
Sep	255.8	12.6	29.1	22.1	25.6	90	72	81	5.3	5	16	3.2	3.5
Oct	79.6	4.4	28.4	17.9	23.2	86	57	72	3.6	7.6	17.7	3.1	3.7
Nov	13.3	0.8	25.9	12.1	19.0	83	45	64	3	8.5	16.6	2.3	3.6
Dec	8.2	0.7	23.2	8.2	15.7	83.2	43	63	3	8.5	15.5	1.7	3.2
Total (average)	1399.3												18.0

more than 20 mm per week was maintained up to week 41. (8—14 October). The highest rainfall (90.9 mm) was received in smw 30 (23—29 July) and lowest (0.5 mm) in smw 51 (17—23 December). The average potential evapotranspiration and average weekly evaporation values are lowest (1.7 and 3—3.8 mm/day) during smws 48 to 5 (26 November—4 February), the value shows a rising trend between standard week 9 and 20 (26 February—20 May), i.e. when the season

changed from winter to summer. The peak in average weekly PET and evaporation was achieved around std week 20 (4.5 and 10.7 mm/day respectively), thereafter, the value showed a sharp decline between std weeks 24 and 35 (11 June—2 September) under the influence of monsoon season. A further gradual decrease in average weekly PET and evaporation value was observed between smw 36 and 52, when climatic condition changed under the influence of winter sea-

Table 2. Seasonal and annual climatic normal with standard deviation (SD) and coefficient of variation (CV%) at Ranchi.

Seasons	Temperature (C)		Rainfall (mm)	Rainy days	Relative humidity (%)		Wind speed (km/h)	BSS (h)	Evaporation (mm/day)
	Maximum	Minimum			I	II			
Summer	34.5	19.6	104.5	8.6	64	29	5.7	8.6	8.9
SD	1.35	0.96	48	3.5	10.6	6.4	1.8	0.7	1.9
CV%	3.9	4.9	46	40.8	16.7	22.2	31.9	8.1	21.8
Monsoon	30.1	22.9	1141	55	88	71	6.2	4.6	4.4
SD	0.74	0.44	244	6.7	2.8	4.3	1.7	0.6	0.9
CV%	2.5	1.9	21	12.3	3.3	6.1	27.6	13	22.3
Post-monsoon	26.8	14.2	93.9	5.3	85	50	3.2	8.1	3.7
SD	0.93	1.15	75	3.2	4.5	8.2	1.0	0.7	0.7
CV%	3.5	8.1	80	59.6	5.4	16.5	32.5	8.8	18.9
Winter	24.1	9.2	57.8	5.1	80	39	3.6	8.4	3.9
SD	0.98	1.05	38	2.9	6.9	6.5	1.3	1.3	1.01
CV%	4.1	11.4	66	58.1	8.7	16.8	36.9	16	25.9
Annual	29.2	17.2	1399	75	79	49	5	7.1	5.3
SD	1.0	1.2	272	9.3	5.14	5.07	1.52	0.8	0.89
CV%	3.5	7.2	19	12.4	6.5	10.4	30.4	11.8	16.8

son. The mean weekly PET varied from 31.5 mm/week in smw 20 to 11.9 mm/week in smw 2, 48 and 52. PET was less than average weekly rainfall from smw 23 to 40 which indicated that there was excess water during these weeks. The weekly average variation of relative humidity (Fig. 1) shows that the driest week was smw 15 with RH I and RH II, 58 and 23% and wettest week is smw 32—33 with the value of 100 and 77% respectively. The variation of bright sunshine hours (BSS) and amount of solar radiation received in different meteorological weeks ranged from 3.3h/day in the smw 31 (14—20 May) with minimum solar radiation of 14.5 MJ/m² per day to 9 h/day in smw 20 with receiving of highest solar radiation (23.5 MJ/m² per day). The average wind velocity was found to be highest (7.6 km/h) in smw 24 and lowest (2.8 km/h) in smw 49.

Monthly Climatic Normal

The monthly mean climatic normal of Kanke is presented in Table 1. The mean monthly maximum temperature varied from 22.9 C during January to 36.6 C during May. The mean monthly minimum temperature varies from 8.1 C during January to 23.7 C during June. The hottest month of Ranchi was May with average monthly temperature of 29.8C and coldest month is January with average monthly temperature of 15.5 C. Rainfall pattern and distribution during different months show that the monthly rainfall increased from January onwards, attained a flat peak during July and August and then falls to the lowest value of 8.2 mm in December. July received the highest average rainfall amount (357.9 mm) distributed in average 16.9 rainy days followed by August (318.8 mm in 16.7 rainy days). The morning and evening mean monthly relative humidity ranged between 61 and 26% in April and 91 and 76% in August. June to October forms the most humid period. The value shows that the driest month of Ranchi is April. The pan evaporation value is high during April—May (9.3 to 10.3 mm/day) and low in the cooler months (November—January). The mean monthly pan evaporation varied from 3.2 mm/day during December to 10.3 mm/day during May. The highest monthly PET value (136 mm) is observed during May. During this period, the temperature and wind speed were considerably high compared to other months. The PET value was

lowest during December to January coinciding with the cool season. This period corresponds to the low temperature, low wind speed and high humidity which is responsible for low PET values during winter season. The mean monthly wind speed ranged from 3 km/h during November—December to 7.3 km/h during June. The longest duration of sunshine hours was observed during February and April (8.7 h/day) with lowest during July (4 h/day). Maximum solar radiation (22.9 MJ/m² per day) was received during May which was associated with highest average temperature, moderatory high wind speed and sun shine hours and relatively low average relative humidity. Lowest amount of solar radiation was received during December (15.5 MJ/m² per day).

Seasonal Climatic Normal

Summer Season. The climatic characteristics of summer season reveals that the mean maximum temperature (34.5 C), mean sunshine hours (8.6 h) and mean pan evaporation (8.9 mm/day) were highest among the other seasons with standard deviation of 1.3 C, 0.7 h and 1.94 mm/day and variability of 3.9, 8.1 and 21.8%. It comprised the driest season of Ranchi with average relative humidity of 64 and 29% for morning and evening respectively (Table 2). Summer season contributes substantial amount of rainfall (104.5 mm) which accounts for 7.5% to the annual rainfall with 46% coefficient of variation. The mean wind speed for summer season is 5.7 km/h with a variability of 31.9%.

Monsoon Season. It was characterized by highest seasonal rainfall (1141 mm, variability 21%), relative humidity 86 and 71% for morning and evening (variability 3.3 and 6.1% respectively), and wind speed 6.2 km/h with 27.6% variability. Southwest monsoon contributed 82% of annual rainfall with 12.3% variability in average 55 rainy days. The mean maximum and minimum temperatures for the season were 30.1 and 22.9 C with a variability of 2.5 and 1.9% respectively. Sunshine hours of the season was lowest (4.6 h/day) and pan evaporation and PET for the season were lower than the rainfall throughout the season which makes it the wettest season with surplus water.

Post-Monsoon Season. The average rainfall for post-monsoon season was 93.9 mm which is 6.7% of annual rainfall in average 5 rainy days. The mean

Table 3. Climatic normal on weekly, monthly, seasonal and annual basis. Values of corresponding week, month and season are in parentheses.

Climatic Elements	Week		Month		Season		Annual
	Max	Min	Max	Min	Max	Min	
1 Maximum temp (C)	22 nd (36.9)	1 st (22.2)	May (36.6)	January (22.9)	Summer (34.6)	Winter (24.1)	29.2
2 Minimum temp (C)	22 nd (24.3)	1 st & 51 (7.5)	June (23.7)	January (8.1)	Monsoon (22.9)	Winter (9.1)	17.2
3 Average temp (C)	22 nd (30.6)	1 st (14.9)	May (29.8)	January (15.5)	Summer (27.1)	Winter (16.6)	23.2
4 Rainfall (mm)	30 th (89.8)	51 th (0.5)	July (357.9)	Dec (8.2)	Monsoon (1141.3)	Winter (59.6)	1400
5 Rainy days	29 th (4.2)	45-46 & 49-51 (0.1)	July (16.9)	Dec (0.7)	Monsoon (55)	Winter (5.1)	75
6 RH 1 (%)	33 rd (91)	15 th (58)	Aug (91)	April (61)	Monsoon (87)	Summer (64)	79
7 RH 2 (%)	33 rd (77)	14 th (23)	Aug (76)	April (26)	Monsoon (70)	Summer (29)	49
8 Av RH (%)	33 rd (84)	15 th (41)	Aug (84)	April (43)	Monsoon (79)	Summer (47)	64
9 Wind speed (km/h)	24 th (7.6)	49 th (2.8)	June (7.3)	Nov-Dec (3.0)	Monsoon (6.4)	Post- monsoon (3.3)	5.0
10 BSS (h)	8 & 20 th (9)	31 th (3.3)	Feb & April (8.7)	July (4.0)	Summer (8.6)	Monsoon (4.5)	7.1
11 Evaporation (mm)	19 th (10.4)	51 th (3.0)	May (10.3)	Dec (3.2)	Summer (8.9)	Post- monsoon (3.6)	5.3
12 Solar radiation MJ/m ² /Day	20 th (23.5)	31 th (14.5)	May (22.9)	Dec (15.5)	Summer (22.1)	Monsoon (16.3)	18.1
13 PET (mm)	20 th (4.5)	2,48, 50 & 52 (1.7)	May (4.4)	Dec (1.7)	Summer (3.8)	Winter (2.0)	3.0

maximum and minimum temperatures for the season were 26.8 and 14.2 C with 3.5 and 8.1% variability. It was the season having lowest wind speed (3.2 km/h), lowest atmospheric demands of moisture (Pan evaporation 3.7 mm/day) and moderate hour of average seasonal sunshine hours (8.1 h/day).

Winter Season. This season was characterized by the lowest average maximum and minimum temperature of 24.1 and 9.2 C with maximum variability of 4.1 and 11.4% respectively. Winter season accounts for the lowest rainfall, having 57.8 mm in average 5 rainy days which is only 4.3% of the annual rainfall. Wind speed and pan evaporation is 3.6 km/h and 3.9 mm/day with maximum variability of 36.9 and 25.9% respectively. Sunshine hour was comparatively high (8.4 h/day) with moderate morning (80%) and evening (39%) relative humidity.

Annual Climatic Normal

The average annual rainfall of Ranchi was 1400

mm with 19% variability and 272 mm standard deviation. The highest annual rainfall of 2065.4 mm was received in 1997 in 82 rainy days. The average annual rainy days was 75 days with a standard deviation of 9 days. In 1962 the lowest rainfall of 950.9 mm was recorded in 65 rainy days. The highest rainfall of 209.2 mm was recorded on 11 July in 1999. The annual average maximum and minimum temperature of Ranchi were 29.2 and 17.2 C respectively. The CV% of minimum temperature (7.2%) is higher than the maximum temperature (3.5%). The annual average temperature of the Ranchi was 23.2 C with 4.5% variability. The annual mean daily BSS was 7.1 with a variability of 11.8%. The annual average evaporation was 5.3 mm/day with 16.8% variability. On an average Ranchi received 6,606.5 MJ/m² per year of solar radiation. The annual average wind speed was 5 km/h with 30.4% variability. Values of overall climatic normal on weekly, monthly, seasonal and annual basis with their corre-

Table 4. Monthly PET, effective rainfall and water balance of Ranchi.

Month	Rain (mm)	PET (mm)	Effective rainfall (mm)	Water balance (mm)
Jan	17.1	56	16.6	-39
Feb	30.0	67	28.6	-37
Mar	27.3	96	26.1	-69
Apr	24.8	114	23.8	-89
May	53.1	136	48.6	-83
Jun	213.4	102	140.5	111
Jul	357.9	109	160.8	249
Aug	318.8	102	156.9	217
Sep	255.8	96	150.6	160
Oct	79.6	96	69.5	-17
Nov	13.3	69	13.0	-56
Dec	8.2	53	8.1	-45
	1399	1096	843.1	303

sponding weak, month and season are calculated and presented in Table 3.

Water Balance

The monthly water balance of Ranchi was calculated as difference between monthly precipitation and monthly PET and is presented in Table 4. The annual water balance of Ranchi was 303 mm having an annual rainfall of 1399 mm with annual PET of 1096 mm. There is a water deficit of 435 mm from October to May. A large surplus of 737 mm occurred during June to September and there was need of supplementary irrigation for rice crop and rainfed crops can be taken without any adverse effect. Of the total average annual rainfall of 1399 mm, 843.1 mm was effective. This works out to 60% of the total rainfall.

Conclusion

Ranchi is privileged to get good amount of rainfall almost throughout the year. The pre-monsoon rain is a boon for land preparation and thereby timely sowing of *kharif* crops. In case of failure of pre-monsoon shower, farmers are unable to prepare land, as the soil of this region is tough to till in the absence of moisture. Post-monsoon rain helps the *rabi* and vegetable crops. Winter season is characterized by bright sunny days with chilled cool night. The temperature range of cold month is high. Three to four days of continuous rise in temperature during summer season is associated with the subsequent rainfall in the coming days which makes the pleasant climate of the region. Instead of high annual rainfall, the region suffers from acute water deficit in summer season due to high evaporative demand, undulating land and lower water retention capacity of the native soil. Average relative humidity of Ranchi is comparatively low. All the aforesaid conditions together constitute the climate of the region as dry climate.

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