Journal of Agrometeorology
ISSN : 0972-1665 (print), 2583-2980 (online)
Vol. No. 26 (4) : 497-500 (December - 2024)
https://doi.org/10.54386/jam.v26i4.2675
https://journal.agrimetassociation.org/index.php/jam

Short communication

Impact of climatic factors on rice production in Bankura district of West Bengal, India

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Climate change is an escalating major concern of the sustainable development. Agriculture is an important part of sustainable development. Agriculture is significantly dependent on weather patterns and variability. Climate change is causing an increase in extreme weather events which can further increase the chance of climate variability. Climate change is already causing adverse impact on the agriculture sector and is also affecting the livelihood of people depending on agriculture (IPCC, 2023). In India, studies on climate change and its impact on different crops have been reported by various workers (Zacharias *et al.,* 2014; Sandeep *et al.,* 2018; Pandey, 2023; Mukherjee *et al.,* 2024).

West Bengal is one of the major rice producing states in India contributing 13.79% of rice production of the country. In West Bengal, rice is grown in all the three seasons viz. *Aus* (pre-monsoon) rice grown during March to June, *Aman* (monsoon) rice during July to October and *Boro* (post-monsoon) rice during November to February. There is increasing uncertainty in agricultural production due to increased rainfall variability due to climate change (Mandal *et al.,* 2022). Bankura is one of the districts falling under Undulating Red and Lateritic zone of the West Bengal (Fig. 1). The present study aims to analyse the trend of rice cultivated area, production, yield and climatic variables of Bankura district using past data.

Considering the objective of the study, the agricultural data of rice cultivated area and production of Bankura district for all the three rice crop seasons for the period of 1992 to 2019 were collected from the Evaluation Wing, Directorate of Agriculture, Government of West Bengal. ERA 5 Reanalysis Climatic data were collected from the Copernicus climate data store (https://cds.climate.copernicus.eu/cdsapp#!/home). In this case climatic variables like mean temperature (°C), rainfall (mm), relative humidity (%) and vapour pressure (kPa) were chosen for the period of 1992 to 2019.

Agricultural and climatic data were tabulated using Microsoft Excel spreadsheet programme, specifically with the use of its pivot tools. To assess monotonic trend in both agricultural and climatic data over the period of 1992 to 2019, Mann-Kendall test was performed. In order to calculate the magnitude of change Sen's estimator of slope was used (Swami, 2024). In order to assess the relationship between rice production and climatic variables, multiple linear regressions were conducted to predict the relation and describe association between variables. To perform linear and multiple linear regressions, crop production and yield was used as dependent variable and climatic variables were selected as independent variables. The climate data were organized for three rice crop seasons viz. *Aus* (pre-monsoon), *Aman* (monsoon) and *Boro* (post-monsoon). Previous studies with similar objectives have notably employed analogous methodologies (Sarker *et al.,* 2012; Sunny and Sidana, 2017; Guntukula, 2020).

The trend analysis of area, production and yield of rice for three seasons were carried out using Mann-Kendall test and Sen's slope estimator are presented in Table 1. The results reveal that except for *Boro* rice, all other season's rice producing area is declining significantly. In case of production, except *Aus* (pre-monsoon) rice all other season's rice production is increasing but not significantly. While *Aus* (pre-monsoon) rice is significantly decreasing. However, yield is significantly increasing for *Aus* and *Aman* season and insignificantly for *Boro* season (Table 1).

The climatic trend analysis using Mann-Kendall test and Sen's slope estimator presented in Table 2, reveals the dynamic nature of the climate in Bankura district. Over the past 28 years (1992 - 2019), the annual mean temperature has increased by approximately 0.56°C, a statistically significant rise. Additionally, annual rainfall is on the rise, although there's a reduction in pre-monsoon rainfall. But trend of rainfall is not statistically significant. Both relative humidity and vapor pressure have been increasing, with the latter showing a significant increase (Table 2).

Article info - DOI: *https://doi.org/10.54386/jam.v26i4.2675*
Received: 29 July 2024; Accepted: 26 August 2024; Published online : 01 December 2024

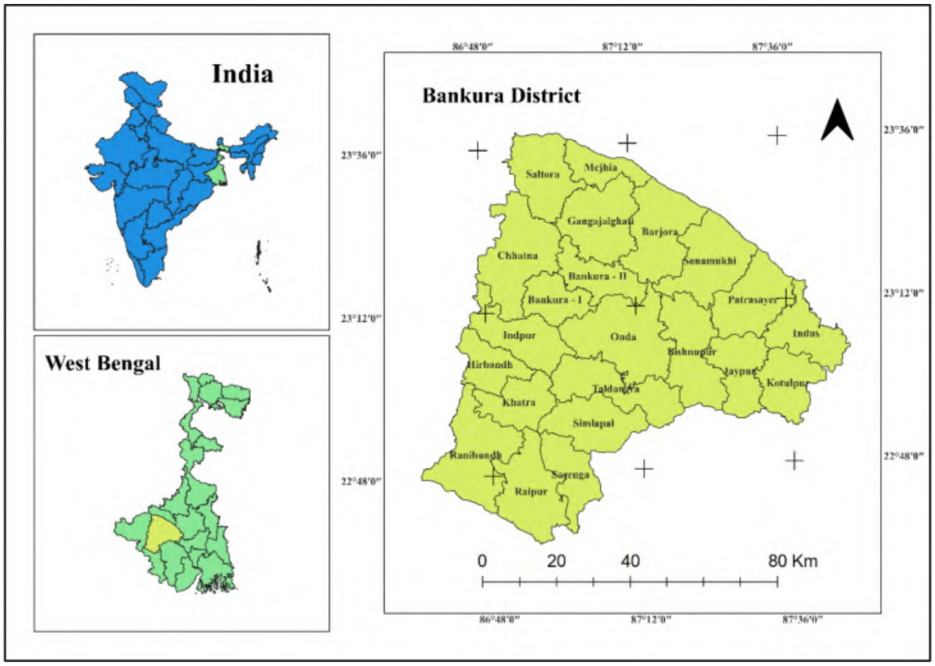

Fig. 1: Location map of the study area

Table 1: Trend of rice cultivated area and production

Crops	Mann-Kendall Test			P Value			Sen's slope (Q)		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Aus	-2.5	-2.4	3.5	0.0	**0.0**	**0.0**	-0.6	-1.1	23.6
Aman	-2.5	1.1	2.7	0.0	0.3	**0.0**	-1.2	2.6	17.6
Boro	0.4	0.5	0.7	0.7	0.6	0.5	0.1	0.3	4.6

Area is in '000 hectares; Production is in '000 metric tonnes; Yield is in kg/ha

Table 2: Trend of climatic variables during 1992-2019 in different seasons

Climatic variables	Seasons	Mann-Kendall test	P value	Sen's slope (Q)	Mean	Change
Tmean	*Aus* rice (March-June)	2.6	**0.0**	0.0	28.8	1.0
Rain		-1.1	0.3	-3.4	425.1	-94.7
RH		1.2	0.2	0.1	61.8	2.3
VP		3.2	**0.0**	0.0	2.5	0.2
Tmean	*Aman* rice (July – Oct.)	4.3	**0.0**	0.0	27.1	0.7
Rain		1.2	0.2	4.5	901.9	125.5
RH		0.3	0.7	0.0	84.0	0.4
VP		3.7	**0.0**	0.0	3.0	0.2
Tmean	*Boro* rice (Nov. – Feb.)	1.1	0.3	0.0	20.1	0.3
Rain		0.5	0.6	0.3	58.2	7.0
RH		2.4	**0.0**	0.2	63.1	4.5
VP		2.3	**0.0**	0.0	1.5	0.1
Tmean	Annual (March to Feb.)	3.6	**0.0**	0.0	25.3	0.7
Rain		0.3	0.8	2.3	1385.2	64.0
RH		1.4	0.2	0.1	69.6	1.8
VP		4.0	**0.0**	0.0	2.3	0.2

Tmean = Mean temperature (°C); Rain = total rainfall (mm); RH = relative humidity (%); VP = vapour pressure (kPa)

Table 3: Regression between climatic variables (X) and rice production and yield (Y)

Season	X variables	Beta		R^2 Value		P Value	
		Production	Yield	Production	Yield	Production	Yield
Aus (March to June)	Tmean	-6.47	716.00	0.33	0.02	0.01	0.38
	Rain	0.02	-1.39				
	RH	0.04	207.44				
	VP	-66.93	-4847.91				
Aman (July to Oct.)	Tmean	-717.05	-982.18	0.24	0.06	0.04	0.27
	Rain	0.37	0.52				
	RH	-110.13	-231.69				
	VP	3543.40	6947.97				
Boro (Nov. to Feb.)	Tmean	-19.12	-691.54	0.02	0.04	0.36	0.57
	Rain	0.09	-0.04				
	RH	-7.36	-121.20				
	VP	358.88	5977.07				

Tmean = Mean temperature (°C); Rain = total rainfall (mm); RH = relative humidity (%); VP = vapour pressure (kPa)

The multiple regression analysis carried out between rice production and yield as dependent (Y) variables and climatic parameters viz. mean temperature (Tmean), Rainfall (rain), relative humidity (RH) and vapour pressure (VP) as independent variables are presented in Table 3. The results reveal that climatic factors have significant impact on *Aus* (pre-monsoon) rice and *Aman* (monsoon) rice production. Climatic variables can explain 33% and 24% variation in rice production of *Aus* and *Aman* respectively. In case of *Boro* (post-monsoon) rice there is no significant impact of climatic factors. Further analysis of beta coefficients reveal that temperature and vapour pressure have negative impact, while rainfall and relative humidity have positive impact on *Aus* rice production. For *Aman* and *Boro* rice temperature and relative humidity have negative impact, while rainfall and vapour pressure have positive impact on production.

The regression results found in this study are also in accordance with other studies. Increasing temperature can cause increase in evapotranspiration which increases production related issues in rice (Holst *et al.,* 2013). Other studies pointed out that increase in rainfall positively affects rice production (Chandio *et al.,* 2020). But increase in temperature without significant increase in rainfall can reduce rice production (IC, 2014). This is the case for *Aus* production in Bankura, the increasing temperature and decreasing rainfall could have reduced the production. Studies also found that increase in relative humidity causes yellowing of paddy and high relative humidity increases sterility (Soponronnarit *et al.,* 1998). In this study the regression results are in accordance with that as well. Increasing temperature without significant increase in rainfall and high relative humidity (83%) could have limited the *Aman* production. *Boro* rice is produced during post-monsoon phase and it depends on irrigation. Hence climatic factors do not have significant impact on *Boro* rice production because of irrigation (Sarker *et al.,* 2012).

The rice production level in the Bankura district, situated in the Red-Laterite Agro-Climatic region, is influenced by various climatic factors, along with the availability of surface irrigation and the characteristics of the land terrain. Over time, it has been observed that there hasn't been a significant increase in the level of rice production. Given these circumstances, there is a need for further studies that focus on changes in agriculture and climate specific to the region. One potential solution to improve the situation could be the provision of location-specific agricultural extension services. These services could promote the adoption of advanced agricultural practices and technologies. Additionally, the introduction of region-specific policy interventions could be beneficial. These interventions would need to be based on the resources available in the region and the prevailing climatic factors. This comprehensive approach could potentially lead to an improvement in the rice production level in the Bankura district.

ACKNOWLEDGEMENT

The authors are grateful to all the institutions for providing necessary secondary data.

***Conflict of Interest*:** The authors declare no conflict of interest.

***Funding*:** University Grants Commission (JRF in Humanities and Social Sciences).

Data Availability: Rice data: Available, can be requested at Evaluation wing of Directorate of Agriculture, Govt. of West Bengal and Climatic data are available at https://cds.climate.copernicus.eu/cdsapp#!/home

***Authors Contributions*: R. Pramanick**: Conceptualization, data gathering, data analysis, manuscript drafting; **B. Pal**: Conceptualization, Manuscript finalization.

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