International Journal of Environment and Climate Change

Volume 14, Issue 11, Page 793-799, 2024; Article no.IJECC.126556
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Analysis of Forecasted Rainfall Across Blocks in Guntur District, Andhra Pradesh, India

Ratnam M [a] and Priya M V [a*]

[a] Gramin Krishi Mausam Sewa, Regional Agricultural Research Station, Lam, Guntur, ANGRAU -522034, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijecc/2024/v14i114588

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/126556

Original Research Article

Received: 11/09/2024
Accepted: 13/11/2024
Published: 19/11/2024

ABSTRACT

This paper represents a block and district level analysis of agro meteorological forecasted rainfall of Guntur district, Andhra Pradesh, during 2022-23. The forecasted rainfall data which was issued by IMD, Amaravathi, Guntur, Andhra Pradesh and the data was validated by employing both qualitative (success rate) and quantitative analysis (Ratio score, Hanssen and Kuipers Score and Probability of Detection). The quantitative analysis was performed by calculating ratio score analysis values ranged from 0.6 to 0.9 during the monsoons, indicating good forecast. Hansen and Kuipers score test results found to have good agreement during north east monsoon (0.5 to 0.8) with highest score values which indicates better forecast agreement, followed by monsoon period (0.3 to 0.5) and south west monsoon (0 to 0.3). Probability of Detection values found in the range of 0.7 to 1.0 indicated that better score values resulting in good forecast during the monsoon seasons. Whereas, the qualitative analysis was performed by deriving success rate for forecasted rainfall accuracy and the results reported that highest success rate was observed during north east

**Corresponding author: E-mail: priya3agrico@gmail.com;*

Cite as: *M, Ratnam, and Priya M V. 2024. "Analysis of Forecasted Rainfall Across Blocks in Guntur District, Andhra Pradesh, India". International Journal of Environment and Climate Change 14 (11):793-99. https://doi.org/10.9734/ijecc/2024/v14i114588.*

monsoon followed by south west monsoon across different blocks and also in the entire Guntur district. The per cent deviation in the analysed data might be due to the spatio-temporal variations in the rainfall distribution pattern over the study area.

Keywords: Forecasted rainfall; Hansen and Kuipers score; probability of detection; ratio score; success rate.

1. INTRODUCTION

Over the past few decades, catastrophes associated with water in India, such as floods, landslides, coastal erosion and other hazards, have gained greater interest. Among these, extreme precipitation events are directly influencing the agricultural production and are predicted to become more frequent and intense, which is a significant effect of global warming. The quantity, intensity and frequency of precipitation in the affected areas have a significant influence on these disasters, which are primarily caused by rainfall events. Extreme rainfall occurrences have been gradually increasing over the past few decades, according to several researchers (Rajeevan et al., 2008; Arelt and Nyamathi, 2024). On the other hand, inconsistent rainfall conditions like either early withdrawal of monsoon or late onset of monsoon and inadequate rainfall leads to drought, which has a major impact on agricultural operations and also on cropping pattern of the region (Barrera-Animas et al. 2022). The quantity of rainfall entirely determines the amount of soil moisture required for crop production, hence rainfall gained more importance in agricultural production of the crops over the other weather elements (Gupta et al., 2014).

The monsoon's unique distribution patterns and variability have had a significant impact on India's agricultural production and economy. In India, the Indian summer monsoon, often referred to as the southwest monsoon, contributes around 75–80 per cent of the country's annual rainfall during the summer season of June to September month (Deshpande et al., 2012). However, about 20-25 per cent of India's annual rainfall is contributed by the northeast monsoon, which is primarily limited to the Southern and Eastern parts of India, which is received during from October to December months (Sahany et al., 2018). Several studies have shown that variations in frequency and quantity of rainfall have a direct impact on the demand for stream flow patterns, the allocation of runoff over space and time, ground water reserves and soil moisture (Srivastava et al., 2014 and Praveen et al., 2020).

Indian Meteorological Department (IMD), issues short to medium range forecast for 5 days based on various national and international weather forecasting model guidance and expertise from the scientists. The forecast is being used for dissemination of agrometeorological advisories which promotes the farmers by fostering the risk mitigation approaches and also enhances the resilience at local level of the region. Agrometeorological advisories *i.e,* alerts and warnings (floods, drought, heat waves, cold waves, cyclones, thunderstorm and lightening) and seasonal forecasts play a crucial role in helping farmers to plan strategically and proactively for climate-related challenges and climate-induced adversities. As a result, more attempts are being undertaken about rainfall forecasting on a real-time basis and thereby adopting contingency strategies to deal with the monsoon's whims. Therefore, in this study, an attempt has been made on the forecasted rainfall against the actual values of rainfall of the Guntur region.

1.1 Study Area

The state of Andhra Pradesh receives 940 mm of rainfall annually, of which 76% comes from the south-west monsoon (June-September) and 24% from the north-east monsoon (October-December). Guntur district receives both south west and north east monsoon throughout the crop growing season (Fig. 1). The study area confined to the 12 blocks and whole district of the Guntur region, which comes under Krishna agro-climatic zone of Andhra Pradesh. The district is bounded on the North by Krishna District, on the West by Palnadu District, on the South by Bapatla District and on the East by Krishna River. It is situated between 16^0-17’-57.18” Northern Latitude and 80^0-25’-55.06” of the Eastern Longitude. In the study region, major crops viz., rice, bajra, jowar, maize, pulses (redgram, bengalgram, blackgram and greengram), cotton, turmeric, chillies and tobacco are cultivated throughout the year depending on the irrigation source and the rainfall. The soils in general are very fertile and they are broadly classified as black cotton soil (74%) and red loamy (26%) in the district.

Fig. 1. Location map of the study area, Guntur district, Andhra Pradesh

2. METHODOLOGY

a) **Data collection** During the study period, *i.e*., 2022-23, the agro meteorological forecasted rainfall data was issued twice *i.e.,* on every tuesday and friday of the month throughout the year by the National Centre for Medium Range Weather Forecast (NCMRWF), India, Meteorological Department, New Delhi through Regional Met Centre, Amaravathi and the actual and normal values of rainfall were collected from various meteorological observatories located in 12 blocks of Guntur district of Andhra Pradesh. In order to find out the utility of the forecasted rainfall, both qualitative and quantitative analysis was employed to validate the forecasted rainfall values against the actual rainfall.

b) **Data analysis and its formulae:** The data is verified by using both the quantitative and qualitative analysis to validate the forecast accuracy.

i. The quantitative analysis was carried out with the following 2 x 2 contingency table:

1. Ratio Score or Hit Score: It is the ratio of correct forecasts to the total number of forecasts.

$$Ratio\ score = \frac{Z+H}{N}$$

N= Total number of observations

2. Hanssen and Kuipers Scores or True Skill Score (HK Score): It is the ratio of economic saving over climatology due to the forecast to that of a set of perfect forecasts.

$$HK\ score = \frac{ZH - FM}{(Z+F)(M+H)}$$

3. Probability of detection:

$$POD = \frac{H}{M+H}$$

ii. **Qualitative analysis for all parameters:** The qualitative analysis has been worked out on yes or no basis which is mentioned in Table 2. The evaluation is conducted by categorizing the observed values within specific ranges and assigning them to three levels: Correct, Usable, and Not Usable. For rainfall, if the observed rainfall is below 35 mm, data is categorized as Correct if it falls within ±5 mm of the observed value, Usable within ±10 mm, and Not Usable if the error exceeds 10 mm. Similarly, when observed rainfall is above 35 mm, correct data should fall within ±10 mm, usable data is associated with forecasted values between 0.5 and 2 times the observed value and data beyond this range is not usable.

Temperature (maximum and minimum) is evaluated with similar precision. Correct data falls within ±1°C, usable within ±2°C and anything exceeding this range is deemed as not usable. Likewise, wind speed is assessed in terms of correct (±2 km/hr), usable (±4 km/hr) and not usable (> 4 km/hr). For any weather parameter, success rate is calculated with the formula mentioned below:

$$Success\ rate = \frac{Correct + Usable}{Total\ number\ of\ forecasts}$$

Table 1. Contingency table for quantitative analysis

		Predicted/ Forecasted	
		No Rain	**Rain**
Observed	**No Rain**	Z	F
	Rain	M	H

Z = Number of correct predictions of rain (Neither predicted nor observed)
F = Number of false alarms (predicted but not observed)
M = Number of misses (observed but not predicted)
H = Number of hits (predicted and observed)

Table 2. Qualitative analysis for weather parameters

Parameter	**Error Structure**		
Rainfall		**Observed**	
		< 35 mm	**> 35 mm**
	Correct	± 5	± 10
	Usable	± 10	0.5 * Obs<Fcst< 2 * Obs
	Not Usable	> 10	-
Temperature (maximum and minimum)	Correct	± 1 ^{O}C	
	Usable	± 2 ^{O}C	
	Not Usable	> 2 ^{O}C	
Wind speed	Correct	± 2 km/hr	
	Usable	± 4 km/hr	
	Not Usable	> 4 km/hr	

3. RESULTS AND DISCUSSION

3.1 Evaluation of Quantitative Analysed Data Across the Study Area

The quantitative analysis of forecasted rainfall of Guntur district and its blocks was performed by calculating ratio score, Hansen and Kuipers score and Probability of Detection values and were mentioned in Table 3.

a) **Ratio score:** The ratio score of different blocks of Guntur district of south coastal Andhra Pradesh was analyzed and the analysed values ranged from 0.6 to 0.9 during the monsoon period. During the south west monsoon, the ratio score of 0.6 was resulted in all the blocks except Tenali, Ponnuru and Repalle blocks (0.7) of the study area. During north east monsoon, better accuracy with highest ratio score was observed in Mangalagiri and Sattenapalli of 0.9 score blocks, indicating good forecast and the lowest score was noticed in Ponnuru and Bapatla blocks with 0.7 ratio score of the Guntur block. Additionally, the ratio score of 0.7 was observed in all the blocks during monsoon period and whereas, in the whole district, a score of 0.8 was observed in all the different monsoon periods.

b) **Hanssen and Kuipers Score or True Skill Score (HK Score):** The HK score of the different blocks of the Guntur district of south coastal Andhra Pradesh was analyzed in both the monsoons (0.1 to 0.8) and during the monsoon period. During the south west monsoon, the score only ranged from 0.1 to 0.3 in all the blocks of the study area and the highest ratio score was observed during north east monsoon in Mangalagiri (0.8) block and a minimum value of 0.6 was observed in Tenali, Narasaraopet, Ponnuru, Repalle and Bapatla blocks of Guntur district. During the monsoon period, 0.4 ratio score was observed in Vinukonda, Narasaraopet, Ponnuru, Repalle, and Bapatla blocks and ratio score of 0.5 was observed in the remaining blocks. However, no skill score was observed during the south west monsoon, whereas, 0.5 and 0.3 was noticed during the north east monsoon and monsoon period, in entire Guntur district, respectively.

c) **Probability of Detection (PoD):** The PoD for various blocks in the Guntur district of South Coastal Andhra Pradesh were analyzed, revealing a range from 0.6 to 1.0 during both monsoons and from 0.7 to 0.9 during the monsoon period. The highest PoD values (0.9 and 0.9) were observed in

Tenali, Ponnuru and Repalle blocks and the lowest PoD value was observed in Vinukonda (0.6 and 0.7) block during the south west monsoon and monsoon period, respectively. The highest PoD values (1.0) were observed in Mangalagiri and Ponnuru blocks and the lowest PoD values (0.8) was observed in Krosuru and Narasaraopet blocks during the south west monsoon. Additionally, the entire Guntur district showed scores of 1.0, 0.9 and 0.9 during the south west monsoon, north east monsoon and monsoon period, respectively. These findings clearly shown that there was a good agreement, indicating good forecasting of rainfall data.

3.2 Evaluation of Qualitatively Analysed Data Across Various Blocks and the Overall District

The qualitative analysis of forecasted rainfall of Guntur district and its blocks was performed by deriving success rate values and were presented in Table 4.

Blocks of Guntur district: The success rate of the different blocks of Guntur district of south coastal Andhra Pradesh was analyzed by qualitative analysis method and that the success rate of south west monsoon (June-September) period indicated that the highest success rate was observed in Vinukonda (88.5%) followed by Ponnuru block (86.1%) but lowest was noticed in Tenali (79.5%) followed by both the Mangalagiri and Bapatla blocks (82.0%). The highest success rate values recorded in both Krosuru and Mangalagiri blocks (89.2%) and the lowest values recorded in Sattenapalli (80.6%) followed by Piduguralla (83.7%), during north east monsoon (October-December).

During the entire monsoon season, highest success rate was observed in Vinukonda (88.2%) followed by Krosuru (88.1%) while, lowest was noticed in Sattenapalli (82.1%) followed by Piduguralla (83.7%).

Table 3. Season-wise quantitative analysis of rainfall for the year 2022-23

Name of the block & district	Ratio Score			HK Score			PoD		
	SWM	NEM	MP	SWM	NEM	MP	SWM	NEM	MP
Guntur District	0.8	0.8	0.8	0.0	0.5	0.3	1.0	0.9	0.9
Guntur Block	0.6	0.8	0.7	0.2	0.7	0.5	0.7	0.9	0.8
Tenali Block	0.7	0.8	0.7	0.3	0.6	0.5	0.9	0.9	0.9
Vinukonda Block	0.6	0.8	0.7	0.1	0.7	0.4	0.6	0.9	0.7
Piduguralla Block	0.6	0.8	0.7	0.3	0.7	0.5	0.8	0.9	0.8
Krosuru Block	0.6	0.8	0.7	0.3	0.7	0.5	0.8	0.8	0.8
Macherla Block	0.6	0.8	0.7	0.2	0.7	0.5	0.7	0.9	0.8
Mangalgiri Block	0.6	0.9	0.7	0.3	0.8	0.5	0.7	1.0	0.8
Narasaraopeta Block	0.6	0.8	0.7	0.1	0.6	0.4	0.7	0.8	0.8
Ponnuru Block	0.7	0.7	0.7	0.3	0.6	0.4	0.9	1.0	0.9
Repalle Block	0.7	0.8	0.7	0.2	0.6	0.4	0.9	0.9	0.9
Sattenapalle Block	0.6	0.9	0.7	0.2	0.7	0.5	0.7	0.9	0.8
Bapatla Block	0.6	0.7	0.7	0.3	0.6	0.4	0.8	0.9	0.8

(HK Score-Hanssen and Kuipers Score; PoD- Probability of Detection)
(SWM-South west monsoon; NEM-North east monsoon; MP-Monsoon period)

Table 4. Season-wise qualitative analysis of rainfall for the year 2022-23

Name of the block & district	South west monsoon	North east monsoon	Monsoon period
Guntur District	77.0	84.8	80.9
Guntur Block	83.7	85.9	84.8
Tenali Block	79.5	86.9	83.2
Vinukonda Block	88.5	87.9	88.2
Piduguralla Block	83.7	83.7	83.7
Krosuru Block	87.0	89.2	88.1
Macherla Block	83.7	88.1	85.9
Mangalagiri Block	82.0	89.2	85.6

Name of the block & district	South west monsoon	North east monsoon	Monsoon period
Narasaraopeta Block	83.7	89.0	86.4
Ponnuru Block	86.1	86.9	86.5
Repalle Block	84.4	85.7	85.1
Sattenapalle Block	83.6	80.6	82.1
Bapatla Block	82.0	88.0	85.0

Guntur district: The qualitative analysis values of entire Guntur district of south coastal Andhra Pradesh indicated that highest success rate was acquired during south west monsoon (84.8%) as compared with north east monsoon (77.0%). However, the success rate of entire monsoon period was 80.9% in the Guntur district. The differential per cent values were identified in the different blocks might be due to the spatio-temporal varation in the rainfall frequency and its distribution and these findings were found similar to that of Ratnam et al., (2018) and Ratnam et al., (2023).

4. CONCLUSION

Block wise and district wise validation of forecasted rainfall was performed in this paper. The qualitative analysis (success rate) and quantitative analysis measures such as Hansen and Kuipers score, Probability of Detection and ratio score results indicated that good agreement was found between the analysis and the forecasted rainfall data during the monsoon season of the Guntur district, which represents good forecast in the study area. Machine learning techniques for further studies can be used to assess the performance of forecasted data, thereby providing the accurate data at block level of the region.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

FUNDING AND ACKNOWLEDGEMENT

Authors are thankful to India Meteorological Department, New Delhi and IMD Agrimet Division, Pune for providing the funds under Gramin Krishi Mausam Sewa. We are also thankful to Regional Met Centre, Amaravathi and APSDPS, Govt. of Andhra Pradesh for the provision of daily forecasted rainfall and rainfall data for the study area, respectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Arelt, A., & Nyamathi, S. J. (2024). Precipitation trend analysis of Highland, India. *International Journal of Environmental Engineering, 4*(1), 2582–2589.

Barrera-Animas, A. Y., Oyedele, L. O., Bilal, M., Akinosho, T. D., Delgado, J. M., & Akanbi, L. A. (2022). Rainfall prediction: A comparative analysis of modern machine learning algorithms for time-series forecasting. *Machine Learning with Applications, 7*, 100204. Deshpande, N. R., Kulkarni, A., & Kumar, K. K. (2012). Characteristic features of hourly rainfall in India. *International Journal of Climatology, 32*(11), 1730–1744.

Gupta, M., Srivastava, P. K., Islam, T., & Ishak, A. M. B. (2014). Evaluation of TRMM rainfall for soil moisture prediction in a subtropical climate. *Environmental Earth Sciences, 71*, 4421–4431.

Praveen, B., Talukdar, S., Shahfahad, Mahato, M., Mondal, J., Sharma, P., AbuReza, M. D., Towfiqul, Islam, A. R. M. T., & Rahman, A. (2020). Analyzing trend and forecasting of rainfall changes in India using non-parametrical and machine learning approaches. *Scientific Reports, 10*, 10342. Rajeevan, M., Bhate, J., & Jaswal, A. K. (2018). Analysis of variability and trends of extreme rainfall events over India using 104 years of gridded daily rainfall data. *Geophysical Research Letters, 35*.

Ratnam, M., Sowmya, D., Rajamani, S., Reddy, A. S., & Subbarao, G. (2023). Validation of agro-meteorological rainfall forecasted to twelve blocks of Guntur district of South Coastal Andhra Pradesh. *Journal of Pharmaceutical Innovation, 12*(3), 333–338.

Ratnam, M., Vindya, S., & Venkatarao, P. (2018). Validation of agro-meteorological rainfall forecast for Krishna agro-climatic zone of

Andhra Pradesh. *International Journal of Agricultural Sciences, 10*(22), 7491–7492.

Sahany, S., Mishra, S. K., Pathak, R., & Rajagopalan, B. (2018). Spatiotemporal variability of seasonality of rainfall over India. *Geophysical Research Letters, 45*(14), 7140–7147. Srivastava, P. K., Han, D., Rico-Ramirez, M. A., & Islam, T. (2014). Sensitivity and uncertainty analysis of mesoscale model downscaled hydro-meteorological variables for discharge prediction. *Hydrological Processes, 28*, 4419–4432.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/126556