

# Artificial Intelligence Techniques for Rainfall Prediction in Mizoram

Abul Kashim Md Fujail<sup>1\*</sup> and Jarita Das<sup>2</sup>

<sup>1</sup>Department of Computer Science, MHCM Science College, Hailakandi, Assam, India

<sup>2</sup>Department of Statistics, MHCM Science College, Hailakandi, Assam, India

E-Mail: <sup>1</sup>abul\_fujail@yahoo.com, <sup>2</sup>jaritadas@gmail.com

\*Corresponding Author

**Abstract**—Rainfall prediction plays a vital role in managing hydrological events. An accurate predictive model can provide timely information to reduce the affects of extreme events such as, drought and flood. In Mizoram, agriculture is a key component of the economy. Accurate and early rainfall predictions are crucial to mitigate the adverse affects of prolonged dry periods or heavy rains on crop yield and the overall economy of the state. Artificial intelligence (AI) models can achieve precise rainfall predictions by uncovering concealed patterns within historical rainfall data. In the present study, AI models viz. extreme learning machine (ELM), artificial neural network (ANN) and support vector machine (SVM) have been used for predicting rainfall in Mizoram state of India. The meteorological data from 2002 to 2021 is used to train and test the predictive accuracies of the models. The study demonstrates reasonably accurate predictive capability of all the aforesaid AI models considered in the study. The performance of ELM was found superior, exhibiting smaller error and higher coefficient of determination than ANN and SVM.

**Keywords:** Artificial neural network, Extreme learning machine, Support vector machine, Rainfall prediction, Artificial intelligence

## INTRODUCTION

Accurate rainfall prediction is crucial due to its significant impact on various activities including agriculture and transportation. In a state like Mizoram, India, where the economy relies heavily on agriculture and occurrences of landslides due to heavy rain is a common phenomenon that results in transportation difficulties and loss of lives and properties, the development of an accurate rainfall estimation model bears immense potential. Alterations in historical rainfall patterns lead to extreme weather events such as droughts and floods which causes change in cropping practices, and pose significant challenges for water resource management authorities. Rainfall prediction is an important research area given its significant impact on lives and property. Heavy rainfall affects various aspects of society and daily life, spanning from agriculture to disaster preparedness measures. Consequently, accurate rainfall

estimation is essential for policymakers, water resource engineering, and farmers (Abebe & Endalie, 2023; Barman & Barman, 2021). The earlier studies on rainfall prediction in Mizoram has centered around traditional ecological knowledge such as, the behaviors of insects, birds, and mammals, as well as the traits of plants, cloud condition etc (Chinlapianga, 2011). There are limited number of statistical studies on rainfall forecasting in Mizoram (Saha *et al.*, 2015; Saha *et al.*, 2021).The existence of nonlinear and chaotic structures within historical rainfall data series disrupts the effectiveness of conventional statistical prediction models. The nonlinear patterns of rainfall makes it is crucial to develop data-driven models for enhancing the accuracy of rainfall prediction (Garai & Paul, 2024). Adopting an intelligent forecasting model would offer significant benefits in the field of water resources management.

Machine learning models represent a recently developed approach to rainfall prediction that utilizes advanced algorithms and artificial intelligence techniques to analyze vast amounts of data and identify patterns and trends that can be used to predict rainfall patterns. Artificial intelligence (AI) methodologies excel in rainfall prediction because they have the capacity to discern intricate patterns, capture non-linear correlations (Waqas, *et al.*, 2023). AI models shows capability in rainfall prediction with significant accuracy. In the last two decades, AI models have shown incredible accuracy in their performance in forecasting across various domains of science and engineering (Dash, *et al.*, 2018a). By learning from existing historical data, AI models can make accurate and efficient rainfall prediction. Various AI models such as, artificial neural network (ANN), support vector machine (SVM), K-Nearest Neighbor (KNN), Echo State Networks, deep neural network and extreme learning machine (ELM) have been employed to predict rainfall with remarkable precision in different regions around the world (Barman & Barman, 2021; Waqas, *et al.*, 2023; Weesakul, *et al.*, 2018; Hussain & Zoremsanga, 2021; Lakshminarayana, *et al.*, 2020). However, there is lack of studies using artificial intelligence methodologies for prediction of rainfall in Mizoram.

ANNs can identify and model functional relationships between data (Fujail & Das, 2023). It has been utilized for rainfall forecasting with satisfactory accuracy (Singh & Borah, 2013; Kala & Vaidyanathan, 2018; Dada, *et al.*, 2021; Nandakumar, *et al.*, 2021; Aizansi, *et al.*, 2024). ANN models and SVM have been employed for predicting rainfall in the Bolangir district, Odisha, India. SVM model has shown superior performance than ANN models in the field of rainfall forecasting (Samantaray, *et al.*, 2019). Different studies have revealed efficiency of SVM in rainfall prediction (Dawoodi & Patil, 2021). SVM is also reported to predict more accurately than Random Forests (Dhamodaran, *et al.*, 2020). Recently, ELM has been introduced in rainfall forecasting that provides reasonable accuracy, however multilayer perceptron (MLP) neural network outperformed ELM, and the researcher suggested for further investigation to improve the accuracy of ELM (Lazri, *et al.*, 2022). The effectiveness of KNN, ANN and ELM in predicting rainfall was assessed in (Dash, *et al.*, 2018a). Among these methods, the ELM model demonstrated superior accuracy compared to both KNN and ANN. This research seeks to evaluate the effectiveness of ANN, ELM and SVM models in predicting rainfall in Mizoram.

## DEVELOPMENT OF RAINFALL PREDICTION MODEL

In this study, artificial neural network, extreme learning machine and support vector machine have been developed to predict rainfall in Mizoram. Brief descriptions about the models have been given in this section.

### ARTIFICIAL NEURAL NETWORK

An artificial neural network (ANN) is a collection of interconnected neurons organized in layers, designed to map input patterns to corresponding output patterns. Neural networks achieve this by training neurons on specific patterns and then using this trained model to predict outputs for new inputs. The study utilized the backpropagation learning algorithm to train a feed-forward neural network comprising of an input layer, a hidden layer, and an output layer. The number of neurons in the input and output layers is determined by the number of input and output variables, respectively. However, figuring out the size of the hidden layer requires a trial-and-error approach. ANN is the most popular data-driven approach in hydrology. The backpropagation neural networks are commonly utilized in rainfall forecasting (Singh & Borah, 2013; Shukla, *et al.*, 2011; Mislán, *et al.*, 2015; Dash, *et al.*, 2018b; Velasco, *et al.*, 2019; Khan, *et al.*, 2024). The ANN produces output ( $o$ ) for each input pattern and adjusted weights to minimize the difference of network output from target ( $t$ ) value. The error between target and predicted values is computed using Eq. (1).

$$Error = \frac{1}{n} \sum_{i=1}^n (t_i - o_i)^2 \quad (1)$$

In the present study, ANN with Levenberg-Marquardt algorithm using logistic sigmoid transfer function in the hidden layer and linear transfer function is employed for rainfall prediction.

### EXTREME LEARNING MACHINE

An Extreme Learning Machine (ELM) is a type of single-hidden layer feedforward neural network. Unlike traditional neural networks, ELMs are characterized by their fast learning capabilities, primarily due to the random assignment of input weights and biases, which are not adjusted during the training process. Instead, only the weights connecting the hidden layer to the output layer are optimized. ELMs often exhibit good generalization performance, meaning they can effectively make predictions

on new, unseen data (Lazri, *et al.*, 2022; Li, *et al.*, 2019). This is partly due to their ability to capture complex patterns with fewer computational resources. ELM offers a fast and efficient alternative to traditional neural networks, with strong performance in many practical applications (Lazri, *et al.*, 2022). Their unique training approach and ability to generalize well make them valuable tools in the sphere of machine learning. In this study, the ELM utilized radial basis activation function.

## SUPPORT VECTOR MACHINE

Support Vector Machine (SVM) is a robust and adaptable supervised learning algorithm employed for both classification and regression tasks. Its primary objective is to identify the optimal hyperplane that separates data points into distinct classes while maximizing the margin, defined as the distance between the hyperplane and the closest data points from each class, known as support vectors. SVM excels at managing high-dimensional data and can find complex decision boundaries by employing kernel functions. These functions transform the input data into a higher-dimensional space, making the classes linearly separable (Yin, *et al.*, 2022). This feature enables SVM to accurately identify complex patterns in the data and make accurate predictions even in cases of non-linear relationships. By leveraging its capability to find optimal decision boundaries, SVM can effectively classify different rainfall levels based on historical data (Mehr, *et al.*, 2019). ANNs focus on minimizing training errors, while SVMs are designed to reduce generalization errors.

## METHODOLOGY

The rainfall data for Mizoram is collected from Directorate of Economics & Statistics, Planning & Programme Implementation Department, Government of Mizoram (MDM, 2022), which compiled data from 45 rainfall collecting stations. The dataset comprises of monthly rainfall of the state for the period 2002 to 2021. Thus, the dataset contains 2 input parameters *viz.* month and year, and one output parameter *i.e.* rainfall in millimeter. For effective training of the machine learning models, the dataset is normalized using Eq. (2).

$$x_N = \frac{x - x_{min}}{x_{max} - x_{min}} \quad (2)$$

where,  $x$  represent the original value, and  $x_N$  denote the normalized value of  $x$ . The variables  $x_{max}$  and  $x_{min}$  denote the maximum and minimum actual values of each parameter. The formula normalizes data in the range 0 to 1.

The dataset was randomly divided into a training set, comprising 80% of the data, and a testing set with the remaining 20%. The training set is utilized for training the AI models, while the testing set is used to assess their performance.

The performance of the AI models is assessed based on root mean square error (RMSE), mean absolute error (MAE), and coefficient of determination ( $R^2$ ).

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (t_i - o_i)^2} \quad (3)$$

$$MAE = \frac{1}{n} \sum_{i=1}^n |t_i - o_i| \quad (4)$$

$$R = \frac{\sum_{i=1}^n (t_i - \bar{t})(o_i - \bar{o})}{\sqrt{\sum_{i=1}^n (t_i - \bar{t})^2 \sum_{i=1}^n (o_i - \bar{o})^2}} \quad (5)$$

Here,  $o_i$  and  $t_i$  represent the predicted and measured outputs for the  $i^{\text{th}}$  input pattern, respectively. The symbols  $\bar{o}$  and  $\bar{t}$  denote the averages of the predicted and measured outputs, respectively, and  $n$  stands for the total number of patterns.

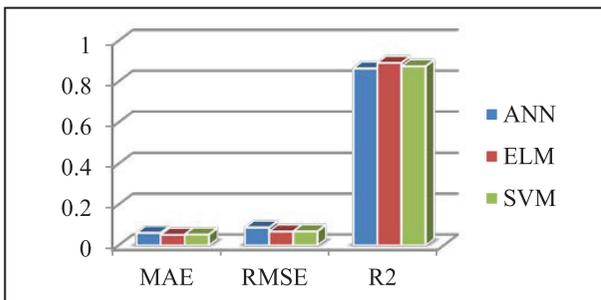
## EXPERIMENTAL RESULTS

The ANN, ELM and SVM models are trained with the normalized rainfall data. The effectiveness of the AI models is assessed using statistical metrics, such as mean absolute error (MAE), root mean square error (RMSE) and coefficient of determination ( $R^2$ ), comparing the AI models predicted values and target values. The best structures for all AI models were identified based on the lowest MAE and RMSE values, as well as the highest  $R^2$  values observed during testing. A grid search strategy was employed to determine the optimal hyper-parameter values of the AI models. The ANN model provided better performance with 12 nodes in the hidden layer, whereas in the ELM model, optimal results are achieved with the hidden layer comprising of 25 nodes. In the present study, the SVM with radial basis kernel function provides superior accuracy compared to other kernel functions. The results obtained on testing dataset with ANN, ELM and SVM with optimal architecture is tabulated in Table 1.

**Table 1: Performance Matrices of AI Models.**

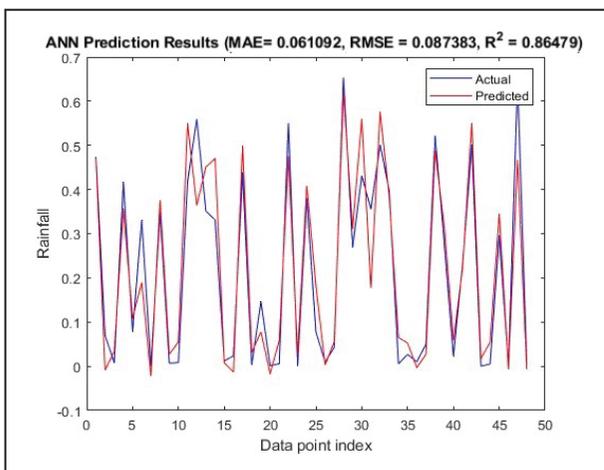
| AI Model | MAE             | RMSE            | R <sup>2</sup> |
|----------|-----------------|-----------------|----------------|
| ANN      | 0.061092        | 0.087383        | 0.86479        |
| ELM      | <b>0.051456</b> | <b>0.068434</b> | <b>0.89202</b> |
| SVM      | 0.053572        | 0.068757        | 0.87476        |

Table 1 show that MAE for ANN, ELM and SVM are 0.061092, 0.051456 and 0.053572, respectively and the corresponding RMSE values are 0.087383, 0.068434 and 0.068757, respectively. Thus, ELM model gives lowest error between predicted and target values than the other models considered in the study. Moreover, ELM provided highest R<sup>2</sup> value i.e. 0.89202 compared to ANN and SVM with R<sup>2</sup> values 0.86479 and 0.87476, respectively. Figure 1 presents a comparison of the results from the AI models using the specified evaluation metrics. Thus, the study suggests that the ELM model outperforms the ANN as well as SVM models in predicting rainfall.

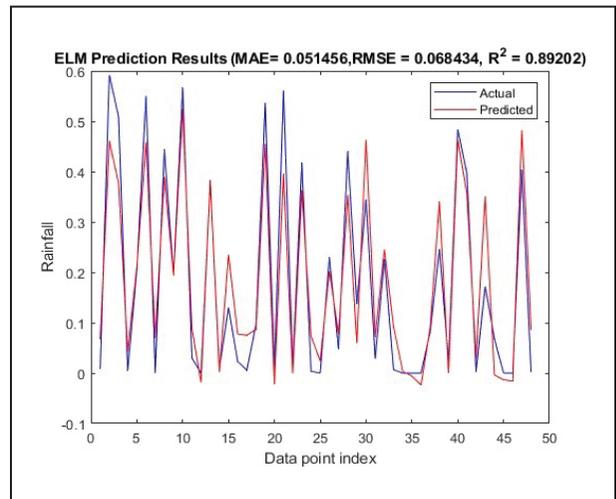


**Fig. 1: AI Models with Different Performance Metrics.**

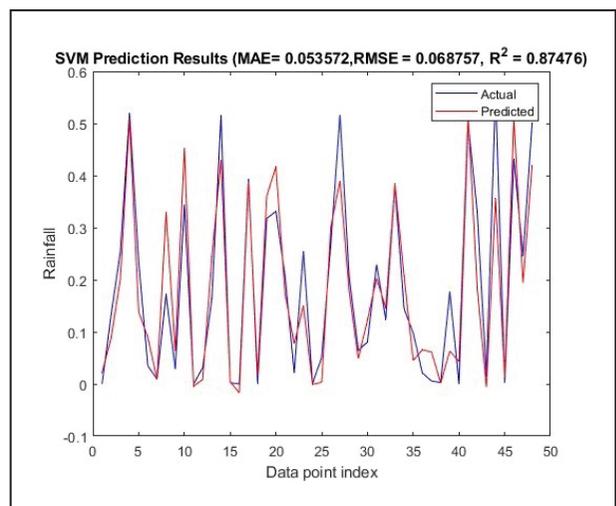
Figures 2-4 visually depict the performance of the different models under consideration, highlighting the errors between the estimated and target values with testing dataset.



**Fig. 2: Normalized Rainfall value Predicted by ANN and Measured Rainfall Value.**



**Fig. 3: Normalized Rainfall Value Predicted by ELM and Measured Rainfall Value.**



**Fig. 4: Normalized Rainfall value Predicted by SVM and Measured Rainfall Value.**

Figures 2-4 illustrate the correlation between the rainfall values forecasted by the AI models and the observed rainfall values, showing a remarkable similarity between the two. However, upon comparison, the ANN model demonstrates the lowest performance among the three models, while the ELM model outperforms both the ANN and SVM models in terms of error and coefficient of determination. The findings of the study highlight the effectiveness of AI models in accurately predicting rainfall. Furthermore, the ELM model demonstrates exceptional performance in precisely estimating rainfall. As a result, the ELM model emerges as a valuable tool for reliably predicting rainfall without climatic data.

## CONCLUSION

The Performances of ANN, ELM and SVM models were evaluated for predicting monthly rainfall using data from meteorological stations in Mizoram. These models were trained with historical data and validated using unseen data, with predicted values closely matching actual measurements. The study shows that ANN, ELM and SVM models can accurately predict rainfall, achieving a high degree of accuracy. The experimental results indicate that the ELM model outperforms the ANN and SVM models. The AI technique can aid in planning effective countermeasures to minimize the impact of prolong dry season or heavy rainfall and thus help in development of overall economic condition of the state. Further study can be carried out to explore the effectiveness of other AI models along with examining the impacts of climate variables and environmental features.

## REFERENCES

- Abebe, W. T., & Endalie, D. (2023). Artificial intelligence models for prediction of monthly rainfall without climatic data for meteorological stations in Ethiopia. *Journal of Big Data*, 10(1). <https://doi.org/10.1186/s40537-022-00683-3>
- Aizansi, A. N., Ogunjobi, K. O., & Ogou, F. K. (2024). Monthly rainfall prediction using artificial neural network (case study: Republic of Benin). *Environmental Data Science*, 3. <https://doi.org/10.1017/eds.2024.10>
- Barman, U., Sahu, D., & Barman, G. G. (2021). Comparison of LR, SVR, and DNN for the Rainfall Forecast of Guwahati, Assam. In *Lecture notes in networks and systems*, 170, 297–304. [https://doi.org/10.1007/978-981-33-4084-8\\_28](https://doi.org/10.1007/978-981-33-4084-8_28)
- Chinlampainga, M. (2011) Traditional knowledge, weather prediction and bioindicators: A case study in Mizoram, Northeastern India. *Indian Journal of Traditional knowledge*, 10(1), 207-211
- Dada, E. G., Yakubu, H. J., & Oyewola, D. O. (2021). Artificial Neural Network Models for Rainfall Prediction. *European Journal of Electrical Engineering and Computer Science*, 5(2), 30–35. <https://doi.org/10.24018/ejece.2021.5.2.313>
- Dash, Y., Mishra, S. K., & Panigrahi, B. K. (2018a). Rainfall prediction for the Kerala state of India using artificial intelligence approaches. *Computers & Electrical Engineering*, 70, 66–73. <https://doi.org/10.1016/j.compeleceng.2018.06.004>
- Dash, Y., Mishra, S. K., Sahany, S., & Panigrahi, B. K. (2018b). Indian summer monsoon rainfall prediction: A comparison of iterative and non-iterative approaches. *Applied Soft Computing*, 70, 1122–1134. <https://doi.org/10.1016/j.asoc.2017.08.055>
- Dawoodi, H.H., Patil, M.P. (2021). Rainfall prediction in North Maharashtra region using support vector machine. *Turk J Comput Math Educ*. 12(7),1501-1505.
- Dhamodaran, S., KipsonRoy, G., Kishor, A., Refonaa, J., & JanyShabu, S. L. (2020). A Comparative Analysis of Rainfall Prediction Using Support Vector Machine and Random Forest. *Journal of Computational and Theoretical Nanoscience*, 17(8), 3539–3542. <https://doi.org/10.1166/jctn.2020.9227>
- Fujail, A. K. M., & Das, J. (2023). Artificial Intelligence Modeling for Scour Depth Prediction Upstream of Bridge Piers. *SN Computer Science*, 4(6). <https://doi.org/10.1007/s42979-023-02336-5>
- Garai, S., Paul, R.K., Yeasin, M., Roy, H.S., Paul, A.K. (2024). Machine learning algorithms for predicting rainfall in India. *Current Science*. 163(3),360-367.
- Hussain, J., Zoremsanga, C. (2021). A survey of rainfall prediction using deep learning. In: 3rd International Conference on Electrical, Control and Instrumentation Engineering (ICECIE); Kuala Lumpur, Malaysia. IEEE; 1-10. <https://doi.org/10.1109/ICECIE52348.2021.9664730>
- Kala, A., Vaidyanathan, S.G. (2018). Prediction of rainfall using artificial neural network. In: International Conference on Inventive Research in Computing Applications (ICIRCA); Coimbatore, India. IEEE; 2018:339-342. <https://doi.org/10.1109/ICIRCA.2018.8597421>.
- Khan, M. U. S., Saifullah, K. M., Hussain, A., & Azamathulla, H. M. (2024). Comparative analysis of different rainfall prediction models: A case study of Aligarh City, India. *Results in Engineering*, 22, 102093. <https://doi.org/10.1016/j.rineng.2024.102093>
- Lakshminarayana, S. (2020). Rainfall Forecasting using Artificial Neural Networks (ANNs): A Comprehensive Literature Review. *Indian Journal of Pure & Applied Biosciences*, 8(4), 589–599. <https://doi.org/10.18782/2582-2845.8250>
- Lazri, M., Ouallouche, F., Labadi, K., Ameur, S. (2022). Extreme learning machine versus multilayer perceptron for rainfall estimation from MSG data. *E3S Web of Conferences*. 353(01006).
- Li, H., Chou, C., Chen, Y., Wang, S., & Wu, A. (2019). Robust and Lightweight Ensemble Extreme Learning Machine Engine Based on Eigenspace Domain for Compressed Learning. *IEEE Transactions on Circuits and Systems I Regular Papers*, 66(12), 4699–4712. <https://doi.org/10.1109/tcsi.2019.2940642>
- Mehr, A. D., Nourani, V., Khosrowshahi, V. K., & Ghorbani, M. A. (2019). A hybrid support vector regression-firefly model for monthly rainfall forecasting. *International Journal of Environmental Science and Technology*, 16(1), 335–346. <https://doi.org/10.1007/s13762-018-1674-2>
- Mislan, N., Haviluddin, N., Hardwinarto, S., Sumaryono, N., & Aipassa, M. (2015). Rainfall Monthly Prediction Based on Artificial Neural Network: A Case Study in Tenggara Station, East Kalimantan - Indonesia. *Procedia Computer Science*, 59, 142–151. <https://doi.org/10.1016/j.procs.2015.07.528>
- Meteorological Data of Mizoram (MDM). (2022) Directorate of Economics & Statistics, Planning & Programme Implementation Department, Government of Mizoram. <https://des.mizoram.gov.in/uploads/attachments/2022/09/>

c7a320a0094f8d1f1de1714562d8788b/meteorological-data-of-mizoram-2021.pdf, Accessed on April 5, 2024

- Nandakumar, S.D., Kumar, S.D., Menon, V.V., Radhakrishnan, K., Sivakumar, R. (2021) Artificial neural network for rainfall analysis using deep learning techniques. *J Phys Conf Ser.* 1964:042022.
- Saha, S., Chakraborty, D., Choudhury, B.U., Singh, S.B., Chinza, N., Lalzarliana, C., Dutta, S.K., Chowdhury, S., Boopathi, T., Lungmuana, Singh, A.R., & Ngachan, S.V.. (2015). Spatial variability in temporal trends of precipitation and its impact on the agricultural scenario of Mizoram. *Current Science.* 109(12), 2278-2282.
- Saha, S., Das, B., Chakraborty, D., Chawdhury, S., Shakuntala I., Mishra, V.K., Lalhmachhuana, P., Lungmuana, Lalliansanga, S., Saithantluanga, H. (2021). Quantitative Accuracy Assessment of District Level Rainfall Forecast in Mizoram. *Journal of Agricultural Physics.* 21(2),332-340.
- Samantaray, S., Tripathy, O., Sahoo, A., & Ghose, D. K. (2019). Rainfall Forecasting Through ANN and SVM in Bolangir Watershed, India. In *Smart innovation, systems and technologies* (pp. 767-774). [https://doi.org/10.1007/978-981-13-9282-5\\_74](https://doi.org/10.1007/978-981-13-9282-5_74)
- Singh, P., & Borah, B. (2013). Indian summer monsoon rainfall prediction using artificial neural network. *Stochastic Environmental Research and Risk Assessment*, 27(7), 1585-1599. <https://doi.org/10.1007/s00477-013-0695-0>
- Shukla, R. P., Tripathi, K. C., Pandey, A. C., & Das, I. (2011). Prediction of Indian summer monsoon rainfall using Niño indices: A neural network approach. *Atmospheric Research*, 102(1-2), 99-109. <https://doi.org/10.1016/j.atmosres.2011.06.013>
- Velasco, L. C. P., Serquiña, R. P., Zamad, M. S. a. A., Juanico, B. F., & Lomocso, J. C. (2019). Week-ahead Rainfall Forecasting Using Multilayer Perceptron Neural Network. *Procedia Computer Science*, 161, 386-397. <https://doi.org/10.1016/j.procs.2019.11.137>
- Waqas, M., Humphries, U. W., Wangwongchai, A., Dechpichai, P., & Ahmad, S. (2023). Potential of Artificial Intelligence-Based Techniques for Rainfall Forecasting in Thailand: A Comprehensive Review. *Water*, 15(16), 2979. <https://doi.org/10.3390/w15162979>
- Weesakul, U., Kaewprapha, P., Boonyuen, K., Mark, O. (2018). Deep learning neural network: A machine learning approach for monthly rainfall forecast, case study in eastern region of Thailand. *Engineering and Applied Science Research.* 45(3):203-211.
- Yin, G., Yoshikane, T., Yamamoto, K., Kubota, T., & Yoshimura, K. (2022). A support vector machine-based method for improving real-time hourly precipitation forecast in Japan. *Journal of Hydrology*, 612, 128125. <https://doi.org/10.1016/j.jhydrol.2022.128125>