

Trend Analysis for Frequency of Cyclonic Systems in Indian Ocean Region during Pre-Monsoon Season by AIML

Sumana Chatterjee*

Ph.D. Scholar (Computer Science), Nirwan University, Jaipur, Rajasthan.

*Corresponding Author: sumana.spssaha.chatterjee@gmail.com

Citation: Chatterjee, S. (2026). Trend Analysis for Frequency of Cyclonic Systems in Indian Ocean Region during Pre-Monsoon Season by AIML. International Journal of Innovations & Research Analysis, 06(03(II)), 51–59. [https://doi.org/10.62823/IJIRA/06.3\(II\).9499](https://doi.org/10.62823/IJIRA/06.3(II).9499)

Abstract

This paper is based on research study with trend analysis of the frequency of occurrence of cyclonic systems in Indian Ocean during pre-monsoon season. The analysis is based on Artificial Intelligence and Machine Learning. The research interest of this study is developed for the purpose of understanding the trend from historical past till present time along with prediction of trend for near future years, to realise whether there is any significant change of trend for near future years will take place or not in comparison with historical years. The data source is online data supply platform IMD DSP PUNE. The data with frequency of cyclonic system since the historical past year 1891, consisting of frequency of cyclonic disturbances, cyclones and severe cyclonic storms in Indian Ocean region, has been obtained for data analysis. For each type of system, developed in each type of source, i.e. systems developed in Bay of Bengal, Arabian sea and Land, during pre-monsoon season, span March to May, data analysis with dataset of frequency of occurrence based on models Mann-Kendall test for monotonic trend, ARIMA time series and Neural network, by AIML python execution on google collaborator platform has been done to visualize the trend from historical past to near future years. Accuracy of the output has been verified with comparison between these models.

Keywords: Mann-Kendall, Cyclonic System, Pre-Monsoon, Arima, Neural Network.

Introduction

For latest research study with trend analysis of the frequency of cyclonic system is related with historical and also present and future trend of three types of cyclonic systems named as cyclonic disturbances, cyclonic storms and severe cyclonic storms. The result of this research study enables to gain awareness about the probable disaster related to cyclone onset. In connection with the study to understand climate change, this latest research study puts added value to the sustainable development goal for taking suitable measures. Every year on account of onset of cyclonic storm during pre monsoon season there is a chance of loss of lives and properties. So if the trend of frequency of cyclonic storm can be obtained by machine learning analysis, then certainly this can be beneficial for all types of sectors such as agricultural sector, urban life development sector, transport system sector, electricity sector, health sector and all types of social corners which have direct impacts with this type of natural calamity.

Literature Review

In the available research papers there are studies based on understanding trend of prediction of cyclonic system, trend of prediction of cyclone track, intensity of cyclone with the help of artificial intelligence and machine learning techniques. The techniques used there are GAN, ANN, RNN, CNN etc. as applied for these types of studies. From the literature review of these research studies it could be understood that to obtain the prediction accuracy either for obtaining the cyclonic count or prediction of track or intensity, it is not possible to predict with accuracy hundred percent because as cyclonic system

is a natural phenomenon, there is a chance of change of its nature influenced by other physical factors at any time but then also it is observed that comparatively prediction by machine learning methods give better accuracy. So in this research study as analysis done here also, it was a try to predict the count of each type of cyclonic system with the help of various machine learning techniques accompanied by cross verification of output results among each other. From the overall analysis in this study it had been observed that no significant increasing or decreasing trend can be noticed from any type of analysis applied for this research study for each type of cyclonic system. The increasing or decreasing value in comparison with the historical average as made in this research study varies for different techniques used but overall comparison does not give any indication of any significant change of count of cyclonic system in near future years approaching 2030. The latest research study is based on study of trend of cyclonic frequency during pre monsoon over Indian ocean. The data set was non linear, non normal, so non parametric tests were performed to get analysis results. The study was done in two parts, first part with the data set of frequency of cyclonic system for pre monsoon system, only this data set was involved for analysis. The technique used was Mann Kendall trend test for test of monotonic increasing or decreasing, and ARIMA time series and neural network (tensor flow). In the second part, two other variables were involved also and the technique used was neural network (tensor flow). The research study was quantitative. Unlike most of the research study for prediction of cyclonic trend, frequency etc., in this study the variables taken were only the frequency of occurrence and the two variables mean seasonal rainfall and mean seasonal temperature.

Research Gap

In this research study, initially the analysis was performed with the data of frequency of cyclonic system, occurrence record since historical year 1891 till 2024, data obtained in online data collecting platform IMD DSP PUNE, type of cyclonic system being cyclonic disturbances, cyclonic storms and severe cyclonic storms originated from Bay of Bengal, Arabian sea and land, all the cyclonic systems which develop in Indian Ocean region during pre monsoon season March to May. Mann Kendall, ARIMA and Neural network, these three types of analysis were executed to get the insights along with the trends of cyclonic frequency in near future till 2030. In the second phase, seasonal mean rainfall during pre-monsoon season and seasonal mean temperature during pre-monsoon for the region of Indian ocean, data obtained from the same source, IMD DSP PUNE, these two parameters, data obtained as available since 1901, were used as predictor variables to determine the trend of the frequency of occurrence for pre monsoon season in near future, prediction done with neural network method. For both first and second phase, accuracy of the models were compared by R^2 , MAE, RMSE. For Mann Kendall test to test monotonic increase or decrease, p value was checked to understand the hypothesis, whether significant increase or decrease. All these types of counter verification could enable to get confirmation towards obtained inference whether any significant change in frequency of occurrence of cyclonic system will take place in near future approaching 2030 or not.

Research Questions / Hypothesis

In this latest research study, the main objective was to determine whether any significant change in frequency of occurrence of cyclonic system will take place in near future approaching 2030 or not. Firstly using the data with occurrence of all types of cyclonic systems originated in Indian ocean during pre monsoon and then secondly data with occurrence of all types of cyclonic systems originated in Indian ocean during pre monsoon along with data of seasonal mean temperature and seasonal rainfall for the pre monsoon season in Indian ocean region, the other two data sets used as predictor columns to predict trend of cyclonic system originated in Indian ocean during pre-monsoon season. From these two data sets and with three types of machine learning analysis done with Mann Kendall test, ARIMA and neural network to get the direction of trend. The hypothesis of research study was that no such significant change in the trend for the occurrence of cyclonic system for near future years approaching to 2030. From Mann Kendall test p value is not ≤ 0.05 and so the null hypothesis could not be rejected. From ARIMA and neural network analysis in the first part of analysis (without predictor columns) as well as neural network analysis for second part of analysis (with inclusion of predictor columns), the plot for visualization of trend of occurrence of all types of cyclonic system could not share any indication of significant change of trend, increasing or decreasing in near future approaching 2030. All the output results along with prediction accuracy, comparison between different techniques have been shared in tabular format and also obtained line plots and bar plots to visualize and gain valuable insights. The data set consisting of occurrence of all types of cyclonic systems, that is data with cyclonic system frequency

for each type of system, originated in Indian ocean region during pre monsoon season, this data set is non linear and skewed data, so non parametric tests were to be performed for trend prediction. For this reason Mann Kendall test for monotonic trend either increasing or decreasing was initially selected by python language code to obtain the test result. From this test no significant change could be noticed. The whole analysis was performed in two parts. In the first part along with Mann Kendall test, other two techniques used were ARIMA time series and Neural network (tensor flow). For this first part of analysis the data set with frequency of occurrence was used only. No other variable was involved as predictor. Unlike first part of analysis, in the second part of analysis, two other variables were used also to get insights and for this analysis the technique used was neural network tensor flow analysis. In total nine (9) systems were there to get insights about trend and to reject or accept null hypothesis that no such significant change. For each type of system by machine learning analysis it was established.

Methods

The latest research study is based on understanding trend of frequency of occurrence of cyclonic system originated in Indian Ocean, source either Bay of Bengal, or Arabian sea or Land region, occurrence period during pre monsoon season March to May. For this study, analysis has been done with python code execution on google collaborator platform in two parts. Initially in the first part of analysis, only the data set with frequency of occurrence of cyclonic system was taken, the data obtained from free data set as available from online data supply platform 'IMD DSP Pune'. The first part was performed by three methods of analysis i) Mann Kendall monotonic test of trend whether increasing or decreasing, ii) ARIMA time series analysis, iii) Neural network analysis (tensor flow). No other variable except data with frequency of occurrence of cyclonic system was involved for analysis of this first part. Python code on google collaborator platform was used for analysis. Initially necessary python libraries were installed for the purpose of execution. Numpy, panda, sea born, matplotlib was installed and also all necessary python libraries for all statistical tests were installed. Then the csv data consisting of occurrence of cyclonic system was subjected to analysis to visualise plots to understand trend of historical period till recent years along with predicted value till few future years approaching 2030. The tabular format consisting of predicted values of trend of all types of cyclonic systems and RMSE, MAE and R^2 value to understand analysis metric supporting prediction accuracy, which were also obtained for each type of analysis method. In the second method, along with the data of occurrence of cyclonic systems, two other variables were involved also and these were seasonal mean temperature and seasonal mean rainfall, both data for all India during pre monsoon. These two variables were used as predictor columns. Merging these data with occurrence of cyclonic system data set on the basis of year, analysis was performed by neural network tensor flow analysis to find the trend of occurrence of cyclonic systems during pre monsoon season. Thus completed the method with different artificial intelligence and machine learning technique to get valuable insights, all results and outputs supported by all techniques, among each other.

Significance of the Study

The insights obtained from this type of research study is beneficial for all sectors which support day to day human lives. Also if trend of such type of natural disaster like cyclonic storm can be predicted for near future, whether trend is increasing or decreasing or no such significant change that can take place in near future, then this type of inference can help for taking precautionary measures in advance to save human lives, animal lives and properties.

Timeline

The latest research study can be classified as longitudinal study as the result and trend had been observed since historical years till current years along with trend for recent future till 2030.

Results and Inference

The whole analysis has been done in two steps. The first one using data with frequency of occurrence of cyclonic system during pre-monsoon originated in Indian ocean, done with three methods ARIMA TIME SERIES model, Neural network model and Mann Kendall trend test. Results and accuracy are as shown below :

- **First case of analysis without inclusion of predictor columns.**

Predicted Values of Cyclonic Systems, 2025-2030 BY ARIMA Time-Series Model

Year	BOBCD	ARSCD	LANDCD	BOBCS	ARSCS	LANDCS	BOBSCS	ARSCS	LANDSCS
2025	1.946380613	0.154328421	4.38E-89	1	0.221486121	0	1	0.021005143	0
2026	1.819050648	0.38504913	9.30E-90	1	0.155147007	0	1	0.13808673	0
2027	1.853758398	0.307279311	9.07E-90	1	0.230069308	0	1	0.21714793	0
2028	1.859292175	0.19828966	1.05E-89	1	0.101923451	0	1	0.085931103	0
2029	1.628209435	0.188238276	1.22E-89	1	0.127837117	0	1	0.089483355	0
2030	1.714548489	0.171161448	1.41E-89	1	0.135093787	0	1	0.097101666	0

Future Prediction Value by Neural Network Method

Year	BOBCD	ARSCD	LANDCD	BOBCS	ARSCS	LANDCS	BOBSCS	ARSCS	LANDSCS
2025	1	0	0	1	0	0	1	0	0
2026	1	0	0	1	0	0	1	0	0
2027	1	0	0	1	0	0	1	0	0
2028	1	0	0	1	0	0	1	0	0
2029	1	0	0	1	0	0	1	0	0
2030	1	0	0	1	0	0	1	0	0

Arima Time-Series Model Performance Metrix for Future Prediction

Storm Type	RMSE	MAE	R2
BOBCD	1.357	0.859	-0.354
ARSCD	0.646	0.579	-0.74
LANDCD	0	0	0
BOBCS	0.206	0.171	0
ARSCS	0.618	0.609	-1.386
LANDCS	0	0	1
BOBSCS	0.531	0.526	0
ARSSCS	0.389	0.319	0.052
LANDSCS	0	0	1

Neural Network Model Performance Metrix For Future Prediction

Cyclonic System	RMSE	MAE	R2
BOBCD	0.780582868	0.614347458	0.085220456
ARSCD	0.559001774	0.468144983	0.007965982
LANDCD	0.120606975	0.032086242	0.010648549
BOBCS	0.635131191	0.519797146	0.023813963
ARSCS	0.489538603	0.406729251	0.006666541
LANDCS	3.20E-05	2.73E-05	0
BOBSCS	0.566188481	0.524695218	0.010971963
ARSSCS	0.388118331	0.298426867	0.007406533
LANDSCS	3.03E-05	9.19E-06	0

Mann-Kendall Test Results for All Cyclonic-System Categories

Data with occurrence of cyclonic storm historical period: 1891-2024 | Significance level: 5%

Cyclone type	Full form	Trend result	h	p-value	Z-statistic	Significance
BOBCD	Bay of Bengal Cyclonic Disturbance	No trend	False	0.421588	0.803670	Not significant
ARSCD	Arabian Sea Cyclonic Disturbance	No trend	False	0.745974	-0.323950	Not significant
LANDCD	Land Cyclonic Disturbance	No trend	False	0.762069	0.302765	Not significant
BOBCS	Bay of Bengal Cyclonic Storm	No trend	False	0.842119	0.199184	Not significant
ARSCS	Arabian Sea Cyclonic Storm	No trend	False	0.676760	-0.416890	Not significant
LANDCS	Land Cyclonic Storm	No trend	False	1.000000	0.000000	Not significant
BOBSCS	Bay of Bengal Severe Cyclonic Storm	No trend	False	0.190525	1.309027	Not significant
ARSSCS	Arabian Sea Severe Cyclonic Storm	No trend	False	0.323120	-0.988070	Not significant
LANDSCS	Land Severe Cyclonic Storm	No trend	False	1.000000	0.000000	Not significant

- Second case of analysis with inclusion of predictor columns.**

(Predictor columns as seasonal mean rainfall and seasonal mean temperature of India for pre-monsoon)

Neural network model ,cyclone-system trends: historical period to 2030 :

Cyclone System	Full Form	Predicted Annual Value, 2025–2030
BOBCD	Bay of Bengal Cyclonic Disturbance	1.4054
ARSCD	Arabian Sea Cyclonic Disturbance	0.4031
LANDCD	Land Cyclonic Disturbance	0.0288
BOBCS	Bay of Bengal Cyclonic Storm	0.8212
ARSCS	Arabian Sea Cyclonic Storm	0.2949
LANDCS	Land Cyclonic Storm	-0.0044
BOBSCS	Bay of Bengal Severe Cyclonic Storm	0.5167
ARSSCS	Arabian Sea Severe Cyclonic Storm	0.2119
LANDSCS	Land Severe Cyclonic Storm	-0.0045

Neural Network Metrics For Analysis Of Trend With Predictors

CYCLONIC SYSTEM	MAE	RMSE	R2 Score
BOBCD	0.6019	0.804	0.0551
ARSCD	0.4675	0.5522	0.0569
LANDCD	0.0339	0.1147	0.1711
BOBCS	0.5251	0.6381	0.015
ARSCS	0.3569	0.4686	0.0988
LANDCS	0.0002	0.0003	0.0
BOBSCS	0.5306	0.5697	0.0182
ARSSCS	0.2964	0.3802	0.0433
LANDSCS	0.0006	0.0007	0.0

Comparison with historical average of count of cyclonic system with predicted value till 2030 follows:

BOBCD Prediction 2025-2030	METHOD
HIGHER THAN AVERAGE	ARIMA (WITHOUT PREDICTOR)
HIGHER THAN AVERAGE	NEURAL NETWORK (WITH PREDICTOR)
LOWER THAN AVERAGE	NEURAL NETWORK (WITHOUT PREDICTOR)
ARSCD Prediction 2025-2030	METHOD
LOWER THAN AVERAGE	NEURAL NET WITHOUT PREDICTOR
LOWER THAN AVERAGE	ARIMA WITHOUT PREDICTOR

BOBCS Prediction 2025-2030	METHOD
HIGHER THAN AVERAGE	ARIMA (WITHOUT PREDICTOR)
HIGHER THAN AVERAGE	NEURAL NETWORK (WITH PREDICTOR)
HIGHER THAN AVERAGE	NEURAL NETWORK (WITHOUT PREDICTOR)
ARSCS Prediction 2025-2030	METHOD
HIGHR THAN AVERAGE	NEURAL NET WITH PREDICTOR
LOWER THAN AVERAGE	NEURAL NET WITHOUT PREDICTOR
LOWER THAN AVERAGE	ARIMA WITHOUT PREDICTOR

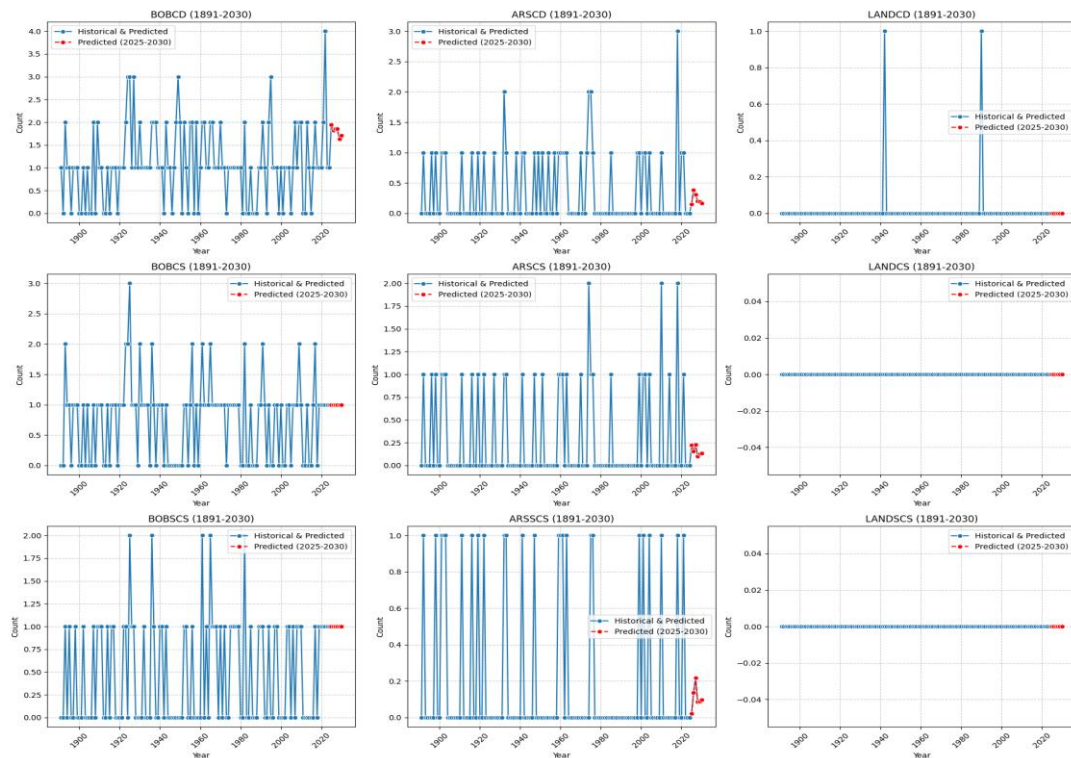
BOBSCS Prediction 2025-2030	METHOD
HIGHER THAN AVERAGE	ARIMA (WITHOUT PREDICTOR)
HIGHER THAN AVERAGE	NEURAL NETWORK (WITH PREDICTOR)
HIGHER THAN AVERAGE	NEURAL NETWORK (WITHOUT PREDICTOR)

Insights Obtained from Analysis

- Comparatively arsscs ,arscs, land system trend is lower than bob system
- The trend of bobcs and bobscs as noticed from result of neural network with predictor shows a decreasing trend in near future which insight is supported by some research study under mentioned reference.
- **From the whole analysis this can be mentioned that no such significant increasing trend is there for count of cyclonic frequency, rather it can be obtained from some technique like neural network, that the trend is decreasing for years approaching 2030.**

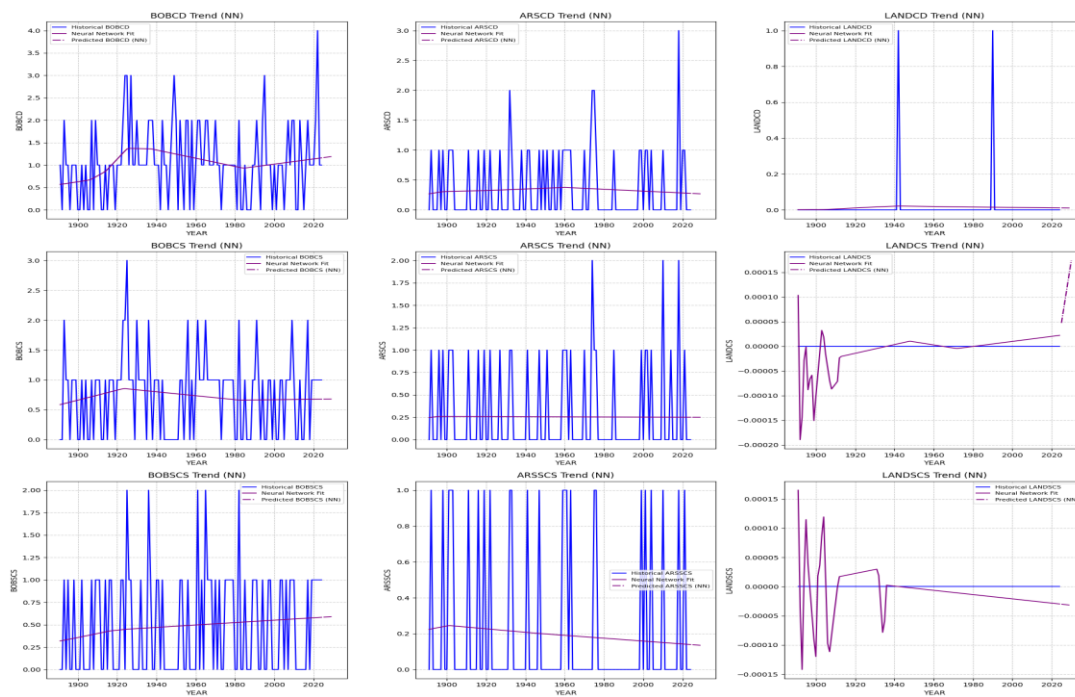
Some Images of Plots Obtained From Analysis for Visualization of Trend

- **Line Plots**
 - Plot For Arima Time Series Prediction For Analysis Of Trend (Without Predictor)

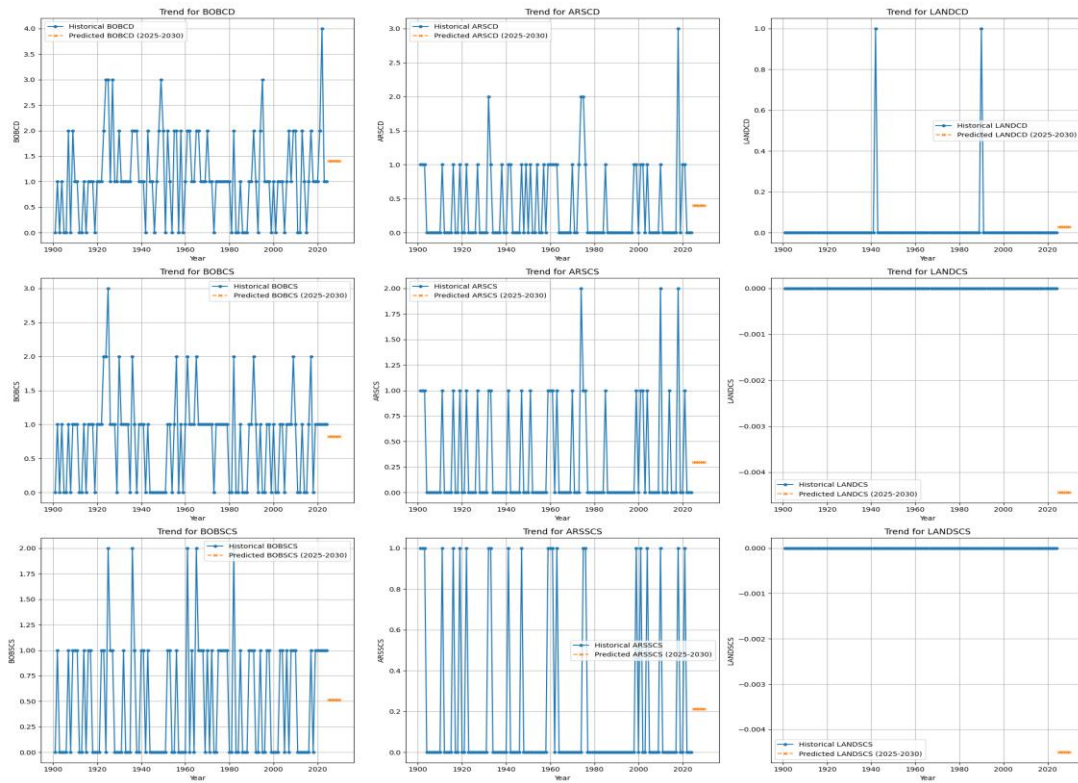


Plot For Neural Network Analysis (Without Predictor)

Composite Neural Network Trend Analysis for All Cyclone Types

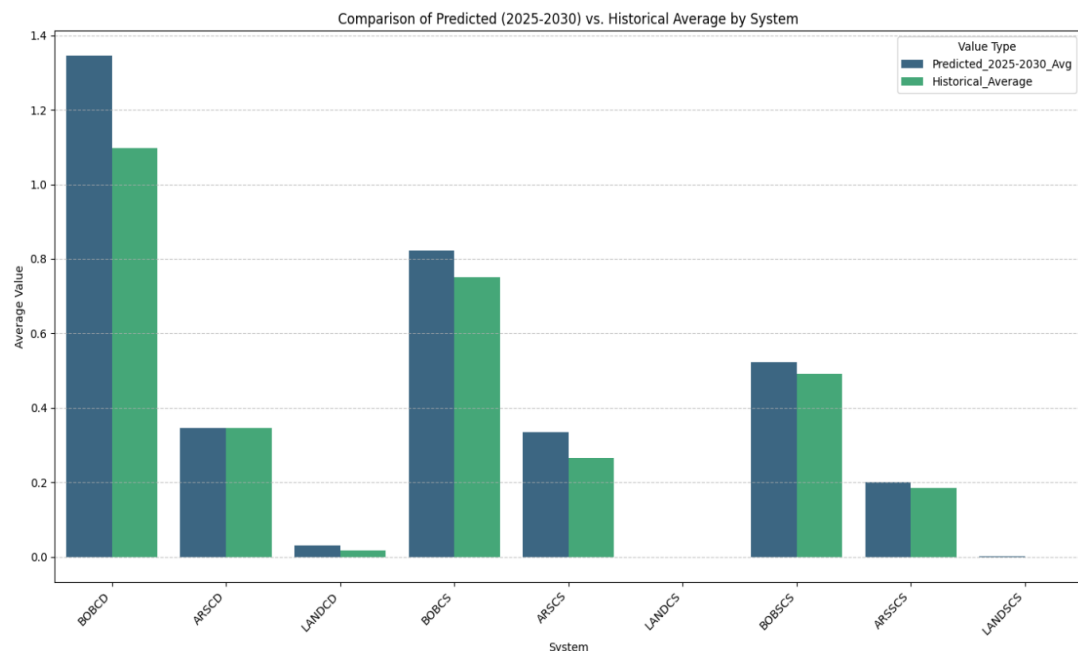


Plot For Neural Network Analysis (With Predictor)

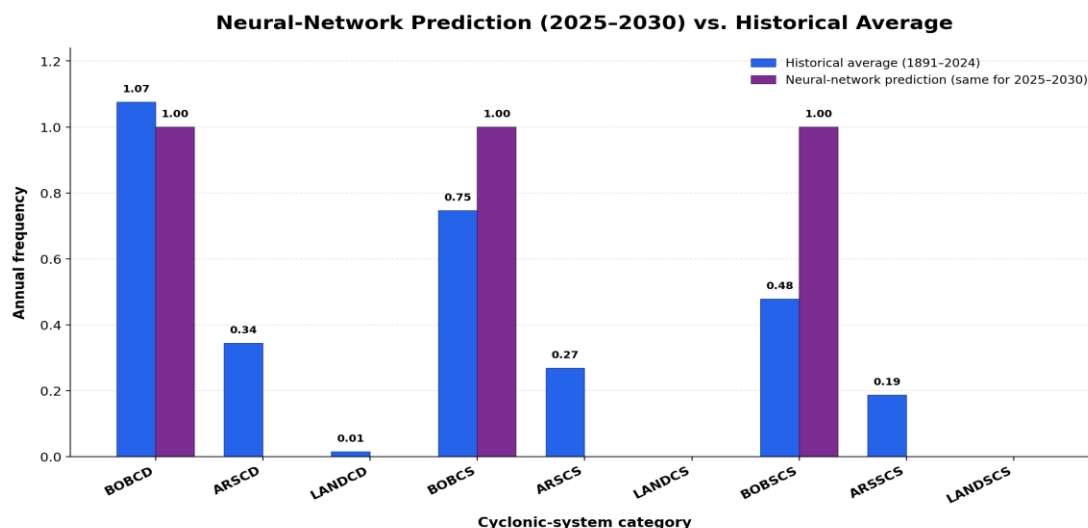


Bar Plots

Prediction By Neural Network With Predictors (Other Variables)



■ Prediction By Neural Network (Without Predictors)



One prediction is shown per category because the predicted value is unchanged from 2025 through 2030.

Comparison of historical average cyclonic system frequency with predicted value till 2030

Conclusion and Future Work

In this research study, the insights as obtained from the overall analysis is that no such significant change can happen with frequency of cyclonic system for near future years approaching 2030. On the contrary this may be mentioned that though in most cases the predicted value is higher than historical average but result as obtained from some analysis the predicted value for future years till 2030, it is even less than 1, indicating prediction of less count of cyclonic system in near future approaching 2030. However similar type of research study will be done in future also to get insights regarding trend of cyclonic system, study accompanied with involvement of other predictor variables such as sea surface temperature, ENSO, IOD, vertical wind shear, relative humidity and mean sea level pressure. Apart from the particular machine learning techniques which were used for this research study, other techniques may be also applied to obtain insights.

References

1. R. C. (2020). Machine Learning in Tropical Cyclone Forecast Modeling: A Review. *MDPI*, 11(7), 1-29. doi:https://doi.org/10.3390/atmos11070676
2. Richmana, M. B. (2012). Adaptive Machine Learning Approaches to Seasonal Prediction of Tropical. *Science Direct*, 276-281. doi:doi: 10.1016/j.procs.2012.09.069
3. Richmana, M. B. (2017). Reducing Tropical Cyclone Prediction Errors Using Machine Learning Approaches. *Science direct*, 314-323. doi:https://doi.org/10.1016/j.procs.2017.09.048
4. Nath, S. (2015). Seasonal prediction of tropical cyclone activity over the North Indian Ocean using the neural network model. *ATMOSPHERA*, 271-281. doi:doi: 10.20937/ATM.2015.28.04.06
5. QiFeng Qian1, 2. X. (2022). Reduced Tropical Cyclone Genesis in the Future as Predicted by a Machine Learning Model. *ADVANCING EARTH AND SPACE SCIENCE*, 1-8. doi: https://doi.org/10.1029/2021EF002455.

