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ANALYSIS OF IMPACT OF CLIMATE CHANGE ON SEA LEVEL VARIABILITY AT CHENNAI PORT

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Abstract
Natural and human-caused climate change affects the different aspects of life, but in this study, we looked specifically at how sea level changes were affected. Recent inquiry has presented a report that the world temperature is continuously altering. Temperature rise has a significant impact on the seasons, which may have an impact on sea level and river flow patterns. This study assesses the sea level variability brought on by climate change at the CHENNAI PORT in Tamil Nadu. By using the tidal data from the CHENNAI PORT, climate data at various different parameters are simulated. And greatest correlated coefficient climate data has been identified as a potential predictor for making model by Feedforward Neural Network (FNN). ***Roshni et all (2017).*** The project cmip5 of the RCP8.5 climate change scenario has been used to provide General Circular Model (GCM) data at the same location for future sea level variability forecasting. Finally, in this study sea level at Chennai Port will change continuously between 2016 and 2050, reaching a maximum of 6.640015 meter in 2024 and a minimum of 6.637672 meter in 2050 relative to mean sea level.

Keywords:
Temperature rise, Sea Level, FNN, Climate Change, GCM, RCP8.5, CMIP5.

I. Introduction

The climate has changed throughout the existence of the Earth and The Sun. The fluctuations in the quantity of solar energy we receive from the Sun over tens of thousands of years are mostly due to the Milankovitch cycles, which control the distance between the Earth and the Sun. Strong links exist between rising sea levels, warmer oceans, and subsequent climate change. Sea levels rise globally during warm or interglacial eras because saltwater expands as temperatures rise and melts the ice that covers Antarctica, Greenland, and the planet's mountain glaciers. When snow changes to ice, allowing ice sheets and glaciers to grow, more precipitation happens during cooler (glacial) times, and sea level drops as saltwater cools and takes up less volume. As a result of the previous century's rise in greenhouse gas concentration and subsequent global warming, sea levels have been rising due to ice sheet melting and ocean thermal expansion. Low-lying coastal regions face a major risk from future sea level rise [1].

The Paris Agreement aims to keep the rise in global temperature well below 2 °C, but given the inertia of ocean processes, the potential of a high-end sea level rise may endure. Coastal locations are especially at risk from sea level rise's consequences. Sea level rise is just one way that climate change affects coasts, though. Climate change also affects the processes and dynamics in coastal zones through seasonal and long-term fluctuations in winds, storm surges, and wave action. [2–6]. Changes in sea levels, wind patterns, and wave strength. [7–12] all significantly affect coastlines. On seasonal, interannual, and long-term temporal periods, these changes vary between locales and coasts, having a variety of local effects, including as floods and erosive processes. [13,14]. The services provided by coastal ecosystems, such as fisheries, coastal protection, and carbon sequestration, will be significantly impacted by anticipated increases in ocean acidity and water temperature. [15–22]. Due to increased coastal risks, urbanisation, and population concentration in coastal areas, adaptation is very necessary. However, the state of implementation is still limited along many coasts because of severe technical, economic, financial, and social hurdles. [23].

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II. Literature

Robert J. Nichol *et al*. (2022) [24] With ongoing worries that significant increases in the twenty-first century cannot be ruledout, the range of future sea-level rise caused by climate change remains incredibly unpredictable. How the massive ice sheets in Greenland and west Antarctica will respond is the main area of uncertainty. For a temperature increase of 4°C or higher by 2100, a feasible estimate of sea-level rise is between 0.5 m and 2 m, and our research indicates that the chanceof rises at the high end is very low yet impossible to quantify.
R. Meissner, (2022) [25] addresses that Various predictions of sea level rise for the twenty-first century have been made by the scientific community, ranging from the worstcase of one meter to less than 25 cm. Sea level rise might have an adverse impact on ecosystems and human societies in various parts of the world, which would subsequentlyhave an adverse effect on the economics of states that depend on particular ecosystems for their economic survival.
Alexandre K. Magnan, *et al*. (2022) [26] Due to sea level rise, low-lying beaches all across the world will need to adapt more (SLR). Little is known about the effectiveness and profitability of the large-scale social adaptation needed in a changing climate, despite millennia of experience with coastal hazard. This study examines two warming and two response scenarios' end-century SLR threats for four different types of coastal towns (Urban Atoll Islands, Arctic Communities, Large Tropical Agricultural Deltas, Resource-Rich Cities).
Veronica Nieves *et al*. (2021) [27] Global climate models (GCMs) have limited ability to simulate spatially non-uniform sea- level rise due to low resolutions and lack of tides in the peripheral seas. Here, regional ocean climate models (RCMs) that take tides into account and dynamical downscaling were used to solve the limits in the marginal seas of the Northwest Pacific. Four GCMs that power the RCMs were selected after considering their performance along the RCM borders. The RCMs were then confirmed by comparing historical findings with observations.
Carmela Mariano *et al*. (2021) [28] Recent territorial consequences brought on by sea level rise have prompted decision-makers to think about how to incorporate these issues into municipal agendas. It was also important to update and expand the skill sets of urban planners and improve territorial governance systems in order to develop viable regeneration and resilience strategies to tackle climate change.
Matthew J. Widlansky, *et al*. (2020) [29] Sea levels rise worldwide, sea level erraticness contributes more to coastal flooding and erosion. This is partially due to the fact that as temperature rises, seawater expands more quickly. According to climate model predictions with rising greenhouse gas emissions, futuresea level variability, such as the yearly and inter-annual oscillations that influence regional astronomical tidal cycles and contribute to coastal repercussions, would probably rise in many places. Here, we examine future sea level projections from the CMIP5 climate model toshow that there is a tendency toward a near-global rise in sea level variability with continued warming that is robust across models, regardless of an increase in ocean temperature variability.
M Balasubramanian and V DhulasiBirundha, (2018) [30] A variety of elements, including as money, environment, sickness, and migration, will have an effect on human well-being as a result of climate change. No matter how terrible the problem is, it is difficult to estimate the value given the current state of the economy. At the absolute least, switching from an agricultural to a non-agricultural economy is necessary for significant progress.
Md. Sajid K, et al. (2017) [31] Increasing forecast efficacy is an extremely difficult challenge. The sea level has been rising significantly due to global warming. Through this work, an effort has been made to determinehow the impact of climate change on Haldia Port, India, will affect sea level fluctuation. There are various statistical downscaling methods available, and in this study, the authors compare and highlight the results of three regression models. At Haldia Port in India, the sea level variability caused by climate change is projected using the models Wavelet Neural Network (WNN), Minimax

Probability Machine Regression (MPMR), and Feed-Forward Neural Network (FFNN).
Public Health Institute/Center for Climate Change and Health, (2016) [32] Adaptation and mitigation methods for climate change and sea level rise. As sea levels rise, saltwater seeps into freshwater, increasing the salinity of groundwater basins and well water. As a result, there is less clean water available and less crop output.
Piyali Chowdhurya, Dr Manasa Ranjan Beherab (2015) [33] The mean sea level variations on a regional scale are the main subject of this study. To understand the changing trend of the sea level in the North Indian Ocean (NIO), the tide gauge data that is currently available and satellite altimetry data are analysed. Even thoughthe majority of tidal gauges show a rising sea level, some also show a declining sea level.
Umair Shahzad and Riphah, (2015) [34] The scientific and environmental sectors agree on the reality of global warming and the part that people have played in it. The work being discussed has only just begun to scratch the surface of a tremendously complicated field of scientific and engineering research. Global warming is a serious problem that needs to be tackled using the appropriate techniques.Along with humans, animals and plants are also experiencing issues as a result of this dilemma.
Bill Brath, *et al*. (2015) [35] The planet has been rapidly warming. This has primarily been brought on by an increase in GHG concentration, particularly carbon dioxide. The two primary drivers of the increase in CO2 concentration are widely understood to be the combustion of fossil fuels and deforestation. Climate change as a result of this will significantly affect every area of human life on earth. As a result, extreme weather phenomena including heat waves, sea level rise, floods, hurricanes, and storms, to name a few, will occur more frequently.
Anny Cazenave and Goneri Le Cozannet (2014) [36] Data on sea level observations from the present, together with a comprehensive list of the various factors that have affected regional sea level changes and the worldwide mean sea level rise, have been assembled. In addition to the rise in the global mean, we highlighted the significance of the regional variability that also exists. We showed that the sea level budget isalmost closed, but we also showed that there are still significant uncertainties regarding the measurements of sea level as well as the steric and mass contributions.
Robert J. Nicholls *et al*. (2014) [37] The bulk of coastal impact and adaptation assessments to date have not taken into consideration regional variations in sea level predictions, mostly because there is a dearth of technical guidance and easy access to the necessary data in usable form. However, regional and local assessments would benefit from taking into account the various aspects of sea-level rise on a more individualized basis because there is very likely to be more uncertainty about sea-level change during the 21st century at any location than the global-mean scenarios alone suggest.
M. Karamouz *et al*. (2013) [38] Expected Sea level fluctuations due to climate change would affect the coastal areas of New York City. For this, an MLP model is developed to imitate the water level in the study area. SST and SLP data from a few locations close to the research area serve as predictors. Simply expressed, the more effective factors among the signals under consideration are investigated using the input data from the model factors analysis. The first half of the developed factorsare utilised for developing a sea level simulation model.
Claudia Tebaldi *et al*. (2012) [39] Add the near- and mid-term SLR component (2030 and 2050, respectively). Global SLR forecasts are where we begin. The trajectory of greenhouse gas emissions going forward, howthey will affect atmospheric and oceanic temperatures, and how they will affect the melting and dynamic collapse of glaciers and ice sheets will all have an impact on and increase the uncertainty surrounding the global mean sea level this century. However, because to significant differences between projected and observed patterns, regional scale numerical model projections of sea level rise, in particular, are not yet sufficiently refined to support their direct use. They are also limited to the rise's thermal expansion component because they do not portray the processes that led to the ice sheet melting and collapsing.
Kumar S., Himanshu S.K. and Gupta K.K. (2012) [40] In addition to changing the weather, global

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warming will obliterate coastlines and increase the frequency of coastal floods. Some island nations will disappear. The problem is importantsince up to 10% of the world's population lives in areas that are vulnerable and are less than 10 metres (about 30 feet) above sea level. Between 1870 and 2000, the sea level rose by 221 millimetres, or 1.7 millimetres on average each year (0.7 feet or 8.7 inches). Additionally, therate of sea level rise is accelerating. Sea levels rose by 48 millimetres (0.16 feet or 1.89 inches) between 1993 and 2009, according to NASA satellite data, which shows that sea levels have been rising more quickly since 1993 at a pace of about 3 millimetres each year.

Ove Hoegh-Guldberg *at al*. (2010) [41**]** The biology of the earth depends heavily on marine habitats, yet there is little knowledgeabout how anthropogenic climate change is harming them. Recent research shows thatrapidly increasing greenhouse gas concentrations are pushing ocean systems towardconditions that haven't been seen in millions of years, with the risk of fundamental and permanent ecological change that goes along with it. Ocean productivity has declined, foodweb dynamics have changed, habitat-forming species are less common, species distributions have changed, and disease prevalence has increased as a result of anthropogenic climatechange.

David W. Yoskowitz, *et al*. (2009) [42] In order to illustrate the potential consequences of climate change, in particular sea level rise, it was shown that the wider Galveston Bay region will benegatively impacted by this shift. By modifying the HAZUS modelling software from FEMAand constructing two scenarios for sea level rise of 0.69 m and 1.5 m, we calculateconservative effect calculations. More than 98000 homes could be relocated, more than75000 buildings could be impacted, and there would be an estimated $12.5 billion in losteconomic production in the worst-case scenario.

Duncan M. Fitz Gerald, *et al*. (2008) [43**]** Through offshore and onshore sediment transfer, SLR causes barrier islands to shift landwardwhile preserving bulk, as shown by a century of studies. Additional factors operating on shorter time periods, such as sediment supply and the rate of hydraulic power consumption, have an impact on the shoreface profile that translates landward during SLR.

Dwijendra Nath dwivedi, *et al*. (2005) [44] The sea level rise in 1975, and he reported that readings from deep-sea cores showed an incredibly rapid rise in sea level. The assumption made by the majority of climate experts— that ice sheet alterations would take many centuries—alarmed Mercer (1997). Global sea level trends have frequently been ascertained using tidal station patterns from all across the world.

Robert J. Nicholls (2003) [45] addresses difficult to assess future implications of sea level rise and climate change in a coastal zone that is already under a lot of stress from other factors. More detailed studies that more accurately portray the complete range of uncertainty would study the full range of change scenarios rather than merely evaluating a 1-m rise scenario on the status of the planet now. Additionally, they would assess the range of adaptation options and how they relate to one another, such as how severely flood defences would impinge on coastal habitats. It is imperative to have greater information on adaptation if these studies are to help in the development of coastal management policy.

Joel Smith and Sam Hitz Stratus (2003) [46] Revealed a significant disparity in local impacts. In general, developing countries and thoseat lower latitudes suffer more negative effects than those at higher latitudes and developed countries. This is not always the case. High latitude locations are particularly at risk of losing diversity in the biosphere. The regional results were nonetheless reported as aggregate results even though the worldwide research distinguished between affects at the regional levels.

James E. Neuma *et al*. (2000) [47] Sea level rise impact estimates severely underestimate the economic value of lost wet areas. Wetlands' ability to migrate may be crucial to their existence. The locations where coastal development and wetland migration are most likely to conflict should be identified as upland areas that may turn into wetlands when sea levels rise. Future analyses will face the challenging task of identifying the complexity of sea level rise consequences while seeking topinpoint climate change effects and recommend appropriate policy solutions for the U.S. coast

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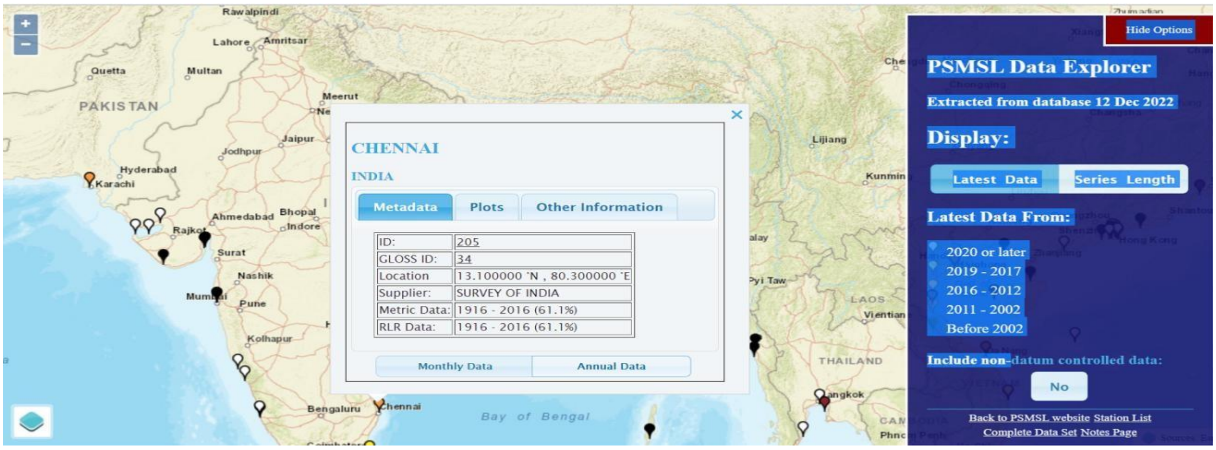
III. Research Gap

The above-given research paper studied and found that climate change depends on Global warming. The authors used regional scale model projection and model factor analysis techniques for Sea level variation. Till now, the correlation technique has not been used for forecasting Sea level variation at Chennai. Here, I will use three types of data. Two data sets are past climate change data and one is future data used as input in the model.

IV. Objectives

1. To analyze effective parameters of climate change which effects the sea level.
2. To create a model between effective parameters and sea level.
3. To Predict the future sea level for 2050 at Chennai Port.

V. Study Area



Source; https://psmsl.org/data/obtaining/map.html

Figure1: Location of Chennai PORT Tidal Gauge Station

Figure 1 shows the station of the CHENNAI tidal station in the red notation mark this is taken from the permanent service for mean sea level website.

VI. Data Collection

The Permanent Service for Mean Sea Level (PSMSL) collected observed field data for monthly mean sea level observations for 25 years, from 1991 to 2015, and will predict this data for the following 35 years, from 2016 to 2050. From 1991 to 2015, a further 25 years' worth of monthly climate data (from the NCEP/NCAR Reanalysis Project) were gathered. A correlation between the historical observed data (sea level), which serves as the predictor, and the historical climatic change variables data, which serves as the predictor, is established. If the correlation coefficient value is greater than 0.4, the variable is taken into consideration as a prospective one since it has a greater influence on the predictor (sea level). Following the selection of a possible predictor, GCM data are obtained from the CMIP5 data access of the same variable that has the greatest influence on sea level variability. For the next 35 years, or from 2016 to 2050, the GCM model used to estimate future data is from the CMIP5 project (coupled model international project 5),

VII. Methodology and Data Processing

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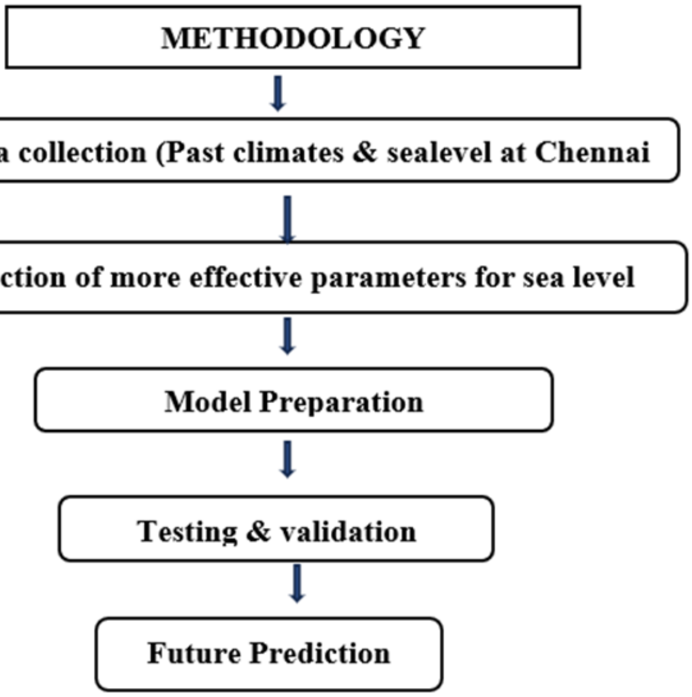

7.1 Selection of Potential Predictors

For calculating the probable climate change predictor that affected the predictor. There are three different kinds of data used. Two of the data sets are historical climate change data and one is future climate change data that are used as model input. For 25 years (1991–2015), historical climate data were gathered from the NCEP/NCAR website, and historical observed data were gathered from the PSMSL website. may find all the prediction data in NC format. ArcGIS is utilized to extract the data in accordance with the research area. Six categories are available at the NCEP site. Data for our investigation were collected from several points on the surface as well as from the NCEO/NCAR REANALYSIS. The variables chosen as prospective predictors are those with the highest correlation coefficient between predictor and predictor. Our predictor is the tidal height (sea level).

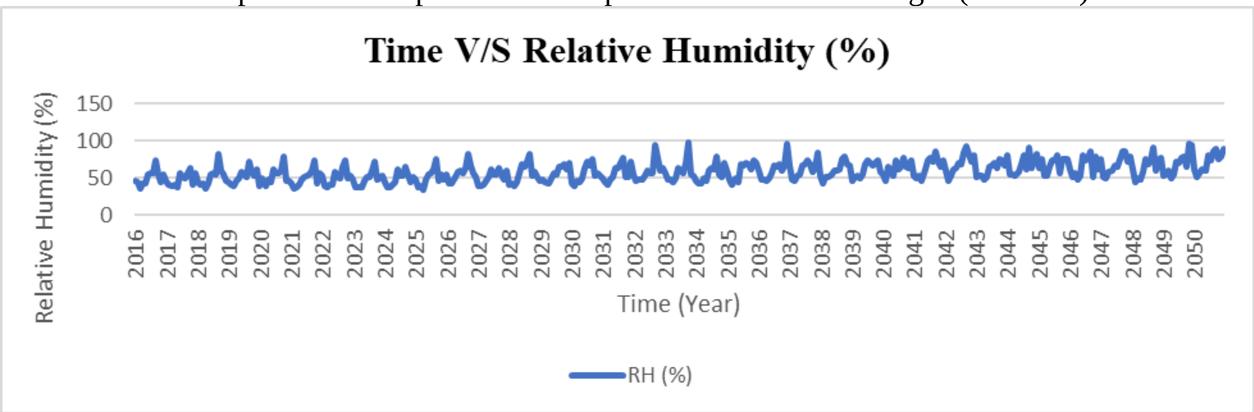

Figure 2: Graphs between CMIP5 Future Data (Relative Humidity) and Time

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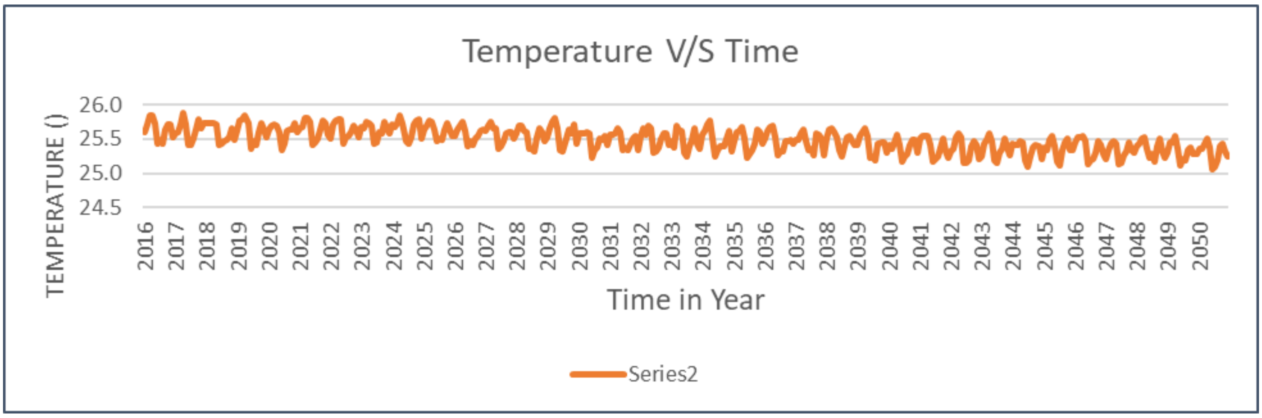

Figure 3: Graphs between CMIP5 Future Data (Temperature) and Time

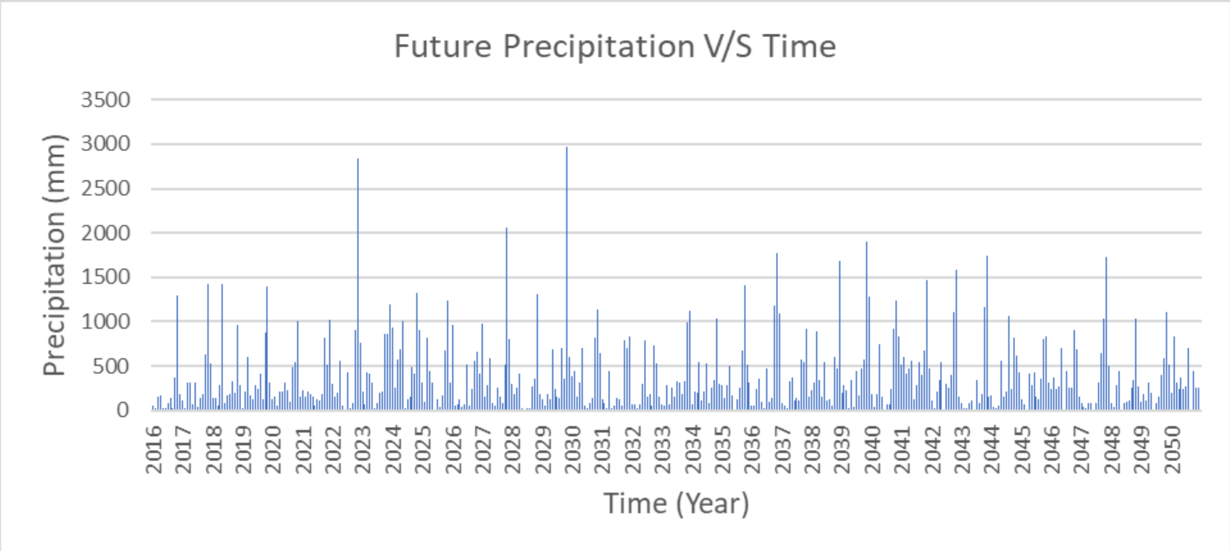

Figure 4: Graphs between CMIP5 Future Data (Precipitation) and Time

7.2 Multilayer Perceptron

The MLP model of ANN uses a hidden layer with several nodes to change the weights between neurons. A MLP's architecture is shown in Figure 4.1.

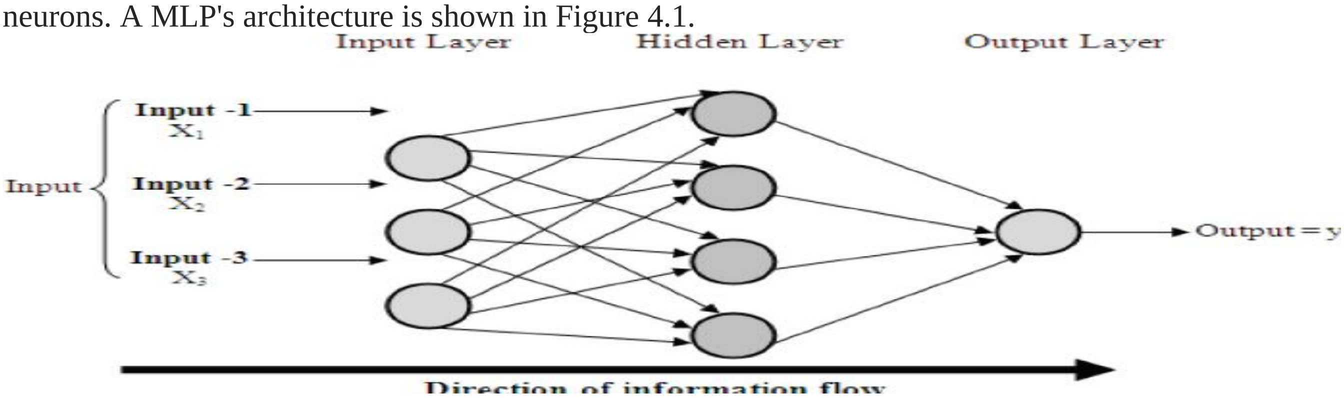

Figure 5: feed forward MLP Diagram with hidden layer

7.2.1 Back Propagation Feed Forward ANN

According to Nayak (2010), the MLP, FNN, uses the supervised training approach of back propagation. The fundamental principle of a feed-forward network is weight adjustment and error reduction between the target and the output provided by the network. If the calculated error is greater than the expected value, the network adjusts its weight. Until the error between the output and the

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target is reduced to a desired level, this procedure is repeated. The weights are always changing throughout the procedure. Training is halted once this requirement is met.

7.2.2 Training of ANN Model:

When an input vector X = (x1, x2, x3, xm) is fed to the ANN, the primary goal of training it (Azim, 2006) is to create an output vector y = (y1, y2, y3, ym) that is roughly near the target vector p = (p1, p2, p3.......pm).

By lowering the previously acquired error function as described, weight matrices W and bias vectors "R" are obtained during training.

$$e=\sum\sum (Y_i-P_i)^2 \qquad (1.1)$$

M M

Where M is the number of output nodes; yi is the output produced by the ANN; pi is a subset of the intended output; and MM is the number of training patterns. An ANN repeatedly processes a training set (input and output data pairs), changing the network's initial conditions and weights along the way. It is important to choose an adequate input dataset for model training that contains useful dataset-related information. The weight adjustments performed across a number of epochs are stored in the model's memory. Each input vector generates an output vector that is extremely close to the goal value thanks to the network's allocated weights, which gradually reach this value.

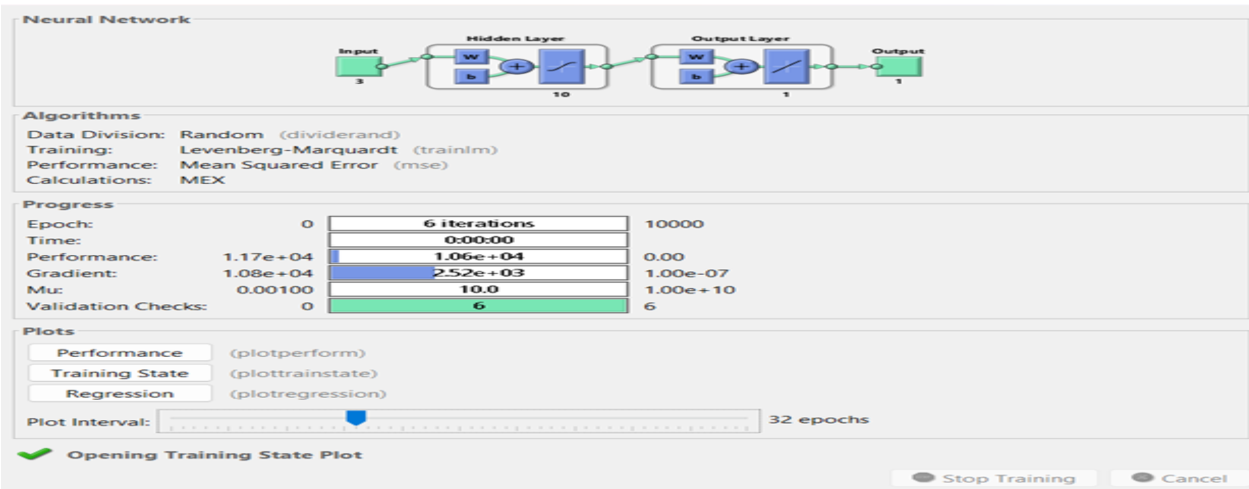

Figure 6: Nural Network Training

Model Performance

The coefficient of correlation (R), model efficacy, and root square error (RMSE) are the numerical performance estimators. The following describes them:

$$RMSE = \frac{\sqrt{\sum_{K=1}^{K}(t-y)2}}{K} \qquad (1.2)$$

where t is observed data; y is computed data; K is the number of observations; y = y-, in which ȳ is the mean of the computed data; and T = t-, in which Ť is the mean of the observed data.

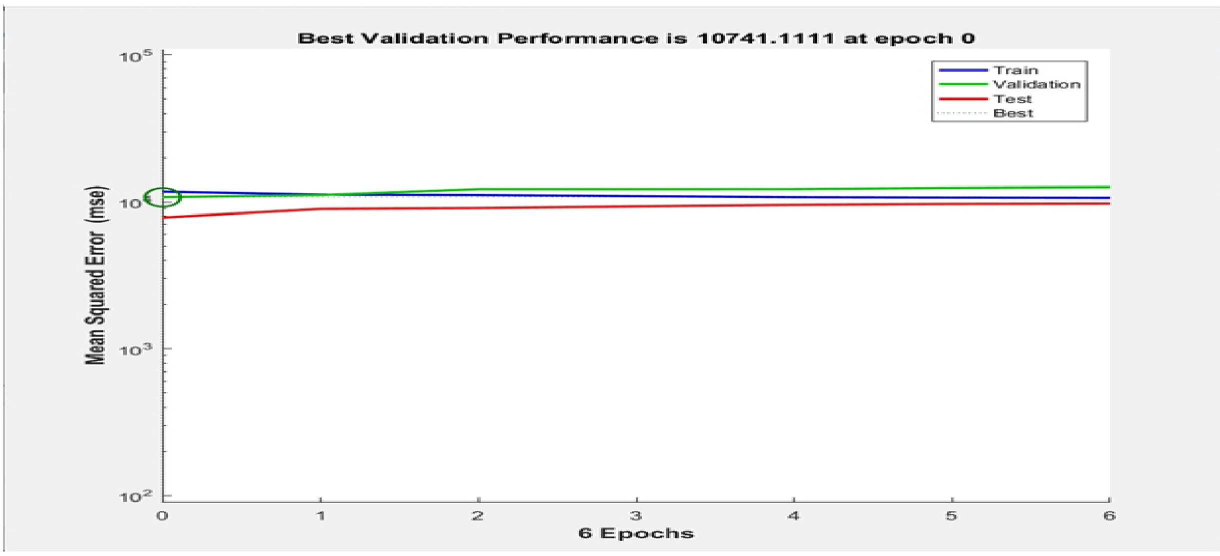

Figure 7: Nural Network Training Performance

VII. Result and analysis

7.1 Selection of Potential Predictor:

The observed tidal gauge data (sea level) acquired from the permanent service of mean sea level (PSMSL) of Chennai Port is connected with potential predictors including air temperature, relative humidity, and precipitation at various levels accessible in the NCEP/NCAR REANALYSIS model. These variables are chosen as prospective predictors for the fluctuation in sea level because they have values of 0.4 and above, which are considered to have a good association.

Table 1: Potential predictor for sea level.

S.N.	Sea Level	Climatic Parameter	Correlation Coefficient
1	1991 TO 2015	Temperature 2M (°C)	-0.41033
2		Relative Humidity 2M (%)	0.49799
3		Precipitation (MM/DAY)	0.427655

As shown in Table 1, the correlation coefficient between NCEP and observed data on sea level was determined. NCEP data for air temperature at 2M, relative humidity at 2M, and precipitation at 2M were substituted for these values in the trained model to find the simulation and the outcome of future predictions.

ANN MODEL ARCHITECTURE:

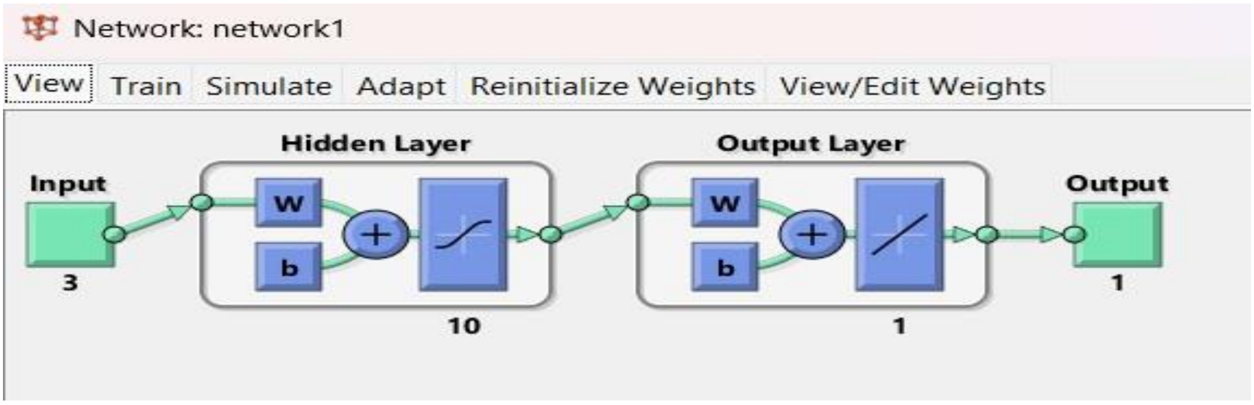

Figure 8: Network Diagram of ANN Model at selected hidden node (10)

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Data from the NCEP/NEAR REANALYSIS PROJECT are fed into an ANN model after being standardized and deconstructed. These inputs are processed using the sigmoid function (transfer function) to get their weight total in the hidden layer of 10 nodes. A separate sigmoid function is used to process the signal from the hidden layer before it is broadcast to the output node, and its weights are added to those allocated to this layer. Backpropagation in this case is done using the Levenburg-Marquardt training method.

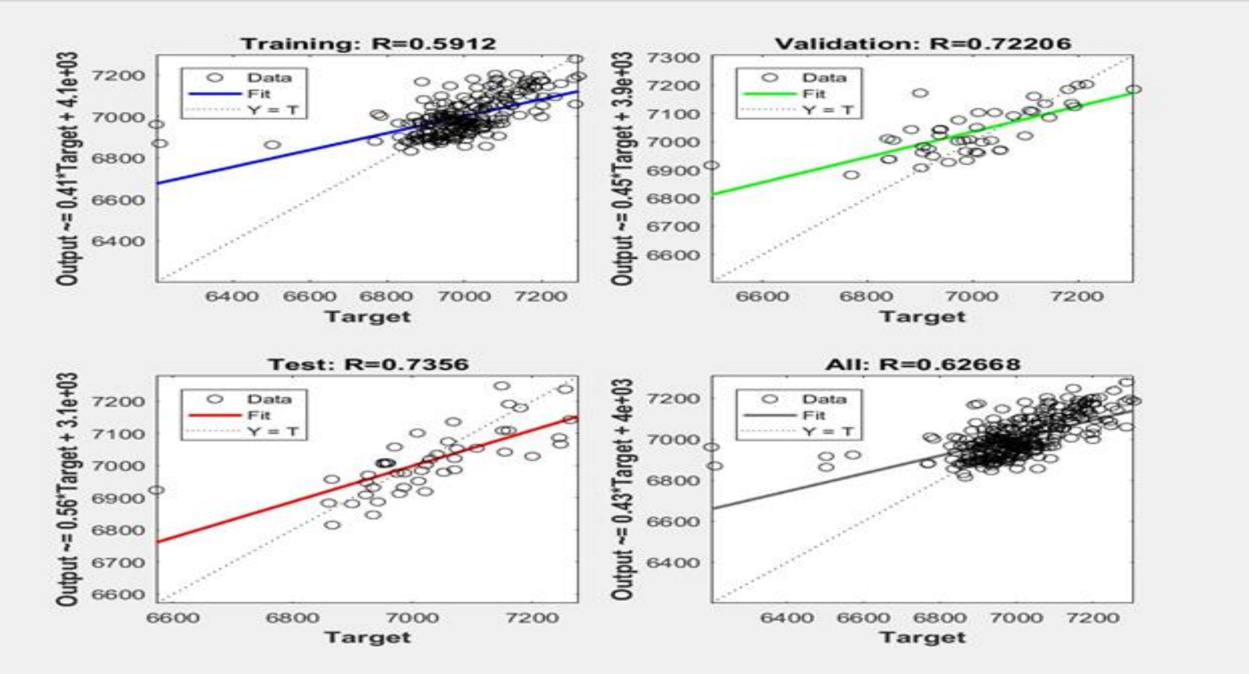

Figure -9: Regression plot at 10 hidden nodes

When training at 10 hidden nodes over 1,000 epochs, the regression plot is obtained (Figure 9). The regression value of 0.62668 indicates that the developed model is accurate and has undergone a thorough training process.

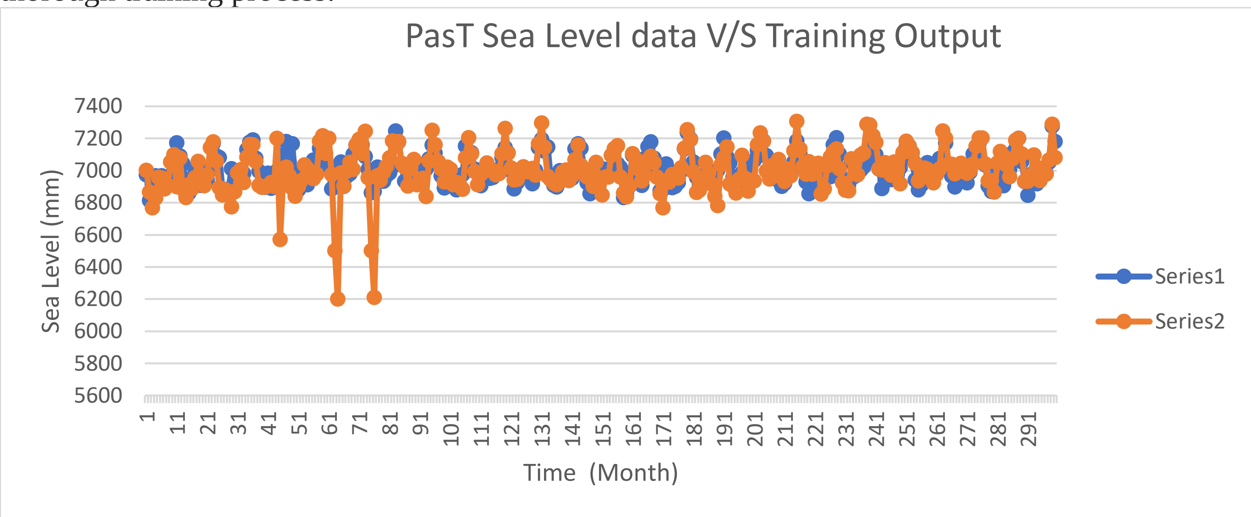

Figure 10: Observed Sea level verses simulated data

The above (figure 10) demonstrates that the output the model produces after training is extremely close to the goal value, demonstrating that the model has been correctly trained.

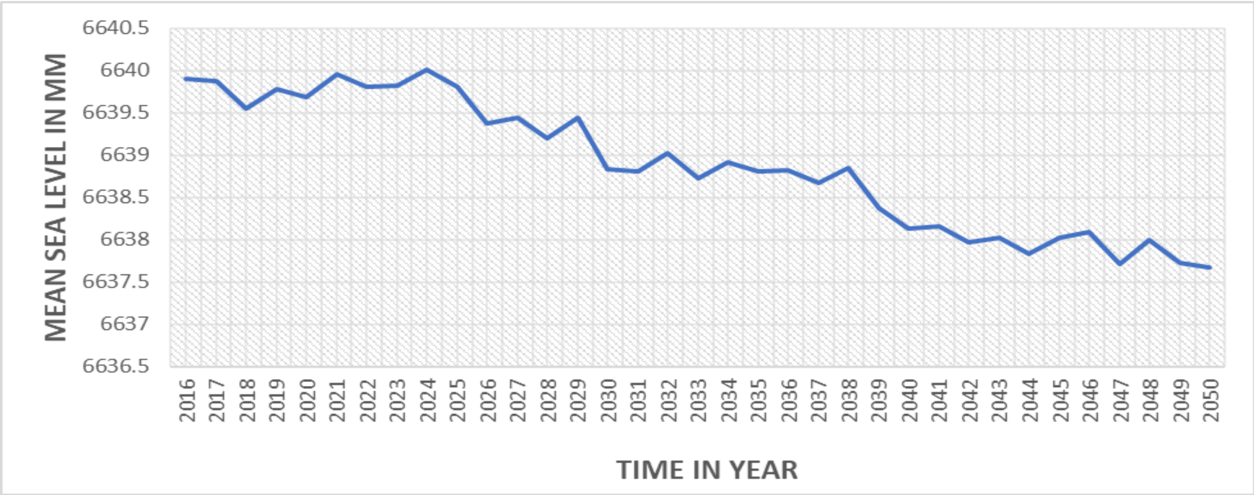

Figure 11: Future Predicted Sea level (Yearly)

The comparison between all historical sea level data and simulated data using FNN is shown in figure 10 above. It follows a trend that is essentially the same, and figure 11 displays the sea level forecast for the future using all available predictors.

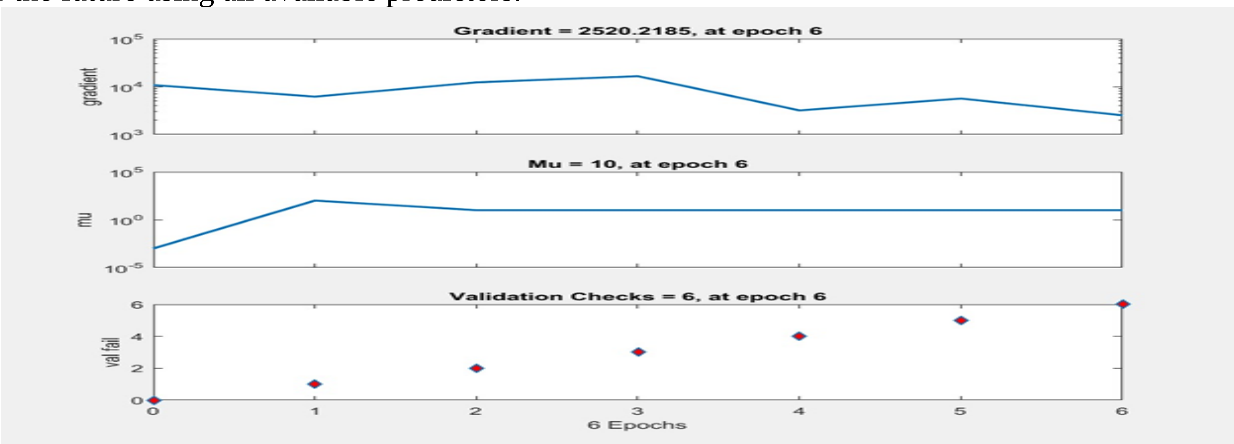

Figure 12: Nural Network Training Status

IX. Conclusion

The goal of this work was to identify a viable predictor for sea level variation at the CHENNAI PORT using a variety of environmental data. However, if the NCEP variable were linked to the observed sea level data for the years 1991 to 2015, future sea level variation may be anticipated. So, it was possible to do more research on this variable. Using ArcGIS and bilinear interpolation, data is produced in accordance with the latitude and longitude of the CHENNAI PORT. Data from potential variables was used to create an ANN model, and the model's training results showed that it had been successfully trained. According to the graph of expected sea levels, there will be variation in the sea level in 2024, with a maximum of 6.640015 meters and a minimum of 6.637672 meters in 2050, which was then verified by predicted sea level variability

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