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STUDY OF IMPACT OF CLIMATE CHANGE ON WATER AVAILABILITY IN THE GUMTI HYDROPOWER PLANT, TRIPURA, INDIA USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

Electricity is recognized as fundamental to industrialization and improving the quality of life of the people. Harnessing the immense untapped hydropower potential in Tripura region opens avenues for growth and provides an opportunity to improve the well-being of the people of the region, while making substantial contribution to the national economy. Gumti hydro power plant generates power to mitigate the crisis of power in Tripura, India. The first unit of hydro power plant (5MW) was commissioned in June 1976 and another two units of 5 MW was commissioned simultaneously. But out of 15MW capacity at present only 8MW-9MW power is produced from Gumti hydro power plant during rainy season. But during lean season the production reduces to 0.5MW due to shortage of water. Hence forecasting models are necessary to predict the future available water based on past and current information. Water prediction will tell us whether the coming years will be good, bad or average. Accordingly contingency measures can be planned well in advance. The present investigation tried to analyze the impact of climate change on availability of water in the Gumti Reservoir using Artificial Neural Network. In this regard a neural network model is developed and implemented for prediction of the volume of water in the reservoir due to the change in meteorological variables which is imminent for the future climate change scenarios as predicted by the PRECIS climate models. As per the model prediction there will be a deficit in the water availability of the reservoir. The level of deficit will be 25.17% in A2 scenario under peak flow conditions and 20.52% in lean flow condition for A1B scenario.

Keywords: hydro power, artificial neural network, climate change.

INTRODUCTION

Hydro power plants convert potential energy of water into electrical energy. The basic principle of hydro power is that if water can be channelized from higher level to lower level than the resulting potential energy of water can be used to do work. Hydro power is a very clean source of energy and only uses the water , the water after generating electrical power, is available for other purposes like drinking water , irrigation etc. Traditionally it is cheap and clean source of electricity. Electricity plays an important role in the development of civilization of a country. The performance of all important sectors in the economy ranging from agriculture to commerce and industry as also the performance of social sectors like health depends largely on the availability, cost and quality of power. The development in power sector in Tripura despite geographical, economic and infrastructural hindrance has come a long way till now, but hydro power generation is not progressed properly.

Gumti is one of the larger rivers in Tripura, India which flows west ward and discharges into Bangladesh. Due to the construction of a dam for hydropower plant a large reservoir is created which is known as Gumti reservoir. This reservoir is at upper catchment of Gumti River. The storage capacity of reservoir is 23570 Hectare metre. The submerged area at F.R.L of 92.05m and M.W.L. of 95.25m was found to be respectively 46.34and 74.86sqkm. With the help of this reservoir, Gumti Hydro Power plant generates power to mitigate the crisis of power in Tripura. Design capacity of this Hydro Power Plant was 15 MW. It has 3 unit(s). The first and 2nd units were commissioned in 1976 and the last in 1984. But out of 15MW capacity at present only 8MW-9MW power is produced from Gumti hydro power plant during rainy season. But during lean season the production reduces to 0.5MW. The present work wants to investigate the level of impact of climate change on availability of water in the Gumti reservoir through which hydro power is being generated using Artificial Neural Network under different climate change scenarios.

SCOPE AND OBJECTIVE

The artificial neural network in the present days is widely used for solution of complex nonlinear and parallel problems of prediction and optimization. The neural network technology of signal processing mimics the same way the human nervous system functions while processing an input signal. The network of nerve cells connected by synapse in between axon and dendrons with the help of nerve fluids communicate and process signals generated from different input stimuli. Based on the knowledge and previous experience every stimulus is answered in the most optimal manner known to the system. The objective of the present investigation is to predict the impact of climate change on availability of water in the Gumti Hydropower Plant using Artificial Neural Network. The advantage of neuro-genetic algorithms is utilized for predicting the impact of uncertainty for environmental as well as socio-economical sustenance of the plant.

ARTIFICIAL NEURAL NETWORK

Artificial neural networks (ANNs) are valuable computational tools that are increasingly being used to solve complex problems as an alternative to using more traditional techniques. Over the past two decades, there has been an increased interest in the use of ANNs in different engineering fields as it possesses the capability to generalize and predict new outcomes from past trends at high speed and in a distributed manner.

An artificial neuron is a computational model inspired in the biological neurons. Biological neurons receive signals through synapses located on the dendrites or membrane of the neuron. When the signals received are strong enough, the neuron is activated and emits a signal though the axon. This signal might be sent to another synapse and might activate other neurons.

The complexity of real neurons is highly abstracted when modelling artificial neurons. These basically consist of inputs (like synapses), which are multiplied by weights (strength of the respective signals), and then computed by a mathematical function which determines the activation of the neuron. Another function (which may be the identity) computes the output of the artificial neuron. ANNs combine artificial neurons in order to process information.

Therefore, a complex ANN architecture is characterized by the following components: a set of nodes, and connections between nodes. The nodes can be seen as computational units. They receive inputs, and process them to obtain an output. And the connections determine the information flow between nodes.

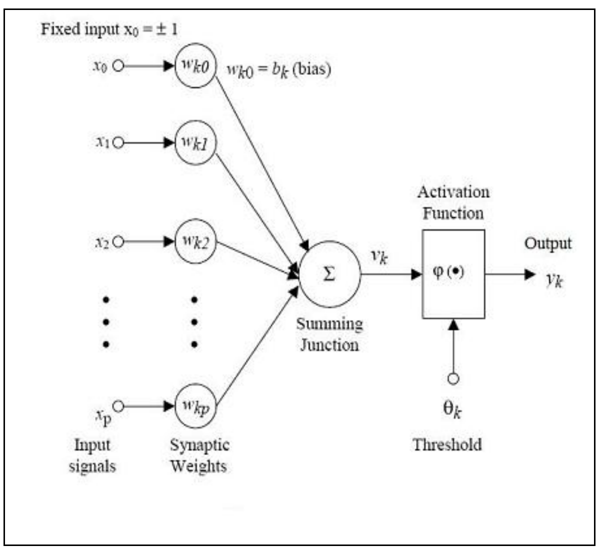

Figure-1. The basic architecture of an artificial neural network.

METHODOLOGY

The present investigation tried to estimate the impact of climate change on availability of water in the Gumti Reservoir through which Hydropower is being generated. The study utilized the advantage of neural network meta-heuristic algorithm to develop the model for prediction of the water availability in the reservoir. For benefit of efficient learning of the problem by neural networks the output water availability in the storage is divided by the summation of the inputs, the result of which is utilized as output of the neural network model. The input to the model is considered to be Rainfall, Evapo-transpiration and Runoff.

The metrological dataset is collected from Indian Meteorological Department, Agartala and hydrological data is collected from Central Water Commission. In Gumti water is supplied to the reservoir either by the surface runoff or from the inflow of Raima and Sarma Rivers.

While calculating the runoff the inflows from the two rivers were added to the surface runoff of the catchment. The temperature and humidity data collected from IMD is utilized to estimate Evapo -Transpiration from Penman-Monteith Equation.

The inflow data at the confluence of the river and the variation in water level of the reservoir is collected from CWC discharge stations situated in the area of interest.

All the dataset is normalized before feeding to the feed-forward neuro-genetic model developed to predict the water availability of the Gumti Reservoir.

The neural network was tested with three different training algorithm and two different topology prediction method. Training algorithms like QP (Quick Propagation), CGD (Conjugate Gradient Descent) and LM (Levenberg Marquadart) was implemented and topology prediction methods like GA (Genetic Algorithm) and SLOA is utilized and compared with each other. The performance metrics like RMSE (Root Mean Square Error), Correlation and Covariance is used and an index representing the overall performance is also applied to retrieve the overall performance of the neural network model under different configurations.

The predictions were performed for three different climate change scenarios like A2, B2 and A1B as conceptualized by IPCC in its fourth assessment report. PRECIS regional climate model is prescribed for the Indian subcontinent by Hadley Center in UK and thus output from the same model is further downscaled to derive the rainfall, evapo-transpiration and runoff for the Gumti Reservoir Catchment. Once the water availability at the reservoir is predicted the power equation may be used to convert the same into equivalent megawatts of power.

RESULT AND DISCUSSIONS

Climate change and the alteration of rainfall and temperature regimes can affect hydropower generation. Hydropower systems with less storage capacities are more vulnerable to climate change, as storage capacity provides more flexibility in operations.

Due to increasing carbon dioxide concentrations it is predicted that global warming would have a variety of environmental and socio-economic impacts over the long term. At the same time, however, hydropower is one of the

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most vulnerable areas to global warming because water resources are closely linked to climate changes.

The present investigation tried to predict the impact of climate change on availability of water in the Gumti Reservoir situated in South Tripura's Gumti District using Artificial Neural Network.

In this regard a neural network model is developed to predict the water availability in Gumti Reservoir from the thirty years rainfall, evapo-transpiration and runoff data.

The surface runoff was estimated from the Rainfall, ET and catchment loss which is found out from the Spatial Water Budget Equation. Inflow from the rivers is collected from CWC discharge station situated in the confluence area. All the data is normalized before feeding into the model.

The model was trained with three different algorithms and its network topology was identified with the help of GA and SLOA.

According to the PI (Performance Index), NGALM (Neural Network Genetic Algorithm Levenberg Marquadart) model or Neural Network trained with LM algorithm and topology predicted with Genetic Algorithm is found to be the better model among all types of configurations. That is why predictions are performed with the help of this selected model for the analysis of the climate change impact on the reservoir. Figures 1 and 2 shows the variation of predicted and actual dataset of the output and the RMSE with actual data of the output respectively. From the former the co-linearity of the model is clearly visible and from the later it can be found that for the estimation of maximum water availability conditions the model RMSE is never above 0.5.

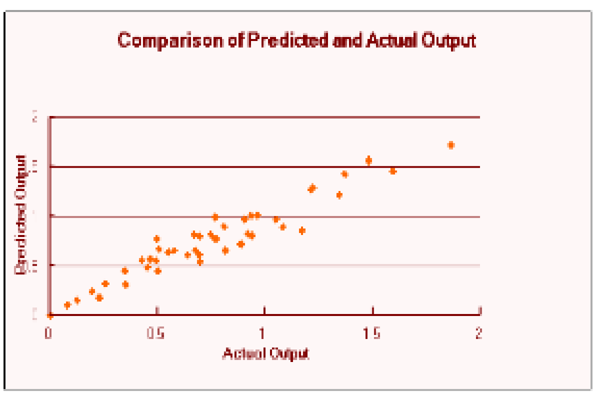

Figure-2. Showing the comparison of predicted and actual output of the top fifty maximum water volume days within the thirty years of data from the selected neural network model (NGALM).

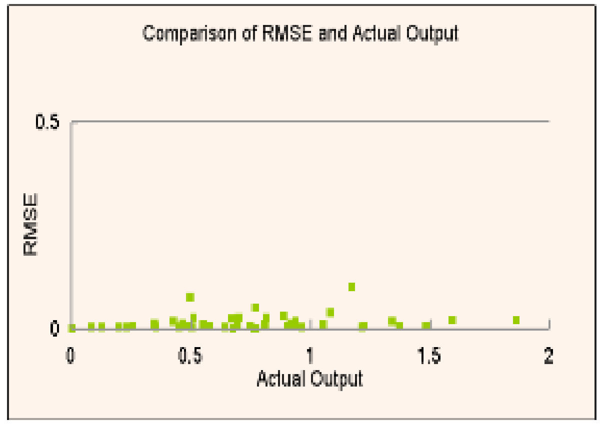

Figure-3. Showing the comparison of RMSE with actual output of the top fifty maximum water volume days within the thirty years of data from the selected neural network model (NGALM).

Table-1. Shows reduction from peak storage possible in the reservoir for three different climate change scenarios (in %).

2020			
	A2	A1B	B2
Peak Flow Conditions	24.21	22.56	23.67
Lean Flow Conditions	19.98	20.52	20.49
2050			
	A2	A1B	B2
Peak Flow Conditions	25.17	24.96	24.83
Lean Flow Conditions	18.52	19.39	18.78
2100			
	A2	A1B	B2
Peak Flow Conditions	24.83	24.46	24.66
Lean Flow Conditions	17.98	19.52	18.19

CONCLUSIONS

The present investigation tried to analyze the impact of climate change on availability of water in the Gumti Reservoir using Artificial Neural Network. In this regard a neural network model is developed and implemented for prediction of the volume of water in the reservoir due to the change in meteorological variables which is imminent for the future climate change scenarios as predicted by the PRECIS climate models.

As per the model prediction there will be a deficit in the water availability of the reservoir. The deficit will be maximum in the A2 scenario and under peak flow conditions. The level of deficit will be 25.17% in A2 scenario under peak flow conditions and 20.52% in lean flow condition for A1B scenario. The predicted impact of climate change shows that there will be uncertainty in the availability of water in the reservoir and thus it will impact on the hydro-power output of the Gumti plant in a similar manner. Thus it will be eminent to implement some mitigation measures so that the further atrocities can be prevented and originality will be possible to restore.

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