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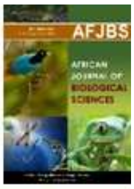

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Surface water availability prediction for the Gumti River basin at the Combined cycle gas turbine power plant (OTPC) , Palatana, Tripura, India.

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Abstract

Predicting the surface water for the Gumti River basin at the combined cycle gas turbine power plant (OTPC) in Palatana, Tripura, India, is the main goal of this study. Water is a vital resource for every community's development, but it's especially critical for emerging nations like India. Water usage needs to be considered carefully. The primary method used to meet water demand is surface water. Hydrological sequence predictions are often necessary for the effective and efficient operation of water resource systems. Therefore, in order to estimate surface water in the future using data from the past and present, forecasting models are required. We can anticipate surface water quality to find out if the upcoming years will be good, bad, or average. As a result, emergency plans can be made far in advance, helping to overcome challenges related to providing more water for the burgeoning population. In this study, the water in the Gumti River Basin at the combined cycle gas turbine power plant (OTPC) is predicted using HEC-HMS models. There will be a significant scarcity of water in the Gumti river basin and its reservoir. The amount of surface water that is accessible in the Gumti River Basin's catchment and reservoir will decrease by 12.69% and 15.83%, respectively, in the two time-domains of 2053–2083 and 2084-2114, with regard to the time-domain (2022–2052), under the climate change scenario. Water prediction is therefore essential for optimal water management and utilisation, as well as for improved planning of water resources.

Keywords: River basin, HEC-HMS, Surface water, Availability

Introduction

Water is a valuable resource that is essential to the growth of any community. Water is the primary component of all living things in the universe, and because of this, it is becoming increasingly scarce for maintaining ecological balance as well as for economic, developmental, and other purposes. As a result, it is imperative to plan and manage this resource and ensure its optimal, economical, and equitable use. Water has become increasingly important in many locations due to the rapid growth of the population and the increased demands of industry and agriculture. The oceans are thought to hold 97.3% of all the water that is accessible on Earth. The majority of the remaining 2.75 percent is solid from both poles. An estimated 1x 10-5 of the world's total water reserves are really above the ground, or in the atmosphere. This is a relatively small fraction of the total water reserves. It is astonishing how little water there is in the atmosphere. The rainfall pattern over the catchment region of the stream or river basin must be taken into consideration before any reservoir is built or even exists. It is necessary to forecast a river basin's water availability in order to establish backup plans well in advance. One of the biggest rivers in Tripura, India is the Gumti, which empties into the Meghna River in Bangladesh after flowing westward. The Raima and Sharma rivers, the former of which originates in the Longtarai Range and the latter in the Atharamura Range, combine to produce the Gumti River. The combined flow of the two rivulets, known as the Gumti, flows southward from the place of confluence. The Gomati River, a perennial river that supplies water to the combined cycle gas turbine power plant (OTPC), palatana , Tripura, India. The power plant's first block, which has a capacity of 363.3 MW, was put into commercial operation on January 4, 2014, and the second block, which also has a capacity of 363.3 MW, was put into operation on March 24, 2015. It is a highly efficient form of power generation that combines two distinct thermodynamic cycles, the Brayton cycle and the Rankine cycle, to produce electricity[1]. By utilizing waste heat from the gas turbine to generate additional power in a steam turbine, CCGT plants achieve significantly higher efficiencies compared to traditional single-cycle power plants [2]. The temperature of the gas turbine exhaust can vary from 450°C to 650°C depending on the pressure ratio and turbine input temperature[3]. It is wasteful to discard this energy into the environment. This wasted heat energy could be used to generate steam in the steam heat recovery generator (HRSG) in the CCGT power plant [4]. This paper deals with the prediction of surface water availability of the Gumti river basin and its reservoir at CCGT power plant (OTPC), palatana, Tripura, India. Prioritisation of surface water availability was not possible due to a lack of information on the actual status of water (surface & ground water combined) in the basin [9].

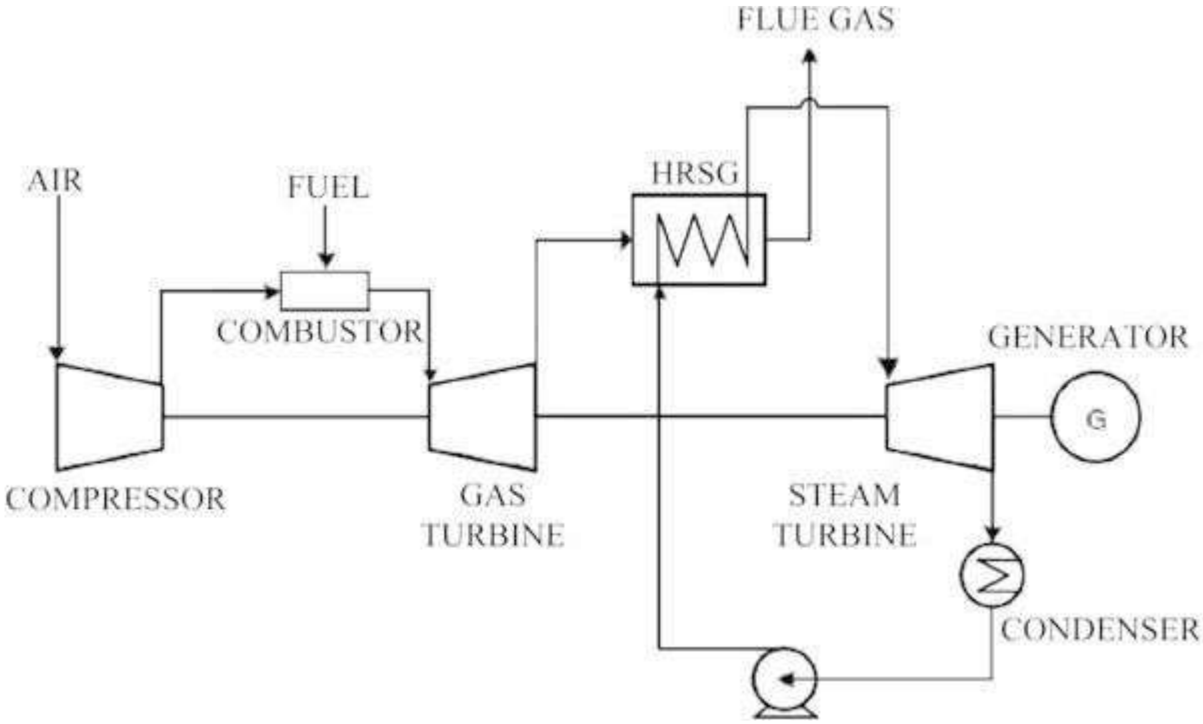

Figure-1. Schematic Illustration of a CCGT.

Methodology

The hydrologic impact of climate variability on the water resources of the Gumti river basin in India has been assessed using the hydrologic simulation tool HEC-HMS model. The Hydrologic Engineering Centre (HEC) created the US Army Corps of Engineers' hydrologic modelling system, known as the HEC-HMS[17]. Both natural and artificial precipitation and routing processes are simulated by the hydrologic model. Hydro-meteorological data, soil conditions at the micro-watershed level, and daily/hourly rainfall are required for the model to function. The calibration and validation will be performed using the basins' historical data. A system schematic of the HEC-HMS-modelled watershed runoff process is shown in Fig. 2.

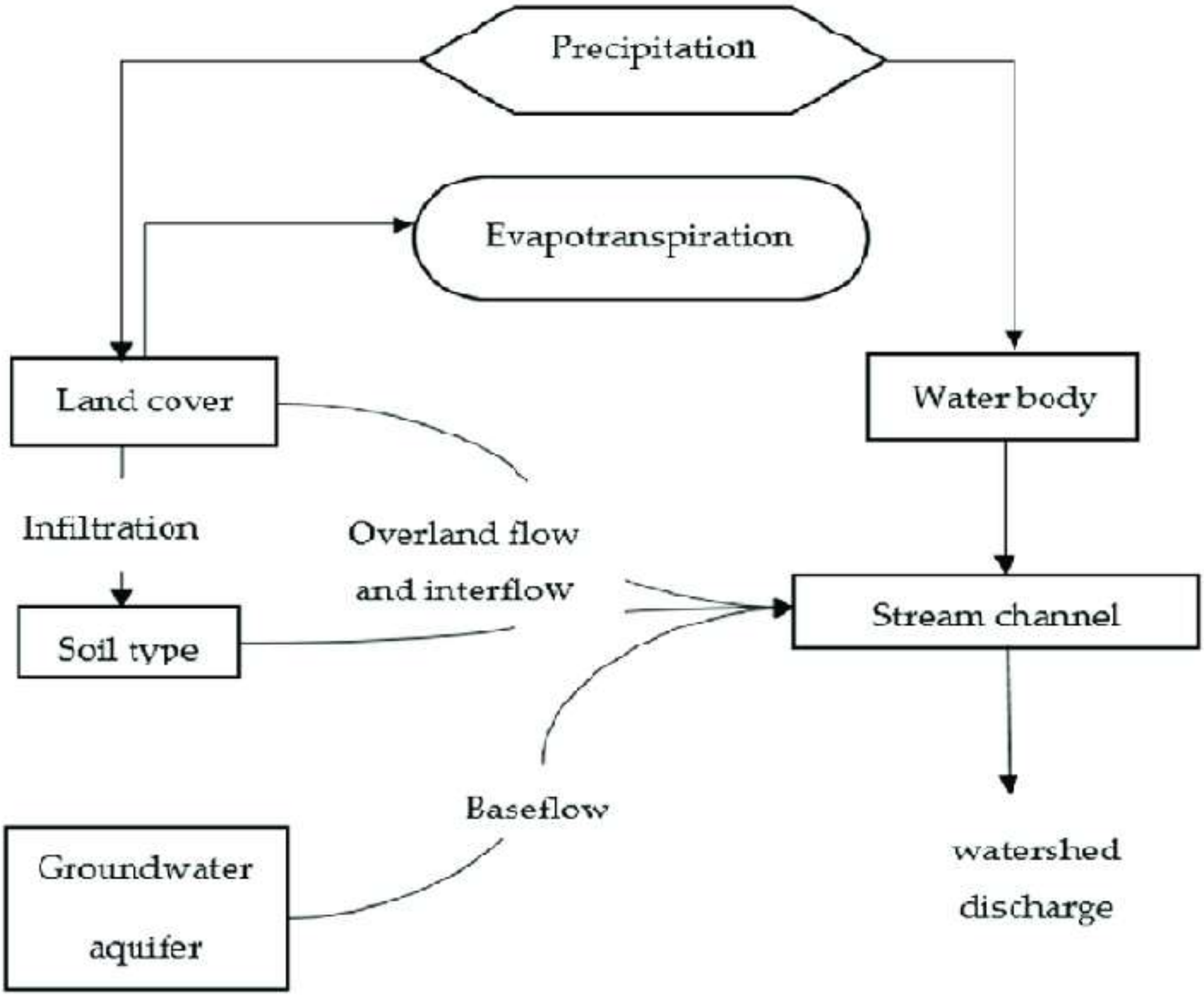

Figure 2: watershed Runoff

The calibration and validation process made use of daily rainfall data for the Gumti basin spanning twenty years, from January 2002 to December 2021. For river basins, the calibration error was determined to be between 0.1% and 10% of the difference between the simulated and observed values, represented as a percentage.

HEC-HMS Model

The purpose of the Hydrologic Modelling System is to simulate the processes of precipitation and runoff in dendritic watershed systems. Because of its adaptable nature, it can be applied to a wide range of problems in different geographical locations. These difficulties include runoff in little urban or natural watersheds, flood hydrology, and the water supply in big river basins. For tasks like water availability studies, urban drainage planning, flow forecasting, evaluating the impact of future urbanisation, designing reservoir spillways, minimising flood damage, controlling flood plains, and overseeing system operations, the system-generated hydrographs can be used alone or in conjunction with other software tools.

The components of the HEC-HMS model are used to simulate a watershed's hydrologic response. Basin models, meteorological models, control requirements, and input data are some of these components. Based on data from the meteorological model, the model computes the runoff response within the basin model throughout a simulation. The simulation's time frame and intervals are set by the control specifications[7]. The basin and meteorological models usually need input data as parameters or boundary conditions, such as time series data, paired data, and gridded data. Several models are included in HEC-HMS to take cumulative losses into consideration during hydrologic simulations[12]. These models comprise the SCS Curve Number (CN) loss model, which can be applied as gridded or composite, the initial and constant-rate loss model, and the deficit and constant-rate model. For every computation time interval in each model, precipitation loss is computed and deducted from the mean areal precipitation (MAP) depth for that interval[19,20]. The remaining depth is referred to as the precipitation excess, and it represents the volume of runoff and is expected to be uniformly distributed over the watershed area. In a unit hydrograph model, the amount of precipitation that falls on directly connected impervious areas is added to the excess rainfall from the watershed's pervious areas to calculate runoff. In a kinematic-wave model, however, the directly connected impervious areas can be treated independently of the pervious areas by defining two overland flow planes. To develop a hydrologic model,

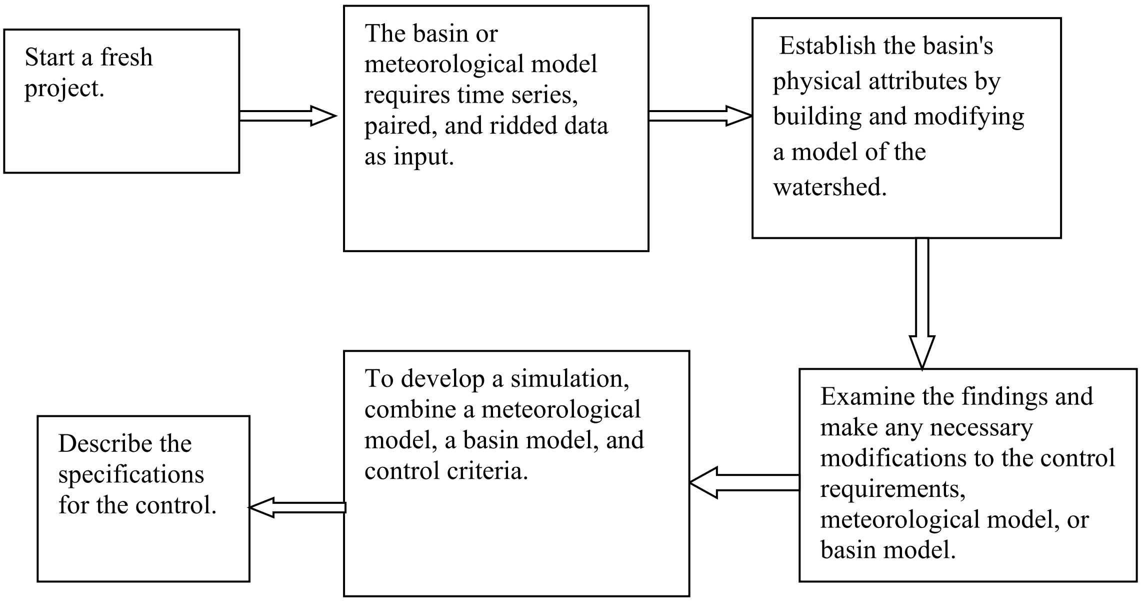

Fig: 3 Hydrological modelling schematic diagram.

Result & Discussion

The daily rainfall data used in this study has been utilized as input for a hydrologic simulation model aimed at estimating the total surface runoff for the study area. The rainfall data, spanning a 20-year period from January 2002 to December 2021, was obtained from the India Meteorological Department, Meteorological Centre in Agartala, Tripura. The flow calculations were performed using the HEC-HMS model, with the results displayed in Figure 4 for the years 2002 to 2011 and in Figure 5 for the years 2012 to 2021.

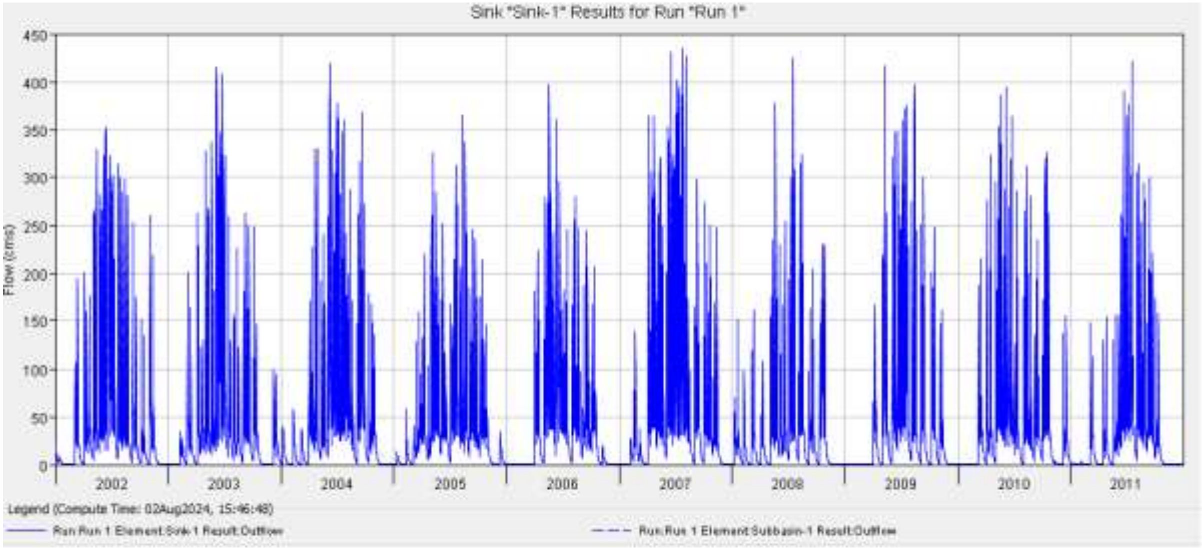

Fig:4 Hydrograph 2002 to 2011

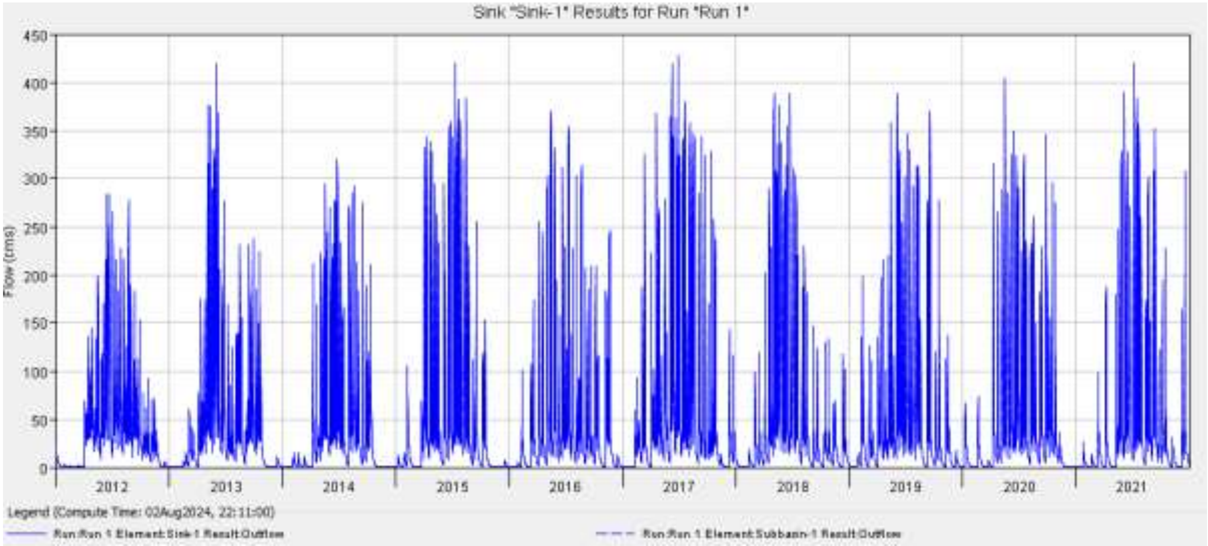

Fig: 5 Hydrograph 2012 to 2021

The data presented in Table 1 provides a comprehensive outlook on the annual water availability of the Gumti River Basin, including its reservoir, for three future periods: 2022 to 2052, 2053 to 2083, and 2084 to 2114. This analysis is crucial in understanding the potential impacts of climate change on regional water resources over the coming decades.

In the first period (2022 to 2052), the Gumti River Basin is projected to experience changes in water availability, although these changes might be moderate compared to later periods. Early impacts of climate change, such as shifts in precipitation patterns and temperature increases, may begin to affect the river's flow and reservoir levels. While water availability might still be sufficient to meet the region's needs, the variability and uncertainty in water supply could pose challenges, especially during dry seasons.

The second period (2053 to 2083) is expected to witness more pronounced effects of climate change. During these decades, the basin is likely to experience a significant reduction in water availability due to more intense and frequent droughts, altered rainfall patterns, and increased evaporation rates. This period could see the beginning of sustained water scarcity, with more frequent instances where the demand for water outstrips supply. The region may start facing severe challenges in maintaining agricultural productivity, meeting the needs of a growing population, and preserving ecological balance.

The third period (2084 to 2114) is projected to be the most critical, with the highest severity of water scarcity. By this time, the cumulative impacts of prolonged climate change will likely lead to drastic reductions in annual water availability. The basin might experience extreme water shortages, with significant consequences for all sectors reliant on water. Agriculture could suffer massive productivity losses, drinking water supplies might become unreliable, and the overall ecosystem health of the basin could be severely compromised. This period underscores the urgent need for comprehensive and long-term water management strategies to mitigate the anticipated extreme scarcity.

MONTH	YEAR		
	2022 -2052 (m^3/s)	2053-2083 (m^3/s)	2084 to 2114 (m^3/s)
January	15.2	16.7	23.7
February	18.7	14.5	42.6
March	60.4	8.6	57.3
April	123.2	128.3	100.5
May	234.4	232.7	256.5
June	440.8	466.9	400.7
July	954.1	716.5	492.6
August	266.6	387.8	413.5
September	526.1	394.9	330
October	170.3	104.7	184
November	34.8	10.2	59.5
December	29.8	26.2	40.4
Annual	2874.4	2508	2401.3

Table 1: The Gumti River basin's surface water availability and its reservoir.

Conclusion:

To predict future water availability, the model requires calibration using historical hydrological data such as rainfall, temperature, and river discharge. The findings indicate that the Gumti River Basin, including its reservoirs, is likely to experience significant water shortages in the future. Under climate change scenarios, surface water availability in the catchment is projected to decrease by 12.69% between 2053-2083 and by 15.83% between 2084-2114, compared to the baseline period of 2022-2052. This steady decline in water resources from 2022 to 2114 highlights the need for proactive measures to manage water scarcity effectively. Such measures include enhancing water storage capacity, promoting water conservation practices, developing climate-resilient agricultural methods, and establishing robust policies to ensure sustainable water use. The data emphasizes the urgency of preparing for and mitigating the severe impacts of climate change on the Gumti River Basin's water resources.

For the Gumti River Basin's Combined Cycle Gas Turbine Power Plant (OTPC) at Palatana, Tripura, to operate efficiently, an integrated management plan is essential. This strategy should actively engage local stakeholders and end users in addition to different government agencies in all phases of the planning, design, development, and management of water resources. It is imperative that municipalities, gramme panchayats, and Water Users' Associations actively participate, especially when it comes to the management, upkeep, and operation of water infrastructure. It is recommended that local bodies and user groups gradually assume responsibility for these facilities in order to guarantee community-led and sustainable management.

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