An Overview of the Research of Hydrological Trends in Various Rivers in West Bengal

Sumit Kumar Banerjee[1], Himanish De[2], Suvendu Kar[3]

[1,2,3]Assistant Professor, Abacus Institute of Engineering & Management, MAKAUT
E-mail: sumitkrbanerjee.aiem@jisgroup.org

Abstract

An important factor in sustaining socioeconomic activity is the Ganges River, which is essential to Bangladesh as well as India. It is maintained by snowmelt from the Himalayas and monsoon rains, spanning 1.25 million km2 over India and Nepal. Its hydrology has been affected by human activities like urbanization, hydropower, and agriculture since the 1980s. The Soil Water Assessment Tool (SWAT) is employed in this work to evaluate water yield and simulate hydrological changes at the Farakka Barrage (1975–1995). The results show an overall decline in flow during both the monsoon and dry seasons. Furthermore, predictions suggest that climate change will have an impact on water output because snowfall is a major factor in the flow of the Brahmaputra River. Similar research Bangladesh's Teesta River Basin emphasizes the need for upstream actions by examining future water supply in the context of changing climatic circumstances. The findings emphasize that in order to address upcoming concerns with water security in these river basins, comprehensive water management is essential.

Keywords: Hydrological trend analysis, discharge, Water yield, Water Management, Hydrology

Introduction

India's cultural and economic history has been largely shaped by the Ganges River, also known as the Ganga, whose significance dates back to the Vedic era. Along its fertile floodplains, numerous civilizations have flourished, and it continues to be essential for industrial and urban activity. The river flows across five Indian states (Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal) after rising from the Himalayan Gangotri Glacier and separating into two streams. The BhagirathiHooghly branch flows into West Bengal, whereas the Padma branch goes into Bangladesh. With a total size of 1.25 million square kilometers, the Ganges basin supports around 8% of global population and accounts for 26.2% of India's land area. Its main tributaries, the Yamuna, Gomti, and Ghagra, as well as the Himalayan glaciers and monsoon rainfall, are its sources of water.

The river's hydrology undergoes seasonal fluctuations, with lower water levels from March to May and flooding during the monsoon season from July to October. The lower stretches of the river are particularly prone to severe erosion and frequent flooding. Analyzing historical hydrological patterns is crucial for forecasting future trends. Hydrological systems comprise various factors, such as precipitation, evapotranspiration, runoff, and changes in water storage, all of which play essential roles in determining water availability.

Numerical models, such the SWAT tool (Soil and Water Assessment Tool), are utilized to replicate natural flow conditions because of the Ganges River's complex hydrology. To forecast the quantity and quality of water, SWAT models use data on weather patterns, soil types, and land use. This instrument has been used extensively throughout the world in river systems, such as the Ganges, providing insightful information for water management. On the other hand, limited access to observable hydrological data makes a thorough comprehension of the dynamics of the river's flow more difficult.

With the help of mountains like the Himalayas, almost 1/6 of the global populace is sustained. within the Hindu Kush Himalayan (HKH) region, which supports over Indus, Brahmaputra, and Ganges river basins, and 800 million people are particularly important. Although the specific effects on hydrology remain unclear, climate models predict significant increases in temperature and precipitation in the HKH region by the middle of the twentyfirst century. During the non-monsoon months, especially from May to October, the river's base flow is provided by snow and glacier melts. However, the river's flow is mostly driven by monsoon rains from June to September.

The hydrology of Himalayan Rivers has been the subject of more recent research, much of which has focused on the effects of climate change. The future availability of water resources is seriously threatened by the retreating Himalayan glaciers. A long-term decline in glacier runoff is anticipated, which could exacerbate the region's water scarcity, despite certain research suggesting a potential short-term increase. However, it is often difficult to fully assess the effects of climate change on water availability because these studies lack comprehensive data across entire river basins.

China, India, Bhutan, and Bangladesh are the countries bordered by the Brahmaputra River, one of the region's principal river systems. From the Chemayungdung Glacier in Tibet, it flows through Bangladesh and India and eventually joins the Ganges. A range of land types, including grasslands, forests, agricultural areas, and snow-ice regions, can be found along the river. 70% to 80% of the river's yearly precipitation comes from monsoon rains, and at its lowest point in Bangladesh, the river discharges an average of 20,200 cubic meters per second.

Last but not least, disagreements over water sharing that are exacerbated by climate change have turned the Teesta River, a major trans boundary river between Bangladesh and India, into a point of contention. Bangladesh's downstream water availability has decreased as a result of India's construction of the Gazoldoba barrage. Floods from glacial lake outbursts are a possibility for the Teesta River, which is primarily dependent on snowmelt from the Himalayas. It is anticipated that climate change will make these floods more frequent, which will have an additional impact on water availability. By utilizing the SWAT model to predict future water balance scenarios, this study evaluates the possible effects of climate change on the Teesta basin.

Review of Previous Work

Determination of hydrological trends analysis of different river in South Asia with the help of different model studies by a number of research work. A brief review of significant trends analysis investigations and contribution of different investigators have been presented briefly here.

A. Titas Ganguly, Amit Kr. Dubey, Subashisa Dutta, Suresh A Kartha, Bimlesh Kumar Department of Civil Engineering, IIT Guwahati, (February, 2011) A hydrological trend analysis during the 1975 construction of the farakka barrage in the Ganga River was discussed in this research. 1975 to 1995 is the period for this trend analysis. The Soil Water Assessment Tool (SWAT) is the first way to use analyses trends using simulated data. The Indian Meteorological Department and Parua 2010 observation data are the second approach used to collect trend data. In the farakka barrage and nearby areas, the annual water yield, variation in monsoon season flow, and variation in dry season flow are computed using these two methods. They construct a hydrograph from the calculated value and use it to compare the simulated and observational data. We conclude from the analysis of this hydrograph that the annual water yield and ganga flow rate have been consistently decreasing across the three time periods shown. Specifically, the river's ecological state in its downstream reach would be impacted by a 0.5% decrease in the dry season flow rate. No statistically significant decreasing trend has been observed within a 20-year period, as evidenced by the temporal fluctuations of the basin-average precipitation. The poor hydrological situation of the river at its reaches can thus be attributed to human pressure based on by intensive agriculture, shifting cropping patterns, and increasing water demand. For this river basin, an urgent water resources planning project with an emphasis on basin scale management is needed.

B. Mohammad Zakwan & Zulfequar Ahmad (2 January 2021) The Ganga River is one of India's longest rivers, with a total length of 2525 km and a catchment area of 8,61,542 km^2. The goal of this paper is to identify patterns in the Ganga River's annual maximum and minimum discharges during the monsoon season. Use non-parametric statistical tests at several Ganga River measuring locations, such as Sen.'s slope, the Mann-Kendall, and inventive analysis of trends to identify any significant trends in the annual minimum discharge, annual maximum discharge, monthly discharge, and water supply from June to October, when the rainy season arrives. This study used Sen.'s slope and the non-parametric Mann-Kendall to ascertain whether a trend in the flow existed. The MATLAB program and other parametric trend tests yield comparable results. Test statistics were acquired for the lowest and highest yearly discharges at different times using the Mann-Kendall, Sen.'s slope test, and ITA. The yearly highest possible outflow time series showed a substantially higher first half than a second half. At the upstream gauging sites of Garhmukteshwar, Kachlabridge, Fatehgarh, Ankinghat, Kanpur, Bhitaura, and Shahzadpur, the yearly lowest flow exhibited a positive trend. Significant negative trends were also observed at the locations upstream, which include Shahzadpur, Kanpur, and Garhmukteshwar. An examination of water discharge data collected during the monsoon season from fifteen gauging sites is covered in the paragraph. Calculating total water volumes and utilizing a variety of statistical tests to look for trends were part of the analysis. The discharge trend was found to be generally declining, with notable decreases in July and August and a positive trend in October. Site-specific trends differed; for example, Garhmukteshwar and Kanpur demonstrated significant declines as a result of recent barrages. Gandhi hat stood out as an anomaly, as the discharge rose there, potentially as a result of fewer rainy days and a higher maximum annual discharge. SiteSpecific Observations refer to the analysis that focuses on different trends at particular locations. For instance, the yields of both water and sediment decreased at Farakka, but increased at Gandhi hat. Significant drops in both discharges were observed at certain locations, including Varanasi and Mirzapur. Water yield at various gauging sites, as well as annual maximum and minimum discharges, were assessed using Mann-Kendall, Sen.'s slope, and creative trend tests. The trend analysis of the Ganga River's hydrologic parameters using Sen's slope, Mann-Kendall, and creative trend tests is covered in the paragraph. Indicating a decrease in annual maximum/minimum discharges and water yield over time, The findings showed a notable downward trend at a number of measuring locations, particularly from Allahabad to Bexar downstream of the Yamuna. A noticeable downward trend was observed in Farakka, probably as a result of a barrage, while Gandhi hat displayed an upward trend..

C. Reazul Zannah, Khaled Mohammed, Afeefa Rahman, and Anika Yunus (July 2020) Originating from the Himalayan glaciers in Sikkim, The Teesta River is Bangladesh's fourth-largest transboundary river. Although the river is vital to the area, the building of the Gazoldoba barrage in India, upstream of Bangladesh, has had a major impact on its flow. There is now less water available downstream, especially in Bangladesh, as a result of this barrage. Frequent flooding in the Teesta River Basin during the monsoon season is a result of climate change, specifically due to the melting of glaciers and increased precipitation. The study focuses on the effects that the people in five northern districts of Bangladesh will experience from changes in river flow brought on by climate change. The Soil Water Assessment Tool (SWAT) was used to create a hydrological model of the Teesta River Basin. The water balance and flow in the basin were simulated by the model using data from digital elevation maps, soil types, data on land use, the weather and river discharge. The calibration and validation data used was from 2001 to 2016. Evapotranspiration, return flow, and surface runoff are just a few of the parameters that the SWAT model takes into consideration through sensitivity analysis. In addition, the study projected river flow for several time periods, including the 2020s (2010–2039), 2050s (2040–2069), and 2080s (2070–2099) under RCP 2.6 and RCP 8.5. It did this by using models such as MIROC-ESM-CHEM and HADGEM2- ES. While dry season flows are anticipated to remain extremely low, an overall increase in wet season flows was anticipated, aggravating the water scarcity in Bangladesh's northern districts. The impact of flow diversion at the Gazoldoba barrage on Bangladesh's downstream flow was also simulated in the study. Models were created for six distinct flow diversion scenarios. Bangladesh's water availability was significantly reduced during the dry season (October to April) as a result of increased flow diversion upstream, as was predicted. The effects were most noticeable in January and February. Using a calibrated hydrological model that closely matches observed data, the study evaluates the possible effects Regarding the Teesta River basin's water flow due to climate change in the future. With an 187% increase in dry season discharge Regarding the MIROC-ESM-CHEM (RCP 8.5) situation, 47.6% increase in wet season flow for HADGEM2-ES, the analysis, which focuses on the Dalia catchment in Bangladesh, predicts significant changes by the 2080s. Future droughts and floods are more likely, based on these changes. Furthermore, these risks might get worse if the flow at Gazoldoba is diverted. Future efforts to lessen the effects summarize the study's findings on the effects of climate change on Bangladesh's principal river basins.

D. Wahid Palash, Sagar Ratna Bajracharya, Arun Bhakta Shrestha, ShahriarWahid, Md. Shahadat Hossain, Tarun Kanti Mogumder and Liton Chandra Mazumder (30 December 2022) The Brahmaputra River Basin and other Himalayan River basins are being severely impacted by climate change in terms of hydrology. In this study, changes in water yield and snowmelt under climate projections are estimated using the Soil and Water Assessment Tool (SWAT). With 21% in the upper basin and 5% in the middle, snowmelt accounts for 6% of the Brahmaputra's yearly flow. While snowmelt may drop by 17%, with the upper Brahmaputra experiencing the biggest decline, an 8% increase in the yearly water output is anticipated., especially in the pre-monsoon season. These results underscore the necessity of basin-wide climate-smart water management. Since mountains provide water to nearly alterations in mountain hydrology brought on by climate change (CC) are considerable, affecting just over one sixth of the world's population. The eight hundred million or so people who live in the Indus, Ganges, and Brahmaputra basins depend on this water. In order to evaluate hydrology and water balance in the Brahmaputra River Basin (1998–2007), this study employs the Soil and Water Assessment Tool (SWAT). It also projects changes by 2050 under two CC scenarios (RCP 4.5, RCP 8.5). With the restricted flow data, the model's ability to simulate seasonal, annual, monthly, and snowmelt processes was judged sufficient. The CC projections show rising temperatures and precipitation, which will have a major effect on the distribution of annual water yield (AWY) throughout the basin and snowmelt processes. Under RCP 4.5 and 8.5, respectively, an AWY increase of 5–9% is predicted for the upper Brahmaputra, which currently provides 20% of the basin's AWY. Because there is less snow during the monsoon season, snowmelt, which makes up 21% of the AWY, will fall by 22% every year. However, its contribution will increase during the non-monsoon seasons. With snowmelt currently contributing 5% of the basin's AWY, a slight decline is anticipated under CC projections for the middle Brahmaputra, which accounts for 42% of the basin's AWY. Because of the rising temperatures, snowmelt will occur more quickly in the winter and before the monsoon, resulting in less snow melting during the monsoon and pre-monsoon seasons. Under both scenarios, AWY increases by 6–9%, with the lower Brahmaputra, which contributes 38% of the basin's AWY, expected to be least affected by CC. Even with an average 17% decrease in the amount of snowmelt contribution the entire AWY of the basin is expected to rise by 8% within two CC scenarios. The study suggests that CC will result in a change in the hydrological balance, particularly in the top and central Brahmaputra regions, with a declining role for snowmelt and an increasing dominance of rain runoff. Because of the limitations of the model, the study did not evaluate glacier melt; however, it does highlight the possibility of higher glacier melt during the monsoon season due to lower snow cover.

Conclusion

A semi-distributed hydrological model is used in the study to simulate the Ganges River's flow volumes using meteorological and geospatial data. Overall hydrological trends are accurately captured by the model, despite its tendency to overestimate flows during all periods (annual, monsoon, and dry season). It is primarily because of human activities like intensive agriculture and growing water demand that the Ganges River is gradually losing flow, particularly during the dry season. Even though the average amount of precipitation in the basin has not significantly decreased, the reduced flow in areas downstream raises ecological concerns. In future climate scenarios, the upper, middle, and lower regions of the Brahmaputra basin are predicted by the SWAT model to experience higher temperatures and precipitation. Rainfall-driven runoff is predicted to replace snowmelt-dominated runoff patterns as a result of this. Future conditions may increase the likelihood of floods and droughts in the Teesta River basin, highlighting the need for efficient basin-scale management and adaptable strategies to deal with these problems.

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