



ANALYSIS ON IMPACTS OF HYDRO-CLIMATIC CHANGES AND ANTHROPOGENIC ACTIVITIES ON WATER OF SUBERNREKHA RIVER JAMSHEDPUR, JHARKHAND

BY

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ABSTRACT

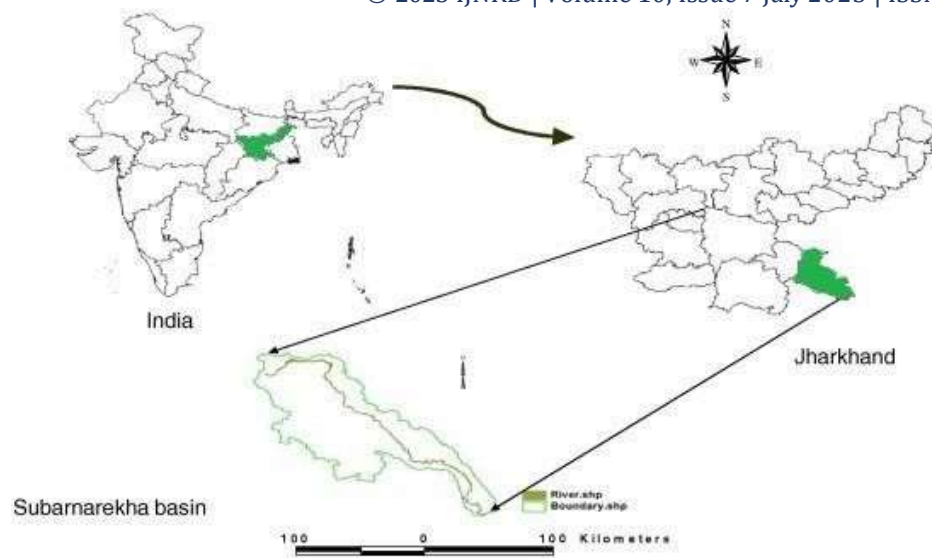
Water resources in Subernrekha are very scarce due to natural and anthropogenic activates impacts. The present study deals with the assessment of impact of climate change on water bodies and land use anthropogenic activities impacts. land cover of the study area. Water supply gets adversely affected due to climate change. Subarnarekha Tom Shed pin River watershed in Jamshedpur region is selected as the study area. The study area coordinates are as latitude 21° 33' to 23° 32' N and longitude 85° 09' to 87° 27' E. The selected river stretch is about 50 kms eight The water samples are taken seasonally from eight sampling points and analysed for basic water quality parameters. The worst affected parameters were salinity and total dissolved solids. Rest of the quality parameters have also shown significant changes with respect to temperature. The climate change induced a change in rainfall and vegetation cover which have eventually caused the change in magnitude and intensity of hydrological variables such as runoff, evapotranspiration and baseflow. The ecosystem in arid and semi-arid areas is degraded as a result of land use/land cover change due to climate change. Sampling of water from different sampling point were done monsoon and post monsoon to determine the coverage of water in the Subarnarekha revier Jamshedpur District.

INTRODUCTION

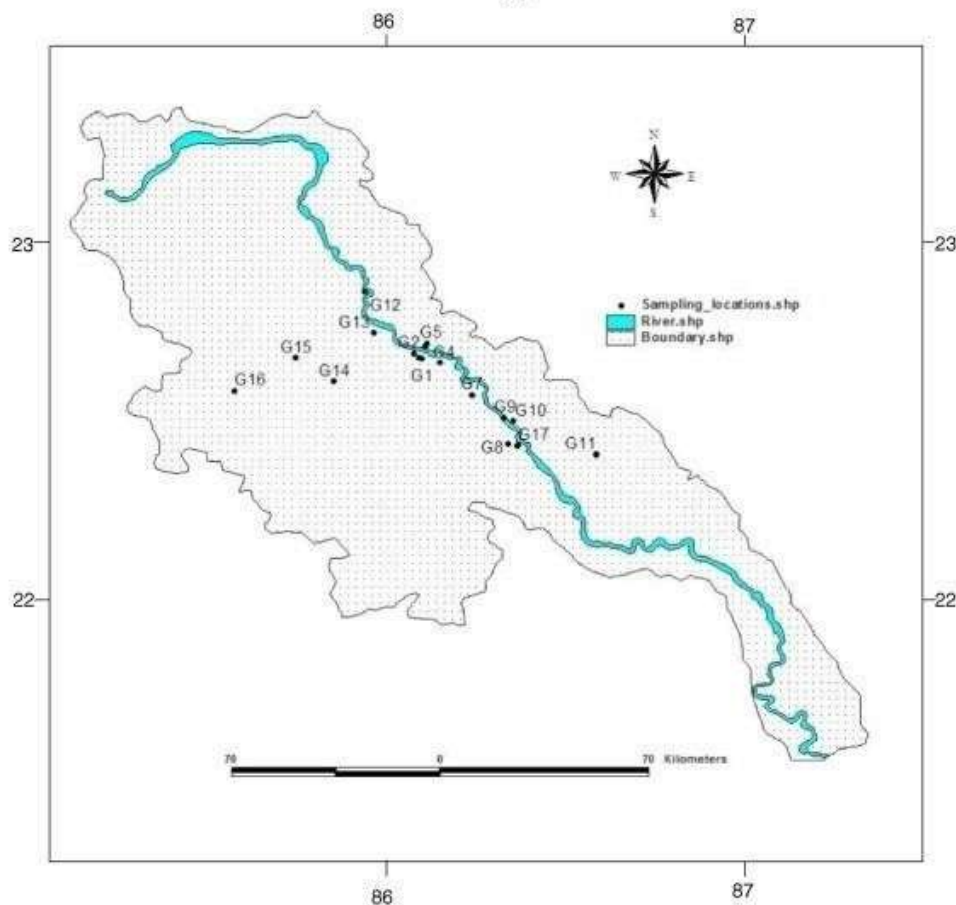
Water is an important component of our life and its availability is at the core of sustainable development of any region (Gebrechorkos, et al., 2020). The appropriate management of water resources is essential to ensure livelihood security to address poverty. Many regions are facing serious water resources shortage. Especially dwindling freshwater resources management challenges, the water resources managers and planners. Allocation of available water resources, keeping in view of the environmental concern, variability in climate and uncertainty need to be planned and implemented for sustainable water use strategies (Wang Meilin, et al., 2020). River Water quality monitoring is necessary especially when the water serves as drinking water sources and threatened by pollution resulting from various human activities along the river course (Wilson, M.F, et al., 2018). Land use/land cover change due to climate change, are responsible for degradation of any ecosystem in arid and semi-arid regions. Studying the ecological variations is particularly essential for any type of sustainable development, in which it considers as one of the chief inputs (Peter Lynch, et al., 2008). The main objective is to evaluate the impacts of Land use/Land cover and climatic changes on the using remote sensing and some statistical models around the Subarnarekha River. The impact of climate change on the Rainfall poses a major threat to water resource management in highly populated countries, such as India. The reliable projection of the future rainfall is very important to understand the changes in water balance components and to define water resource management policies (Stephan Hülsmann, et al., 2020).

The work also quantifies the relative impact of recent climate and Land use/Land Cover changes in the Subarnarekha River basin using climate and hydrological models (Robert Leconte, et al., 2011).





(a)



(b)

Map of India, highlight Jharkhand and Jamshedpar with Supernrekla River.

The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things. Climate is often defined as 'average weather' Climate change refers to a change in the state of the climate that can be

identified using statistical tests and that persists for an extended period, typically decades or longer climate change describes changes in the global temperature over time i.e., increase in global temperature or global warming (Henderson- Sellers, et al., 1985). One of the major causes of global warming is the emission of greenhouse gasses due to anthropogenic activities. According to Intergovernmental Panel on Climate Change (IPCC) 5th assessment report (IPCC, 2013), the increase in carbon dioxide concentration in the atmosphere follow the same pattern as the increase in global mean temperature, which is 1.4°C higher than in 1980. The consequences of global warming are reflected in global as well as the regional climate in terms of changes in key climatic variables such as precipitation and atmospheric moisture, snow cover, the extent of land and sea ice, sea level and patterns in atmospheric and ocean circulation. Therefore, the study of climate change is necessary to understand its impact on hydrological processes.

RIVIEW OF LITRATURE

Most of the researchers have reported work on climate change, Subarnarekha River and its hydrology (Anirban Dhar, et al., 2021). They have used climatological data for assessment but did not compare water quality parameters and its corelation with climate change. In this work the comparative studies for different seasons such as monsoon, pre-monsoon and post monsoon seasons are done. The water availability and the quality of water available should be adequate (Hengade Narendra, et al., 2016). Water resources assessment aims to measure quantity and quality of the water in a system, including data collection, data validation, and water accounting techniques, using both ground and remote sensing. Climate change will affect water resources through its impact on the quantity, variability, timing, form, and intensity of precipitation (Madhusudana Rao, et al., 2020). Assessment of hydrological response in Subarnarekha River basin under anticipated climate change scenario (Sudhindra N. Panda, et al., 2021). Two hydrological climate modelling techniques, general circulation model (GCM) and hypothetical climate change scenarios, were used to analyse the hydrological response to the anticipated climate change scenarios in the Subarnarekha River basin in Eastern India. The duration for study was considered for 14 years from 2000-2013. The impact of climate change at global and regional scale and can be used for assessing future changes in streamflow of River basin.

It indicates any change in climate over time, whether due to natural variability or as a result of human activity. There are several causes of global warming including natural and anthropogenic causes. The natural causes include volcanic eruption, solar radiation variation, the rotation of the earth, El nino effect and the movement in tectonic plates (Wilson, M.F, et al., 2018). During the volcanic eruption volcanic aerosols are released into the troposphere and stratosphere. These aerosols contain carbon dioxide, Sulphur dioxide, ash, dust and some bacteria and they affect the insolation of the solar radiation.

Changes in the area water supply will be one of the future climate change's most significant socioeconomic effects. Nearly every area of human well-being will be impacted by these hydrologic changes, from energy consumption and agricultural productivity to flood control, municipal and industrial water supply, and fish and animal management (Christian Bernhofer, et al.,2020). A watershed for a tiny mountain creek might be as small as a few square meters. Some watersheds are enormous and usually encompass many smaller ones. Climate change has effects on precipitation and evapotranspiration (Hengade Narendra, et al., 2016). The effect on river

discharge by changes in precipitation, potential/actual evapotranspiration and temperature is an important factor in environmental (transport of nutrients, sediment, and habitats of flora and fauna), agricultural (drainage and flooding) and economic applications (e.g., water supply, flooding, engineering, and agro-economics). The hydrological impacts of climate change are very important and enable water resource managers to make robust decisions on future policy adaptations (Henderson-Sellers, et al., 1985).

Most papers have used climatological data for assessment but did not compare water quality parameters and its correlation with climate change. So, in this work we have included the comparative studies for different seasons such as monsoon, pre-monsoon, and post monsoon seasons. The research paper work did not include the future prediction on Rainfall patterns. The future prediction of rainfall for the study region is involved. This is necessary in order to plan out the water requirement of the city in future. The water availability and the quality of water available should be adequate. Work is done for soil erosion, not for water and climate change. There are two objectives of this research. They are to find out seasonal water quality parameters and thus find out WQI for all seasons. And the second objective is to find the NDWI to determine the area of land cover for the region of study.

2. METHODOLOGY

2.1 Water sampling and analysis

Twelve distinct locations were chosen for sample collection based on major milestones in the area like settlement of any industries around and settlement of people around. These eight points were selected on the approx. 50 kms stretch of Subarnarekha River. The samples were collected seasonally like monsoon (August-September), pre monsoon (March-April) and post monsoon (November-December) of 2024. The testing of water quality parameters was done as Acidity, Alkalinity, TDS (ppm), TSS, Hardness, DO, BOD, Chlorides, EC, Salinity, resistivity, pH (Garg, et al., 2016) temperature, COD,

2.2 Calculation of water quality indices (WQI)

The water quality index may be defined as the rating, reflecting the composite influence of different water quality parameters on the overall quality of water (Sandeep Kumar, et al., 2015). Water Quality Index calculation was done by using the values given by BIS (Bureau of Indian Standards) for water for different water quality parameters. The Weighted arithmetic mean method was used to determine the WQI (brown, et al., 1972). The parameters selected for finding out WQI were alkalinity, total dissolved solids, hardness, BOD, DO, chlorides, and ph. The formula used as per Brown's method is as follows, where w_i represents the unit weight of the parameter and Q_i represents the quality of parameter:

$$WQI = \sum_{i=1}^n w_i Q_i \dots \dots \dots \text{Equation 1}$$

The preparation of comparative maps of water quality were made as a representation of spatial distribution maps in ArcGIS and Google Earth Pro. Initially prepare google earth file containing all the locations with its labelling. This file will be imported in ArcMap. By using the values of nearby, well-known data points, a

technique called kriging is used to estimate the value of an unknown variable at a given place. The approach takes into consideration spatial autocorrelation, which states that data points close together have more similarity than those far away.

2.4 Calculation of Normalized Difference Water Index (NDWI)

NDWI refers to the Normalized Difference Water Index that highlights open water features as well as measure moisture content in a satellite image (Surya Singh, et al., 2020). It clearly differentiates between a water bodies and land, soil and vegetation. ArcGIS software was used for preparing the intensities of different water quality parameters. To fulfil objective of NDWI for pre monsoon and post monsoon was prepared to determine the coverage of water in the region of Ranchi District. NDWI can be computed using the combination of visible green and near infrared, where green refers to visible green and near NIR refers to near infrared. The values of NDWI ranges between - 1 to 1 (B. R. Nikam, et al., 2018). Values of Water bodies represents greater than 0.5, very low value corresponds to vegetation differentiating water bodies from vegetation or soil. The cloud coverage must be kept less than 10%. The raster calculator was used to calculate the NDWI using the formulae as given in Eq. 2.

$$NDWI = (Band\ 5 - Band\ 8) / (Band\ 5 + Band\ 8) \dots\dots\dots Eq. 2$$

The raster calculator uses 'float' and values of Band 5 and Band 8 for calculating the NDWI. The extraction of data of NDWI for Ranchi map was done using extraction of mask. And these values were calculated by classifying different colours, then the values were little adjusted by ground truthing. Reclassifying will help to get the attribute table from which the values of areas can be determined (Christian Bernhofer, et al., 2020). Then, the maps were generated in which the co-ordinates and other legend were added.

3. Results and Discussion

The data for different seasons such as pre-monsoon, monsoon, and post monsoon were produced by collecting samples and performing the tests in the laboratory. By comparing the maps, the chloride concentration has increased after the monsoon when the temperature drops in the climate (Wang Meilin, et al., 2020). Hard water is water that contains high levels of dissolved minerals, particularly calcium and magnesium. The hardness of water can have significant impacts on human health, the environment, and infrastructure (Surya Singh, et al., 2020) changes in temperature can affect the solubility of minerals in water. Higher temperatures can increase the solubility of minerals, leading to higher levels of dissolved calcium and magnesium in water (Sandeep Kumar, et al., 2015). Changes in precipitation patterns can also affect water hardness. Drought conditions can lead to increased concentrations of minerals in surface water and groundwater due to reduced dilution. Conversely, heavy rainfall events can increase dilution and reduce water hardness. Also, it can be observed that the hardness in post monsoon have increased as the climate change affects the rainfall patterns (Arnab Bandyopadhyay, et al., 2020). Similarly, BOD is a measure of the amount of oxygen that is required to biologically degrade organic matter in water. Climate change can affect BOD levels in several ways. One way is through changes in temperature (Surya Singh, et al., 2020). As water temperatures increase, the rate of biological activity in water also increases. This can lead to an increase in organic matter decomposition, which in turn can

increase BOD levels. Changes in precipitation patterns can also affect BOD levels. Heavy rainfall events can lead to increased runoff, which can carry pollutants into waterways and increase BOD levels. Drought conditions, on the other hand, can reduce water flow and dilution, leading to increased BOD concentrations. Land use changes, such as deforestation or agricultural practices, can lead to increased nutrient runoff and sedimentation in waterways. This can increase the amount of organic matter in water, leading to increased BOD levels. The variation of BOD levels found both during the monsoon as well as post monsoon season (Inmaculada C., et al., 2021). Rainfall and flooding can lead to higher TDS concentrations in surface water due to increased runoff and erosion. Changes in temperature can also affect TDS levels. Higher temperatures can increase the rate of chemical reactions, leading to increased solubility of minerals and other substances in water. This leads to higher TDS concentrations. Another way in which climate change can affect TDS levels is through changes in land use. Land use changes, such as deforestation or agricultural practices, can lead to increased erosion and sedimentation in waterways. This increases the levels of minerals and other substances in water, leading to increased TDS concentrations (Garg, et al., 2016).

This states that during monsoon, the rainwater carries pollutants like sediments, nutrients, pesticides and fertilizers from agriculture, industrial areas, and other sources like rivers, lakes. The increase in concentration of these pollutants can cause a decrease in the dissolved oxygen levels, pH and increased turbidity, BOD, and total suspended solids (brown, et al., 1972).

By calculating the values for different water quality parameters, the above data was obtained. It could be observed that acidity was less in the monsoon season as compared with the post monsoon season. At few locations hardness value was zero. The values of dissolved oxygen were more in the monsoon season.

The WQI is describing that the index for pre-monsoon and monsoon is between the range of 26-50 which marks its good quality (B. R. Nikam, et al., 2018). Whereas, the index for post. monsoon season is between the range of 76-100 making the water to fall under the very poor quality of water.

4. Conclusion

Water quality is significantly being impacted by climate change on a global scale. Some of the ways that climate change is altering water quality are that, increasing water temperature. Water temperatures are rising together with the world temperature. Warmer water can lead to algal blooms, which can produce toxic substances that can contaminate sources of drinking water. Precipitation patterns are changing due to climate change, with some areas seeing more frequent and heavy rainfall events while others are dealing with longer-lasting droughts. These variations in precipitation patterns have the potential to cause erosion, more frequent and severe flooding, and an increase in the sediment and nutrient loads that affect the water quality of rivers, lakes, and other bodies of water. The work shows that different water quality parameters can be related with the change in climate as the data acquired in monsoon and post monsoon period are varying significantly. This shows that change in temperature affects the WQI (Water Quality Index).

Overall, the relationship between climate change and water quality parameters is complex and multifaceted. While it is difficult to predict exactly how climate change will affect quality levels in specific regions, changes

in temperature, precipitation patterns, and land use will have significant impacts on water quality and human health. It is important to continue monitoring of water quality and to take steps to mitigate the impacts of climate change on water resources. This may include implementing best management practices to reduce erosion and sedimentation, and developing adaptive management strategies to address changing conditions. Climate change is causing an increase in global temperatures, which is having significant impacts on the environment, human health, and ecosystems. Higher temperatures can disrupt ecosystems by altering the timing of seasonal events, such as flowering and migration. They can also lead to changes in the distribution and abundance of species, and increase the risk of extinction for some species. Climate change is affecting the temperature of water is through increased air temperatures. Higher air temperatures can cause an increase in water temperatures, particularly in shallow water bodies such as lakes, rivers, and streams. This can have a range of impacts on aquatic ecosystems, including changes in the distribution and abundance of fish and other aquatic organisms.

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References

1. Abd El-Hamid, Hazem T., Wei Caiyong, Mohammed A. Hafiz, and Elhadi K. Mustafa. "Effects of land use/land cover and climatic change on the ecosystem of North Ningxia, China." *Arab J Geosci* 13 (2020): 1099.
2. Boyer, Claudine, Diane Chaumont, Isabelle Chartier, and André G. Roy. "Impact of climate change on the hydrology of St. Lawrence tributaries." *Journal of hydrology* 384, no. 1-2 (2010): 65-83.
3. Chen, Jie, François P. Brissette, and Robert Leconte. "Uncertainty of downscaling method in quantifying the impact of climate change on hydrology." *Journal of hydrology* 401, no. 3-4 (2011): 190-202.
4. Climate change impact assessment on the hydrology of a large river basin in Ethiopia using a local-scale climate modelling approach.
5. Evans, Michael N., Susan E. Tolwinski-Ward, Diane M. Thompson, and Kevin J. Anchukaitis. "Applications of proxy system modeling in high resolution paleoclimatology." *Quaternary science reviews* 76 (2013): 16-28.
6. Frank, David, Jan Esper, Eduardo Zorita, and Rob Wilson. "A noodle, hockey stick, and spaghetti plate a perspective on high-resolution paleoclimatology." *Wiley Interdisciplinary Reviews: Climate Change* 1, no. 4 (2010): 507-516.
7. Garg, V., I. R. Dhumal, B. R. Nikam, P. K. Thakur, S. P. Aggarwal, S. K. Srivastav, and A. Senthil Kumar. "Water resources assessment of Godavari River basin, India." In *Proceedings of ACRS*, vol. 2016, p. 37th. 2016.

8. Gaur, Srishti, Ateeksha Mittal, Arnab Bandyopadhyay, Ian Holman, and Rajendra Singh. "Spatio-temporal analysis of land use and land cover change: a systematic model inter-comparison driven by integrated modelling techniques." *International Journal of Remote Sensing* 41, no. 23 (2020): 9229- 9255.
9. Gautam, Sandeep Kumar, Chinmaya Maharana, Divya Sharma, Abhay K. Singh, Jayant K. Tripathi, and Sudhir Kumar Singh. "Evaluation of groundwater quality in the Chotanagpur plateau region of the Subarnarekha River basin, Jharkhand State, India." *Sustainability of Water Quality and Ecology* 6 (2015): 57-74.
10. Gebrechorkos, Solomon H., Christian Bernhofer, and Stephan Hülsmann. "Climate change impact assessment on the hydrology of a large river basin in Ethiopia using a local-scale climate modelling approach." *Science of The Total Environment* 742 (2020): 140504.
11. Giri, Soma, and Abhay Kumar Singh. "Assessment of surface water quality using heavy metal pollution index in Subarnarekha River, India." *Water Quality, Exposure and Health* 5, no. 4 (2014): 173- 182.
12. Hattermann, Fred Fokko, Shaochun Huang, and Hagen Koch. "Climate change impacts on hydrology and water resources." (2015).
13. Hengade, Narendra, and T. I. Eldho. "Assessment of LULC and climate change on the hydrology of Ashti Catchment, India using VIC model." *Journal of Earth System Science* 125, no. 8 (2016): 1623- 1634.
14. Jain, C. K., and Surya Singh. "Impact of climate change on the hydrological dynamics of River Ganga, India." *Journal of Water and Climate change* 11, no. 1 (2020): 274- 290.
15. Jiménez-Navarro, Inmaculada C., Patricia Jimeno-Sáez, Adrián López-Ballesteros, Julio Pérez-Sánchez, and Javier Senent-Aparicio. "Impact of Climate Change on the Hydrology of the Forested Watershed That Drains to Lake Erken in Sweden: An Analysis Using SWAT+ and CMIP6 Scenarios." *Forests* 12, no. 12 (2021): 1803.
16. Lane, Rosanna A., and Alison L. Kay. "Climate change impact on the magnitude and timing of hydrological extremes across Great Britain." *Frontiers in Water* (2021): 71.
17. Liang, Xu, Dennis P. Lettenmaier, Eric F. Wood, and Stephen J. Burges. "A simple hydrologically based model of land surface water and energy fluxes for general circulation models." *Journal of Geophysical Research: Atmospheres* 99, no. D7 (1994): 14415-14428.
18. Madhusudana Rao, C., A. Bardhan, and J. P. Patra. "Assessment of hydrological response in Subarnarekha River basin under anticipated climate change scenarios." *Global NEST J* 22, no. 2 (2020): 207-219.
19. Madhusudana Rao, C., and A. Bardhan. "Uncertainties and nonstationarity in streamflow projections under climate change scenarios and the ensuing adaptation strategies in Subarnarekha River basin, India." (2020).
20. Mahmood, Rezaul, Roger A. Pielke Sr, Kenneth G. Hubbard, Dev Niyogi, Gordon Bonan, Peter Lawrence, Richard McNider et al. "Impacts of land use/land cover change on climate and future research priorities." *Bulletin of the American Meteorological Society* 91, no. 1 (2010): 37-46.
21. Mandal, Uday, Dipaka R. Sena, Anirban Dhar, Sudhindra N. Panda, Partha P. Adhikary, and Prasanta K. Mishra. "Assessment of climate change and its impact on

hydrological regimes and biomass yield of a tropical river basin." *Ecological Indicators* 126 (2021): 107646.

22. Miller, James D., Walter W. Immerzeel, and Gwyn Rees. "Climate change impacts on glacier hydrology and river discharge in the Hindu Kush-Himalayas." *Mountain Research and Development* 32, no. 4 (2012): 461-467.
23. Saha, Priti, and Biswajit Paul. "Assessment of heavy metal pollution in water resources and their impacts: A review." *J. Basic Appl. Eng. Res* 3 (2016): 671-675.
24. Steele-Dunne, Susan, Peter Lynch, Ray McGrath, Tido Semmler, Shiyu Wang, Jenny Hanafin, and Pau Nolan. "The impacts of climate change on hydrology in Ireland." *Journal of hydrology* 356, no. 1-2 (2008): 28-45.
25. Tarekegn, Negusu, Brook Abate, Alemayehu Muluneh, and Yihun Dile. "Modeling the impact of climate change on the hydrology of Andasa watershed." *Modeling Earth Systems and Environment* 8, no. 1 (2022): 103-119.
26. Thapa, Pawan. "The Relationship between Land Use and Climate Change: A Case Study of Nepal." In *The Nature, Causes, Effects and Mitigation of Climate Change on the Environment*. IntechOpen, 2021.
27. Wang, Meilin, Yaqi Shao, Qun'ou Jiang, Ling Xiao, Haiming Yan, Xiaowei Gao, Lijun Wang, and Peibin Liu. "Impacts of climate change and human activity on the runoff changes in the Guishui River Basin." *Land* 9, no. 9 (2020): 291.
28. Willems, Patrick, Jan Staes, and Patrick Meire. "Impact of climate change on river hydrology and ecology: case study for interdisciplinary policy-oriented research." In *CD-Rom proceedings 2nd International Interdisciplinary Conference on Predictions for Hydrology, Ecology, and Water Resources Management: Changes and Hazards caused by Direct Human Interventions and Climate Change*, pp. 1-13. Charles University; Prague, 2010.
29. Wilson, M. F., and A. Henderson-Sellers. "A global archive of land cover and soils data for use in general circulation climate models." *Journal of Climatology* 5, no. 2 (1985): 119-143.

