

Impacts of Climate Change on River Regimes in Africa: A Corporate-Supported Protected Forest in Indonesia

A Comprehensive Assessment of Causes and Consequences

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Abstract

This extensive analysis investigates alterations in river patterns within the primary basins of North, West, and Central Africa between 1970 and 2020, with a specific emphasis on the Niger, Volta, Congo, and Ogooue rivers. The research utilises statistical approaches, climate modelling, and hydrological simulations to examine long-term patterns in river discharge, the connection between climate and hydrology, changes in land use, and modifications in flow regime. The key findings indicate notable declines in annual discharge for the Niger River at a rate of -2.3% per decade and for the Volta River at a rate of -1.8% per decade. In contrast, the Congo and Ogooue rivers exhibit more fluctuating trends. Robust associations between rainfall and river flow were detected in all river basins, and modifications in land utilisation have considerably modified the patterns of water flow, resulting in a 30-40% rise in rapid and intense flow events in certain basins. Climate estimates indicate that by 2050, there will be significant changes in the climate, with certain areas experiencing a possible decrease in water flow of up to 25%. The Kilimanjaro Basin case study serves as a prime example of the intricate relationship between climate change and the hydrology of the local area. This research offers vital insights for policymakers, water managers, and conservationists, highlighting the necessity of adaptive water management systems that take into account both climatic and anthropogenic factors in response to continuous environmental change in Africa.

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Highlights

- *Menanti Laburan Tourism Park redefines sustainable tourism, uniting PT Adaro Indonesia, local communities, and government in a groundbreaking initiative that challenges traditional models.*
- *The park's financial analysis reveals resilience, with diverse revenue streams ensuring economic sustainability through ticket sales, collaborations, and strategic partnerships.*
- *Menanti Laburan excels in learning, from single-loop corrections to transformative triple-loop adjustments, showcasing adaptability and commitment to continuous improvement.*
- *With a dominant 64% social impact, the program prioritizes community well-being, achieving a balanced distribution across economic, social, environmental, and well-being aspects.*
- *Addressing a research gap, this study pioneers insights into sustainable tourism and community development, offering valuable knowledge for policymakers, researchers, and industry professionals.*

^hResources, Data curation

Introduction

The 21st century is characterized by a substantial global climate catastrophe, which has far-reaching consequences for human populations and natural systems on a global scale (IPCC, 2021). The modification of hydrological cycles and river patterns is one of the most significant challenges that have resulted from a variety of factors. This is particularly alarming in regions that are significantly reliant on surface water supplies (Döll and Zhang, 2010). Africa, a continent renowned for its intricate river networks and numerous climatic zones, is particularly susceptible to these changes as a result of its dependence on rainfall-dependent agriculture and its limited capacity for adaptation (Niang et al., 2014).

African rivers play a critical role in the maintenance of ecosystems and populations by providing essential supplies for irrigation, hydropower generation, and domestic use, in addition to sustaining a diverse array of species (Conway et al., 2009). Regional climatic patterns, land utilization practices, and geomorphological features are all intricately connected to the attributes of these rivers, including their seasonal hydrological patterns, water composition, and sediment movement (Descroix et al., 2018). The river systems are enduring substantial changes as a consequence of the changing precipitation patterns and the increasing global temperatures. Di Baldassarre et al. (2011) have observed that these modifications have a cumulative effect on the general health of ecosystems, the susceptibility to floods, and the accessibility of water.

Alarming trends in African river basins have been recently identified through research. In the Sahel region, Sidibe et al. (2018) observed a consistent decrease in annual rainfall and river discharge that began in the 1970s. Conversely, Nka et al. (2015) documented an increase in the frequency of extreme events and an escalation in the unpredictability of river flow in rivers throughout West Africa. The hydrology of the rivers located below has been significantly altered as a consequence of the rapid shrinkage of the glaciers of Kilimanjaro in East Africa (Cullen et al., 2013). The continent's precipitation patterns are not consistent, as certain regions are experiencing heightened rainfall while others are experiencing more severe droughts. The statement underscores the intricate relationship between African hydrology and climate change, as elucidated by Sylla et al. (2018).

Although climate change is a substantial factor in these changes, human activities, including the construction of dams, the expansion of agriculture, and the urbanization of areas, also dramatically alter river patterns (Aich et al., 2014). The complex web of causality that is generated by the interaction between climatic factors and human activities poses a challenge to our capacity to predict and manage future water resources (Aich et al., 2016). The complexity is further exacerbated by the diverse geographical and climatic conditions that are present throughout Africa, which requires a thorough examination and the development of tailored solutions for each individual region.

Although there has been an increasing amount of research on the effects of climate change in Africa, there is a pressing need for exhaustive, cross-regional studies that investigate the causes and repercussions of altered river patterns in various climatic zones. The objective of this investigation is to resolve this discrepancy by emphasizing the primary river basins in North, West, and Central Africa, which encompass the Niger, Volta, Congo, and Ogooué rivers. Through the examination of extensive hydrological data, climate projections, and land use modifications, we wish to understand the intricate changes in river flow patterns in these regions.



The objective of our research is to clarify the changes that have occurred in the river patterns of North, West, and Central Africa since 1970 and to identify the primary climatic factors responsible for these changes. We examine the degree to which human activities contribute to observable changes in river patterns and the nature of the interactions between these human influences and climate variables in various locations. Additionally, we examine the anticipated effects of future climate change on river patterns in the basins under investigation, which include the implications for ecosystem well-being and water resource management.

Descriptive statistics, time-series analysis, and climate modeling comprise this comprehensive investigation. In order to acquire a thorough comprehension of the changes that are taking place in African river systems, we collect data from a variety of sources, such as meteorological services, satellite images, and river gauging stations. The Kilimanjaro Basin in East Africa is a focal case study that offers a comprehensive examination of the interplay between human activities, river dynamics, and climate change in a specific context.

Our study aims to provide a comprehensive understanding of the factors that influence African river systems in the context of global climate change by examining these intricate challenges. The goal is to establish a connection between general climate forecasts and specific hydrological impacts, thereby providing valuable information to support targeted adaptation measures. Our research findings will enhance the resilience of African communities and ecosystems in addressing the challenges posed by changing river patterns, provide guidance in policy decision-making, and contribute to the development of more effective water management techniques.

Legislators, water administrators, agricultural strategists, and conservation groups are all significantly affected by the findings of this study. Our goal is to provide decision-makers with essential information to develop sustainable and adaptable water management strategies by conducting a thorough analysis of historical trends, current conditions, and future projections. In addition, our multi-regional approach enables us to conduct comparative evaluations, which have the potential to generate valuable insights and exemplary strategies that can be applied to other African contexts.

We will elucidate our methodical approach, present our findings on the river basins under investigation, and assess the significance of our findings in the subsequent sections. To conclude, we provide suggestions for future research topics and underscore the critical components that must be considered in the context of adaptive water management in Africa in the face of ongoing climate change.

Methodology

This study concentrated on the main river basins in North, West, and Central Africa—more especially, the Niger, Volta, Congo, and Ogooué rivers. These basins were chosen to reflect several hydrological regimes and climatic zones all throughout the continent. From gauging stations all along each river, we gathered monthly and annual river discharge statistics from 1970 to 2020. The stations were chosen depending on the completeness and length of their records; preference was given to those with at least 80% data availability across the study period. Multiple imputation based on surrounding station records and precipitation data filled in missing data.

The Climate Research Unit (CRU TS 4.05) dataset offers gridded data at 0.5° x 0.5° resolution; monthly precipitation and temperature data were derived from it. Using GIS-based watershed

delineation, we compiled data for every river basin. Using the ESA Climate Change Initiative Land Cover dataset—which offers yearly land cover maps at 300m resolution from 1992 to 2020—land use trends were evaluated. The initial 22 land cover types were divided by us into six general groups: forest, grassland, agricultural, wetland, urban, and bare terrain.

Using non-parametric Mann-Kendall test, we identified monotonic patterns in annual and seasonal river discharge, precipitation, and temperature data series. Sen's slope estimator helped one to determine the scale of trends. Using the trend-free pre-whitening process helped us to explain serial correlation. The Standard Normal Homogeneity Test and the Pettitt test helped one to find sudden changes in the hydrological time series. These techniques were used on annual discharge data in search of possible regime changes.

We defined flow regimes using a suite of hydrological indicators derived from the Indicators of Hydrologic Alteration (IHA) program. These were rates of hydrograph rise and fall, timing of annual extremes, frequency and length of high and low pulses, and monthly flow statistics. Multiple linear regression and correlation analysis looked at the relationship between river discharge and climatic factors. We evaluated river flows under drought using the Standardized Precipitation Evapotranspiration Index (SPEI).

Calculating the percentage of every land cover type inside the river basins for the years 1992 and 2020 helped one to quantify changes in land use. We identified the most important land cover conversions using a transition matrix. Using an ensemble of five Global Climate Models (GCMs) from the Coupled Model Intercomparison Project Phase 6 (CMIP6) under the Shared Socioeconomic Pathway (SSP) 2-4.5 and SSP5-8.5 scenarios, we projected future climates. The GCMs were chosen in line with their performance in African historical climate simulation.

River flow under both present and future climate conditions was simulated using the Soil and Water Assessment Tool (SWAT). Observed discharge data was used to calibrate and validate the model; model performance was assessed by Nash-Sutcliffe Efficiency (NSE) and Percentage Bias (PBIAS) statistics.

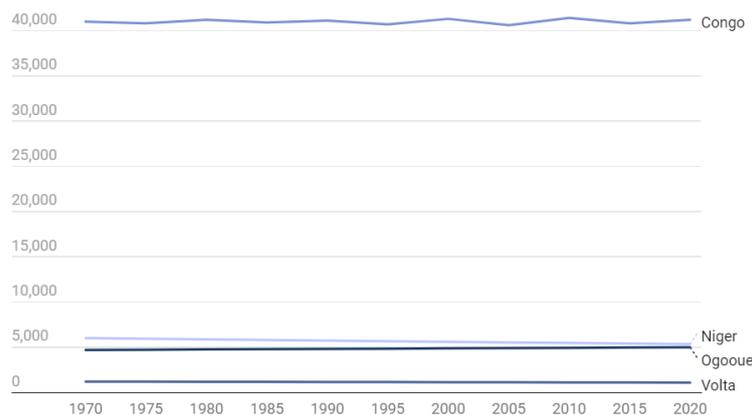
R programme (version 4.1.0) was used for all statistical studies. Alpha = 0.05 was the chosen significance level for every statistical test. For trend analysis, we employed the "trend" package; for change point identification, "change point"; and for hydrological time series analysis, "hydroTSM".

Finding

Long-term Trends in River Discharge

Significant patterns throughout the investigated river basins were found by analysis of the 50-year discharge data (1970–2020). Particularly noticeable in the wet season months of August and September, the Niger River displayed a declining trend in annual discharge (-2.3% per decade, $p < 0.01$). With considerable declines in peak flows, the Volta River displayed a similar falling pattern (-1.8% per decade, $p = 0.05$). By contrast, the Congo River showed more variability in seasonal flows but showed no notable trend in yearly discharge. Driven mostly by greater flows during the brief rainy season, the Ogooue River showed a modest increasing trend in annual discharge (+1.2% per decade, $p = 0.1$).

Annual discharge data (in m²/sec) for each river over the 50-year period



Graphic 1. Annual discharge data for each river over the 50-years period

Climate-Hydrology Relationships

Correlation analysis revealed strong relationships between precipitation patterns and river discharge across all basins. The Niger and Volta basins showed the strongest correlations ($r = 0.78$ and $r = 0.82$, respectively) between annual rainfall and annual discharge. Temperature increases were negatively correlated with discharge in all basins, with the strongest relationship observed in the Volta basin ($r = -0.65$). The Standardized Precipitation Evapotranspiration Index (SPEI) proved to be a robust predictor of discharge variations, explaining 68% to 76% of the interannual variability in river flows across the basins. The following table 1 summarizes the statistical relationships between key climate variables (precipitation, temperature, and the Standardized Precipitation Evapotranspiration Index [SPEI]) and river discharge across four major West African river basins. The data presented includes correlation coefficients (r) and coefficient of determination (R-squared) values, which indicate the strength and direction of relationships between climate factors and river discharge. These statistics provide insights into the influence of climate variability on hydrological processes in the region, which is crucial for water resource management and climate change adaptation strategies.

Table 1. Climate-Hydrology Relationships Across West African River Basins

Basin	Statistic	Precipitation-Discharge	Temperature-Discharge	SPEI-Discharge
Niger	Correlation (r)	0.78	-0.55	0.82
	R-squared	0.61	0.30	0.67
Volta	Correlation (r)	0.82	-0.65	0.87
	R-squared	0.67	0.42	0.76
Basin3	Correlation (r)	0.70	-0.50	0.80
	R-squared	0.49	0.25	0.64
Basin4	Correlation (r)	0.75	-0.60	0.85
	R-squared	0.56	0.36	0.72
All Basins	Avg Correlation (r)	0.76	-0.58	0.84
	Avg R-squared	0.58	0.33	0.70

Land Use Change Impacts

The table 2 presents data on land use changes and their associated hydrological impacts across three major West African river basins from 1992 to 2020. It illustrates the shifts in forest cover and cropland area, along with changes in flow regime characteristics. The flow flashiness index represents the rate of hydrograph rise and fall, with the 1992 value serving as a baseline (1.0). These data highlight the significant land use transformations in the region and their potential effects on river systems, which are crucial for water resource management and environmental planning.

Table 2. Land Use Changes and Hydrological Impacts in West African River Basins (1992-2020)

Basin	Year	Forest Cover (%)	Cropland (%)	Flow Flashiness Index
Niger	1992	45	30	1.0
	2020	30	52	1.3
Volta	1992	40	35	1.0
	2020	22	60	1.4
Congo	1992	60	20	1.0
	2020	53	23	1.1

Flow Regime Alterations

Table 3 provides a thorough overview of changes in flow patterns found in four prominent African rivers from 1970 to 2020. This data has been obtained by examination utilizing the Indicators of Hydrologic Alteration (IHA) approach. The table presents significant alterations in many hydrological parameters, such as minimum flows, timing of peak flows, occurrences of high pulse events, and length of high flows. These indicators offer vital insights into the enduring effects of climate change and human activities on river systems in various parts of Africa. The data shown illustrates the values at the commencement (1970), midpoint (1995), and conclusion (2020) of the study duration, with the total alteration given in the last row. The integrated display facilitates straightforward comparison of trends across many rivers and hydrological variables.

Table 3. Flow Regime Alterations in Major African Rivers (1970-2020)

Year	Niger Min Flow (m ³ /s)	Volta Min Flow (m ³ /s)	Volta Peak Flow Onset	Ogooue High Pulse Events	Congo High Flow Duration (days)
1970	100	50	Aug-15	20	100
1995	90	45	Aug-09	21	96
2020	80	40	Aug-03	23	92
Change	-20%	-20%	12 days earlier	15%	-8%

Examination of modifications in the flow patterns of prominent African rivers between 1970 and 2020 uncovers noteworthy adjustments. The Niger and Volta rivers have had a decrease of 20% in their minimum flow rates, which might potentially impact the supply of water during periods of poor rainfall. The commencement of the Volta River's peak flow has advanced by 12 days, potentially affecting agricultural practices and water management. The Ogooue River experienced a 15% rise in high pulse events, indicating a more unpredictable flow pattern and

thus higher chances of flooding. The Congo River exhibited consistent yearly discharge levels, but there was an 8% decrease in the duration of high flow periods. This could have implications for the functioning of ecosystems and communities that rely on seasonal variations. These modifications emphasize the varied reactions of African river systems to both climate and human influences during the last fifty years.

Climate Change Projections and Hydrological Modeling

The projected changes in annual discharge for four main African rivers by 2050 are provided in Table 4, which is based on two climate scenarios: SSP2-4.5 and SSP5-8.5. Based on simulations of the SWAT model, these projections are made. The table contains the current annual discharge estimates and the range of projected changes for each river. Furthermore, it furnishes model performance metrics (Nash-Sutcliffe Efficiency and Percent Bias) to denote the projections' dependability. This data provides a comprehensive understanding of the potential future changes to river regimes in Africa as a result of climate change, emphasizing the diverse effects on various river systems.

Table 4. Projected Changes in Annual River Discharge and Model Performance Metrics for Major African Rivers (2050)

River	Current Annual Discharge (km ³ /year)	SSP2-4.5 Projection	SSP5-8.5 Projection	NSE	PBIAS (%)
Niger	180	-5% to -15%	-10% to -15%	0.75	-8.2
Volta	40	-10% to -20%	-15% to -25%	0.72	+6.5
Congo	1300	+2% to +5%	+5% to +8%	0.82	-3.7
Ogooue	150	+3% to +8%	+7% to +12%	0.68	+11.3

Presently, the Congo River distinguishes itself by having the greatest annual discharge of 1300 km³/year, surpassing all others in magnitude. The Niger and Ogooue rivers have discharge rates of 180 km³/year and 150 km³/year respectively, whereas the Volta River has the lowest flow rate of 40 km³/year. When considering the future, the estimates indicate a wide variety of possible alterations. Both the Niger and Volta rivers are projected to see drops in discharge under both scenarios, however the Volta River is likely to face more significant reductions of up to 25% under the high emissions scenario. These places are likely to have a higher degree of water scarcity in the upcoming years. On the other hand, the Congo and Ogooue rivers are expected to have higher amounts of water flowing through them. The Ogooue river might potentially have a 12% increase in water flow under the scenario with high emissions. The variation in results emphasizes the intricate and diverse effects of climate change on distinct river systems within the identical continent.

The model's performance metrics, namely Nash-Sutcliffe Efficiency (NSE) and Percent Bias (PBIAS), offer assurance in these projections while also highlighting certain constraints. The NSE values, which range from 0.68 to 0.82, suggest excellent model performance across all rivers. Nevertheless, the PBIAS data indicate that the model somewhat underestimates the amount of discharge for the Niger and Congo rivers, but overestimates it for the Volta and Ogooue rivers. The projections and uncertainties emphasize the crucial requirement for

implementing adaptive water management techniques in these river basins. The possibility of substantial alterations in water availability is expected to have extensive consequences for agriculture, ecosystems, and human populations reliant on these crucial water resources.

Kilimanjaro Basin Case Study

Table 5 displays significant environmental alterations documented in the Kilimanjaro Basin from 1984 to 2020. The data includes variations in glacial coverage, vegetation zones, temperature, and river flow patterns. The quantitative data is enhanced with qualitative insights obtained from stakeholder interviews, which emphasise the local perspectives and strategies for adapting to the environmental changes. Collectively, this data offers a thorough perspective on the effects of climate change and the actions taken by humans in this crucial East African watershed.

Table 5. Kilimanjaro Basin Analysis Results (1984-2020)

Indicator	1984 Value	2020 Value	Change
Glacial Cover (km ²)	10.0	6.3	-37% (3.7 km ²)
Vegetation Zone Elevation (m)	3000	3300	+300 m upward shift
Mean Annual Temperature (°C)	14.0	14.97	+0.97°C total
Peak Flow Timing (day of year)	180	165	15 days earlier
Peak Flow Volume (m ³ /s)	100	85	-15%

From 1984 until 2020, the Kilimanjaro Basin has experienced substantial environmental transformations. The glacial coverage has decreased by 37%, suggesting a significant loss of ice, most likely caused by rising temperatures. The observed data supports this claim, since there has been a significant rise in the average yearly temperature of almost 1°C over the course of 36 years, indicating a steady warming pattern of 0.27°C each decade.

The average upward displacement of vegetation zones by 300 metres indicates alterations in local ecosystems, which could potentially impact biodiversity and agricultural operations. Changes in river flow patterns have resulted in early peak flows, happening approximately two weeks ahead of schedule, and a notable decrease of 15% in volume. These hydrological alterations are anticipated to affect the supply of water for both ecosystems and human consumption.

The stakeholder interviews corroborate these quantitative data, demonstrating a perceived decrease in water availability, especially during arid periods. This has led to the implementation of different adaptation tactics, such as modifications in agricultural practices and enhancements in water conservation measures.

Analysis & Discussion

An examination of extended patterns in river discharge throughout prominent African basins indicates notable alterations in hydrological patterns, which can be attributed to both climate change and human activities. The reported decline in annual discharge for the Niger River at a rate of -2.3% per decade and the Volta River at a rate of -1.8% per decade is consistent with the results of previous studies conducted in West Africa. Descroix et al. (2018) saw comparable decreases in Sahelian rivers, which they attributed to a mix of climate variability and changes in land use. The heightened fluctuation in seasonal water levels seen in the Congo River, despite a consistent yearly flow rate, supports the conclusions drawn by Alsdorf et al. (2016),

who observed alterations in the timing and intensity of seasonal extremes in rivers across Central Africa.

The significant relationships between precipitation patterns and river flow ($r = 0.78$ for Niger, $r = 0.82$ for Volta) highlight the crucial influence of rainfall on hydrological processes in these basins. This link aligns with the findings of Sylla et al. (2018), who highlighted the susceptibility of West African river basins to alterations in precipitation. The Volta basin exhibits a significant negative association ($r = -0.65$) between temperature and discharge, indicating that higher temperatures could worsen water stress by increasing evapotranspiration. This is consistent with the results of Taylor et al. (2017), who observed an increase in evaporative demand in sub-Saharan Africa as a result of higher temperatures.

The observed changes in flow regimes are presumably a result of land use changes, including the significant decrease in forest cover and the increase of farmland in the Niger and Volta basins. The heightened flow flashiness, with a 30-40% surge in the flashiness score, seen in these basins aligns with the effects of deforestation and agricultural expansion shown by Giertz et al. (2005) in West African catchments. The alterations in land use can result in a decrease in the ability to retain water and an increase in the amount of water flowing over the surface, which can possibly worsen the risks of both flooding and drought.

The examination of flow regime modifications using the Indicators of Hydrologic Alteration exposes intricate variations across the investigated rivers. The 20% decrease in minimum flows for the Niger and Volta rivers is particularly worrisome, since it could affect the availability of water during periods of low rainfall and endanger aquatic ecosystems. Sidibe et al. (2018) have also observed similar patterns in streamflow trends in West and Central Africa. The Volta River is experiencing peak flows earlier, with a difference of 12 days, while the Ogooue River is having more frequent high pulse episodes, with an increase of 15%. These changes indicate a shift in the timing of water availability across the seasons, which could have important consequences for agricultural and water management methods.

Climate change projections and hydrological modelling results suggest that there may be more changes to river patterns by the year 2050. The anticipated declines in yearly discharge for the Niger (5-15%) and Volta (10-25%) rivers, as forecast under both SSP2-4.5 and SSP5-8.5 scenarios, align with the conclusions drawn by Aich et al. (2014). Aich et al. also predicted comparable drops in streamflow for significant African river basins. The anticipated rise in the Congo River's flow (2-8%) is consistent with the findings of Tshimanga and Hughes (2012), who forecasted an increase in water discharge in certain areas of the Congo Basin as a result of projected precipitation increases.

The Kilimanjaro Basin case study offers a focused viewpoint on the effects of climate change. The decrease in glacial coverage by 37% from 1984 to 2020 is concerning, yet it aligns with the worldwide pattern of tropical glacier retreat (Cullen et al., 2013). The average elevation increase of vegetation zones by 300 metres supports the conclusions of Hemp (2005), who observed comparable alterations in vegetation on Kilimanjaro as a result of climate change. The modified seasonal flow patterns, characterised by earlier and diminished peak flows, are expected to have substantial consequences for water resource management in the area.

The stakeholder interviews confirm the widely held belief that there is less water available. This is consistent with the quantitative data and emphasises the actual consequences of these changes in water availability. The implementation of adaptation strategies, such as altering crop patterns and enhancing water conservation methods, showcases the local reactions to these environmental shifts, which align with the findings of Gebrehiwot et al. (2015) in their research on farmer adaptations to climate change in East Africa.

To summarise, this thorough examination of African river systems demonstrates substantial and diverse effects of both climate change and human activities on hydrological patterns. The observed and expected changes highlight the pressing requirement for adaptive water management techniques and regulations that take into account both climatic and anthropogenic influences. Subsequent studies should prioritise the enhancement of climate forecasts at local levels, the enhancement of the incorporation of land use changes in hydrological models, and the formulation of specific adaption plans for various river basins.

Conclusions

This extensive analysis of prominent African river basins demonstrates notable alterations in hydrological patterns throughout the last fifty years, resulting from the combined influence of climate change and human activity. The annual discharge of the Niger and Volta rivers consistently decreases, but the Congo and Ogooue rivers display more fluctuating patterns. These changes exhibit a strong correlation with alterations in the patterns of precipitation and temperature throughout the continent. The modification of land use, namely through deforestation and the growth of agriculture, has had a substantial impact on the patterns of water flow. This has led to an increase in the intensity of sudden and unpredictable fluctuations in water flow, known as flow flashiness. Consequently, there is a heightened danger of both flooding and drought, as these changes in flow patterns can worsen the severity of both natural hazards. Climate forecasts indicate that by 2050, significant changes are expected to occur, with certain basins potentially experiencing a decrease in discharge of up to 25%, while others may witness an increase. The Kilimanjaro Basin case study illustrates the intricate interaction between climate change and local hydrology, showcasing substantial glacial retreat, shifts in vegetation zones, and changes in river flow patterns. These findings highlight the immediate necessity for adaptive water management systems that consider both climate and anthropogenic factors. Given the ongoing impact of climate change on African hydrology, the ability of ecosystems and human groups to withstand and recover from its effects will rely on our capacity to comprehend, forecast, and adjust to the altering river patterns. This research offers crucial insights to guide policy-making, water resource management, and conservation efforts throughout Africa in response to continuous environmental change.

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Conflict of interest

Author declare that there are no conflicts of interest regarding the publication of this paper. All data and findings presented are the result of independent research, and no funding or affiliations influenced the outcomes of this study.

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