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Research Article

Hydrological Streamflow Modelling Using the SWAT+ Model in the Chari-Logone Catchment, Lake Chad Basin

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Abstract

The Chari-Logone catchment, as a hydrologically active part of the Lake Chad basin, is under great pressure stemming from climate change, rapid growth of population, soil erosion, and flooding. Therefore, the development of modelling tools at desired scales for soil and land use, based on hydrology, topography, and weather is of great importance to meet the challenges facing the catchment. This study aimed to assess the performance and applicability of the Soil Water Assessment Tool (SWAT+) model for the prediction of streamflow of the Chari-Logone River. The application of the SWAT+ model to the Chari-Logone basin enables the assessment of how topography, land use and land cover (LULC), soil properties, and climatic conditions influence the hydrological processes of the Chari-Logone River. Results showed that the SWAT+ model performed well; there is good agreement between measured and simulated flows where during the calibration period, the model achieved NSE and R^2 values of 0.71 and 0.76, respectively, while validation period yielded values of 0.54 and 0.82, respectively. As first SWAT+ model for the Chari-Logone basin, it will help to investigate the effect of climate and land use and land cover changes on streamflows at the catchment scale.

Keywords

SWAT+, Hydrological Modelling, Chari-Logone Catchment, Lake Chad Basin

1. Introduction

The rational management of water resources is one of the major challenges of the millennium because water plays a fundamental role in ecological stability and socio-economic development. However, climate variability and rapid environmental change increasingly threaten their sustainability [6, 8, 32]. Climate-driven environmental changes introduce continuous hydrological shifts in watersheds [21], which influence catchment water balance and hydrological regimes [44]. Hydrological modelling tools help assess the effects of environmental and climate change on water resources [22, 29, 46]. Developing reliable hydrological models at the catchment scale, as well as at decadal, yearly, and seasonal timescales, will help to implement climate-adaptive strategies for sustainable water resources management [17, 35].

Worldwide, many modelling tools, including the Soil and Water Assessment Tool (SWAT), are used in hydrological streamflow simulation. The most popular and well-documented are Hydrologic Engineering Center's Hydrologic Modelling System (HEC-HMS) [40], topographic hydrologic model (TOPMODEL) [15], and MIKE SHE [28]. They are classified according to their mathematical formulations, parameterization approaches, and data-driven methodologies

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[23]. Among these models, the SWAT model is widely recognized and extensively applied in hydrological modelling to address a wide range of water-resource management challenges worldwide [5, 10, 14, 48, 50]. SWAT is a continuous-time simulation model developed to represent hydrological processes across different spatial scales. Initially introduced in 1993, the model has undergone several developments, resulting in updated versions with enhanced capabilities and additional modules, including the more recent SWAT+ framework. In Africa, the SWAT model is commonly used in several applications such as land use change, climate change, erosion, and water quality [26, 37, 41, 48]. Chaibo et al. [20] assessed the performance and predictive uncertainty of the SWAT model on the Bani River Basin, and their results are useful to make predictions in ungauged basins. SWAT model has been applied in the context of Lake Tana Basin in Ethiopia, and results showed that base flow is an important component of the total discharge within the study area [43]. Meless et al. [33] used the SWAT model to assess the sensitivity of the daily flow to changes in land use, and they deduced that a reduction in rainfall translates to a reduction in annual flow. The SWAT model is also used to assess the impact of potential future climatic changes and how they might affect water access and availability in the Dinder River Basin (DRB), Sudan [12]. Although several modelling studies using the SWAT model have been done in Africa, there are very few studies that have applied this tool at the Lake Chad basin scale, even fewer in the Chari-Logone catchment, which is part of the Lake Chad basin.

The Chari-Logone catchment is the hydrologically active part of the Lake Chad basin where the major challenge of water security, which includes issues with both quantity and quality, is not getting much attention. The catchment is currently under great pressure stemming from climate change, rapid growth of population, soil erosion, flooding, and pollutant transport [16, 25, 47, 52]. Therefore, assessing the potential effects of these anthropogenic activities on the Chari-Logone catchment ecosystem is of great importance to combat flooding, soil erosion, and over-exploitation of specific fish species. Developing modelling tools at desired scales on soil and land use, based on hydrology and topography, and weather is essential in this large catchment. Previously, there is no research that has been conducted to assess the impact of land use, climate change, and other anthropogenic activities on the streamflow of the Chari-Logone River using a physically based SWAT model. However, at a large scale, this model has been applied to the Lake Chad basin based on multiple satellite remote sensing data for calibration [13]. Furthermore, different calibration techniques were used by Nkiaka et al. [36] to calibrate the SWAT model at different locations along the Logone River channel.

In this study, we focus on hydrological model development for the prediction of streamflow of the Chari-Logone River using the SWAT+ model, which will contribute to better water resources management in the Chari-Logone catchment. This goal was achieved through the following specific objectives: (1) to compile datasets to set up the SWAT+ model in the Chari-Logone catchment conditions; (2) to calibrate and validate the model at the outlet of the catchment; (3) to assess its performance and uncertainty using different analysis methods.

2. Materials and Methods

2.1. Study Area

The Chari-Logone catchment is a sub-basin of the Lake Chad basin and covers an area of 613,000 km^2 (Figure 1b). Cameroon, Chad, and the Central African Republic share this transboundary catchment. The Chari-Logone catchment contributes approximately 90% of Lake Chad's water input [52]. The two main rivers in the Chari-Logone catchment are the Chari and Logone, and their confluence is located in N'Djamena. According to Cabot [18], the Logone River has an altitude ranging from 305 to 835 m, and its origin is in the Adamawa Plateau of Cameroon. The Chari River originates from the Central African Republic at an altitude of between 500 and 600 meters [18]. In the Chari-Logone catchment, there are flood-prone areas where income-generating economic activities such as fishing, breeding and agriculture develop around these zones. These rich ecosystems are recognized as Ramsar sites for their importance in ecology, zoology and botany [49]. The climate in the catchment studied is dominated by seasonal changes of two air masses, namely the Harmattan (the tropical continental air mass) and monsoon (the marine equatorial air mass) [19]. There are two distinct seasons: a wet season (May to October) and a dry season (November to April). Estimated annual rainfall (1984-2014) was 550 mm/year in the north (N'Djamena) and 970 mm/year in the south (Sarh) [3].

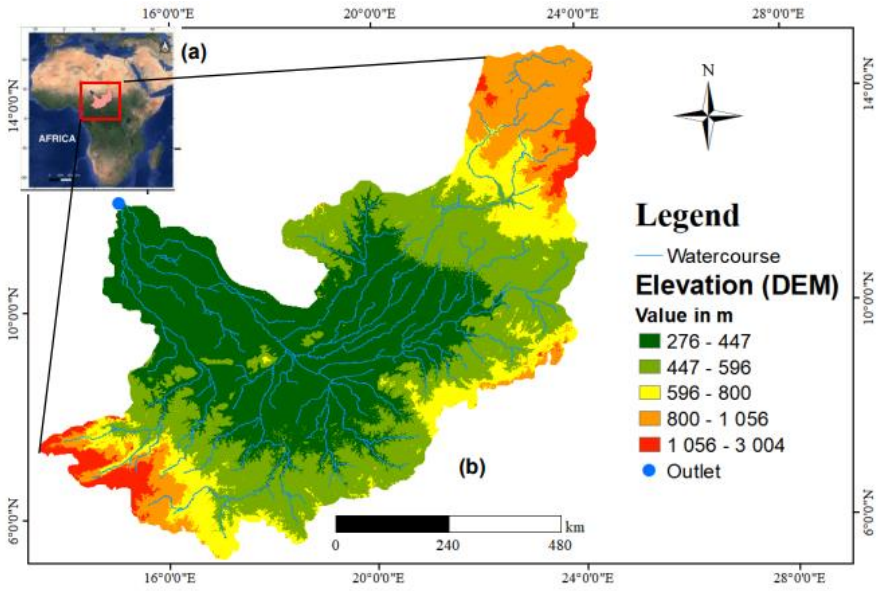


Figure 1. *(a) Africa map showing the Chari-Logone catchment [3], (b) Map of the Chari-Logone catchment, displaying river networks.*

2.2. SWAT+ Model Description

The SWAT+ model [9] is an enhanced version of the SWAT, originally developed by the Agricultural Research Service (ARS) of the United States Department of Agriculture (USDA). It is a physically based, semi-distributed hydrological model designed to simulate streamflow and pollutant transport under varying climatic conditions, land management practices, and environmental scenarios, including those associated with climate change. SWAT+ model uses the same basic algorithms as the SWAT model to compute hydrological processes, but the structure and organization of both the source code and the input files are considerably modified [45]. The latest version of SWAT, known as SWAT+, is integrated into the QGIS environment and provides greater flexibility than its predecessors in representing spatial interactions and hydrological processes within a watershed. It combines multiple geospatial datasets to characterize watershed features at the hydrologic response unit (HRU) level, while allowing users to explicitly define hydrological connections and interactions to achieve a more accurate representation of the watershed's physical characteristics [45]. The SWAT+ model simulates the hydrological cycle and associated processes using the following water balance equation.

$$SWt = SWo + \sum t(Rday,i - Qsurf,i - Ea,i - Wseep,i - Qgw,i) \quad (1)$$

In this equation, SWt is the final soil water content, SWo is the initial soil water content on day i, t is the time, Rday is the amount of precipitation on day i, Qsurf is the amount of surface runoff on day i, Ea is the amount of evapotranspiration on day i, Wseep is the amount of water entering the vadose zone from the soil profile on day i, and Qgw is the amount of return flow on day i. All units are considered in millimeters, and the time (t) is measured in days.

A detailed description of hydrological processes that govern the latest equation (1) is provided in the SWAT and SWAT+ documentation (https://swat.tamu.edu/docs/)

2.3. SWAT+ Input Data

Topographic Data

The Digital Elevation Model (DEM) data for the Chari-Logone catchment was downloaded from the Shuttle Radar Topography Mission (SRTM) website. The dataset downloaded has a spatial resolution of 90 by 90 m^2. The topographic data (DEM data) were used to delineate the watershed and define the slope length of the terrain. Furthermore, the drainage pattern characteristics such as channel slope, length, and width were derived from the DEM. Figure 2a and Figure 2b and shows the topography and slope variation of the Chari-Logone catchment, respectively.

Soil data

SWAT+ model requires soil properties such as soil texture, available water content, hydraulic conductivity, bulk density, and organic carbon content for different layers of each soil type in the catchment studied. In our study, soil data were obtained from the Food and Agriculture Organization (FAO) Harmonized World Soil Database (HWSD) at a spatial resolution of 1 km. Major soil types in the Chari-Logone catchment are Acrisols, Aenosols, Cambisols, Fluviosols, Ferrasols, Geysols, Leptosols, Luvisols, Lixiosols, Nitisols, Pianosols, Histosols, Regosols, Solonchaks, Technosols and vertisols (Figure 2c).

Land use and land cover (LULC) data

SWAT+ model requires LULC data for better prediction of

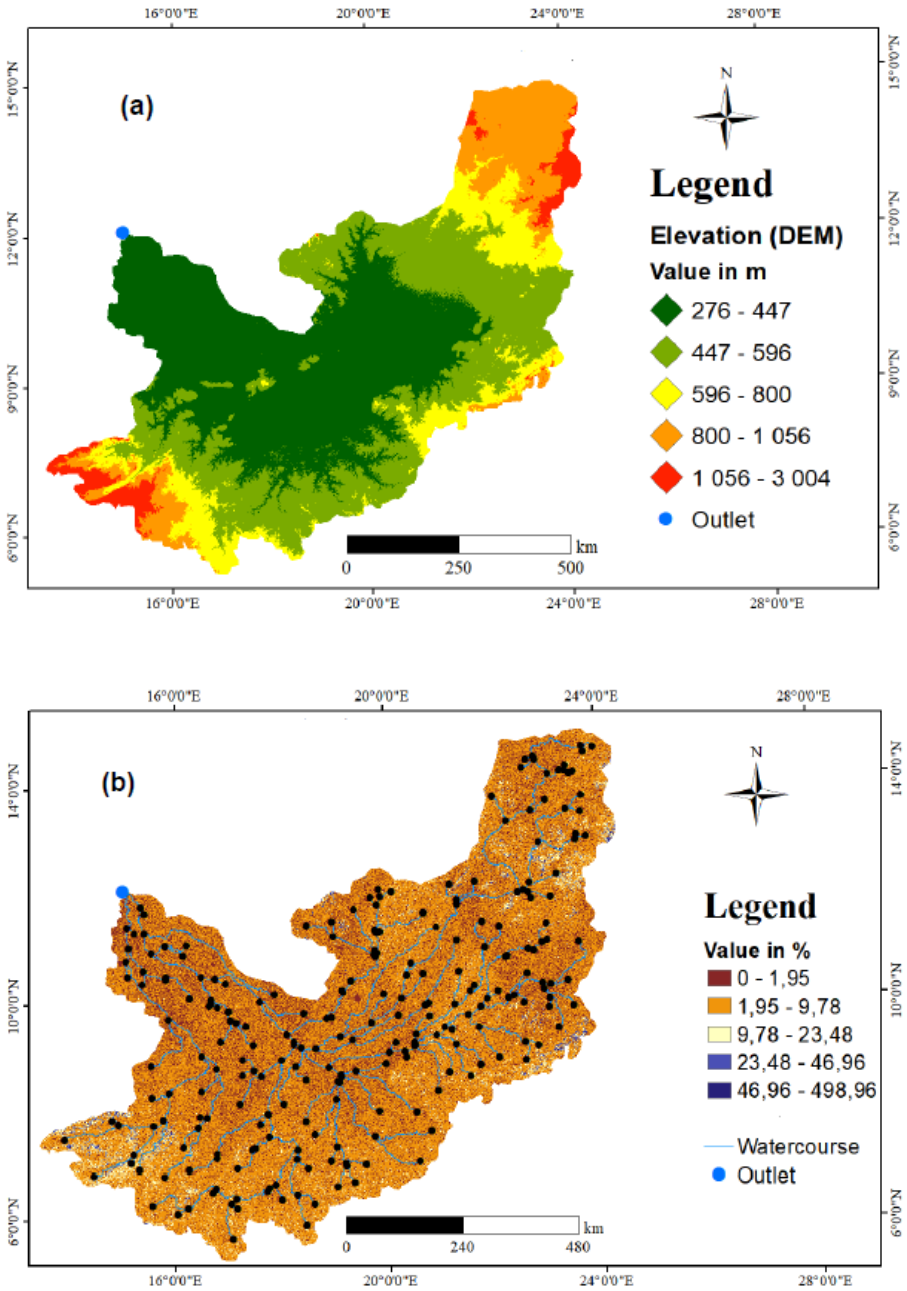
runoff, evapotranspiration, and surface erosion in a watershed. The LULC data of the Chari-Logone catchment were obtained from GlobCover of the European Space Agency at a spatial resolution of 300 m. The main LULC types of the catchment studied are (Figure 2d): Water, Mixed forest, Wetland, agricultural land, Urban area, Barren land, and Savannah.

Meteorological data

In this study, climatic variables such as maximum and minimum temperature, solar radiation, and relative humidity are used as input data for driving the hydrological modelling via SWAT+ for the period 1990-2023. These data are obtained from the National Meteorological Agency of Chad for stations located within and around the watershed. Due to data scarcity in the Chari-Logone catchment, Data provided by the National Meteorological Agency of Chad are supplemented by the CHIRPS (Climate Hazards Group InfraRed Precipitation with Station data) databases for poorly gauged areas, covering the period 1990-2023.

Streamflow data

Monthly streamflow data at the outlet of the Chari-Logone catchment (N'Djamena TP gauged station) were obtained from the Water Resources Department of the Ministry of Water Resources of Chad. These monthly streamflow data were used for model calibration and validation. These streamflow datasets are needed for evaluating the fidelity of the hydrological model developed.



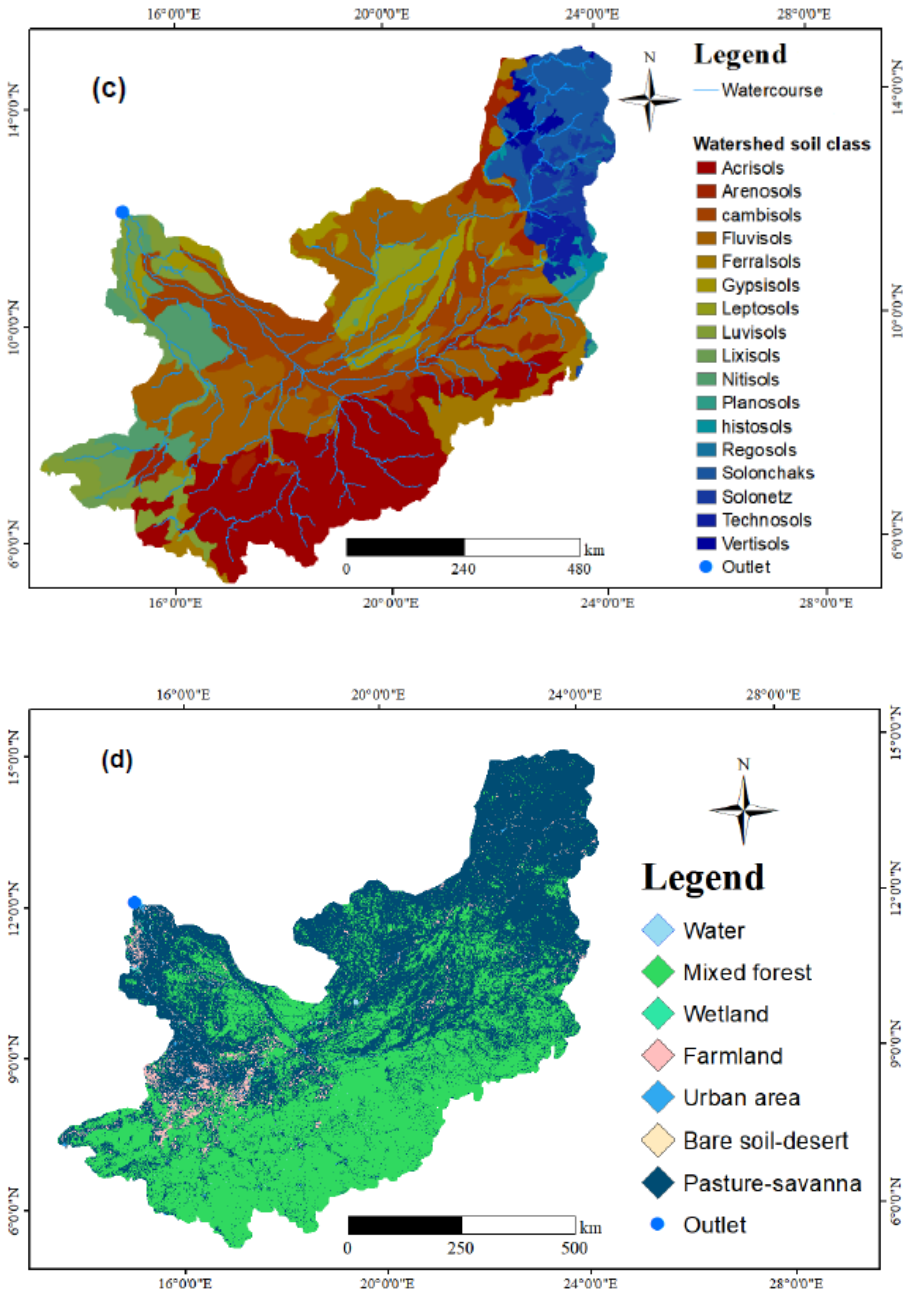


Figure 2. *Chari-Logone catchment thematic maps using as inputs for the model: (a) Topography map, (b) Slope map, (c) Soil map and (d) LULC map.*

The summary of both spatial and hydrometeorological datasets used in the SWAT+ model is presented in Table 1.

Table 1. *Summary of spatial and hydrometeorological datasets used in SWAT+ model.*

Type of data	Period	Resolution	Source
DEM	-	90 m	(SRTM) (https://www.earthdata.nasa.gov/data/instruments/srtm)
Soil	-	1000 m	Harmonized World Soil Database (FAO)
LULC		300 m	GlobCover of the European Space Agency
Meteorological data	1990-2023	Daily	National Meteorological Agency of Chad/ CHIRPS

Type of data	Period	Resolution	Source
Streamflow data	1990-2023	Monthly	Water Resources Department of the Ministry of Water Resources of Chad.

2.4. SWAT+ Model Setup

The model setup involved data preparation, basin delineation, and HRU definition before running the model. We used a DEM to delineate the catchment, and superimposed the stream network on the DEM to accurately locate streams. This basin and stream network delineation procedure is automated via the QSWAT interface. The Land use and land cover, soil, and slope datasets were imported, overlaid, and linked to generate hydrological response units (HRU's). HRUs make it possible to characterize the differences in evapotranspiration and other hydrological conditions for different land covers, soils, and slopes at a small scale instead of a broader subbasin level. The Chari-Logone basin has 538 HRUs. The characteristics of these HRUs in terms of the distribution of land use, soil, and slope within each HRU are the key factors affecting the streamflow in the Chari-Logone catchment.

2.5. Model Calibration, Validation and Uncertainty Analysis Procedure

The goodness of the streamflow hydrological modelling is assessed through the well-known calibration and validation procedure. Furthermore, a sensitivity analysis is combined with the calibration phase to identify impactful parameters affecting streamflow within the catchment [31]. In this study, the SUFI-2 algorithm [1, 2] was used for the calibration and uncertainty analysis. The SWAT-CUP interface of SWAT+ that incorporates the SUFI-2 algorithm was used to simplify the model calibration process. In the calibration process, the model variables are adjusted within suggested limits to ensure that the simulation matches the observed data. After the model calibration, a validation process is carried out using the same settings obtained at the end of calibration to confirm the agreement between the observed and simulated results. The data for the period 1993-2012 were used for calibration, and data from 2013 to 2023 were used for validation of the hydrological model at the outlet of the Chari-Logone catchment. Data from 1990 to 1992 and 2010 to 2012 were used as 'warm-up' periods for model calibration and validation. These warm-up periods for both calibration and validation are useful for getting the hydrological cycle fully operational [43].

The goodness of calibration and prediction uncertainty of the hydrological model developed is judged through some statistical metrics such as the coefficient of determination (R^2), the Nash-Sutcliffe coefficient (NS), and the percent bias (PBIAS).

The coefficient of determination (R^2), which illustrates the proportion of the total variance that can be explained by the regression equation as:

$$R^2 = \frac{[\Sigma(Q_{obs}-\overline{Q_{obs}})((Q_{sim}-\overline{Q_{sim}})]^2}{[\Sigma(Q_{obs}-\overline{Q_{obs}})2\times\Sigma(Q_{sim}-\overline{Q_{sim}})2]} \quad (2)$$

Nash-Sutcliffe (1970) coefficient is calculated as:

$$NS = 1 - \left[\frac{\Sigma(Q_{obs}-Q_{sim})2}{\Sigma(Q_{obs}-\overline{Q_{obs}})2}\right] \quad (3)$$

The percent bias (PBIAS) is calculated as:

$$PBIAS = \left[\frac{\Sigma(Q_{obs}-Q_{sim})}{\Sigma(Q_{obs})}\right] \times 100\% \quad (4)$$

In these equations, Q_{obs} corresponds to observed streamflow and Q_{sim} to simulated streamflow. $\overline{Q_{obs}}$ and $\overline{Q_{sim}}$ represent the mean values of observed and simulated streamflow.

The performance ratings associated with statistical metrics chosen for model evaluation (calibration and validation) are shown in Table 2.

Table 2. *Performance parameter ratings for streamflow simulation.*

Performance parameters	Value range	Performance classification	References
R^2	$0.7 < R^2 < 1$	Very good	[34]
	$0.6 < R^2 < 0.7$	Good	
	$0.5 < R^2 < 0.6$	Satisfactory	
	$R^2 < 0.5$	Unsatisfactory	
NS	$0.75 < NS \leq 1.00$	Very good	[34]
	$0.65 < NS \leq 0.75$	Good	

Performance parameters	Value range	Performance classification	References
PBIAS	0.50 < NS ≤ 0.65	Satisfactory	[30]
	NS≤0.50	Unsatisfactory	
	PBIAS < ±10	Very good	
	±10 ≤ PBIAS < ±15	Good	
	±15≤ PBIAS < ±25	Satisfactory	
	PBIAS ≥ ±25	Unsatisfactory	

The methodological approach for this study is shown in the flowchart (Figure 3) below.

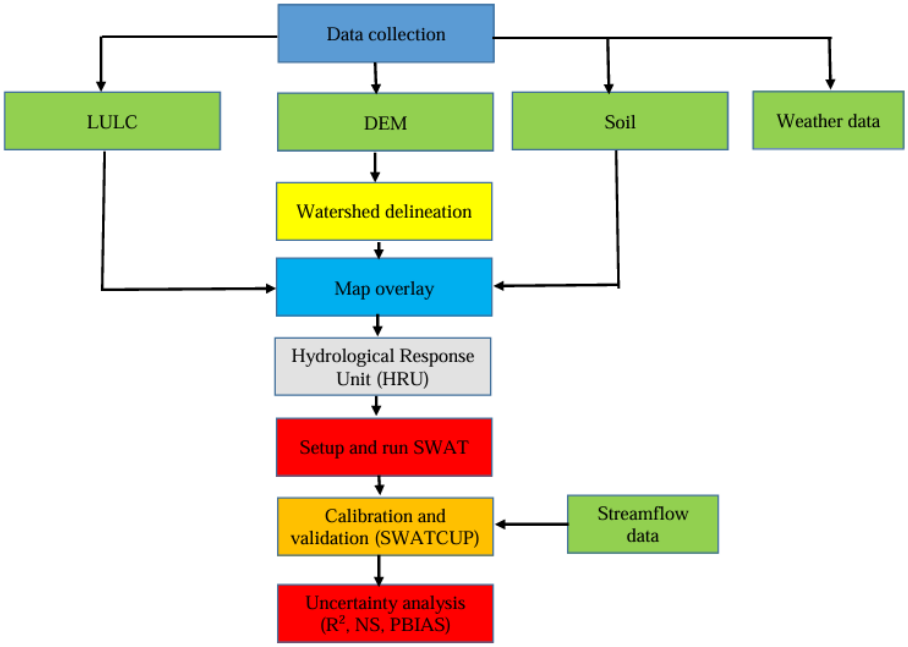


Figure 3. *Hydrological streamflow modelling flowchart.*

3. Results and Discussion

3.1. Parameter Sensitivity Analysis

In this study, we have conducted the parameter sensitivity analysis via the SWAT+ interface for the whole Chari-Logone catchment area. The most sensitive parameters considered for SWATCUP calibration are illustrated in Table 3. As presented in Table 3, the most sensitive parameters influencing streamflow and therefore selected for calibration and uncertainty analysis using SWAT-CUP include the initial SCS curve number (CN2) (%), soil evaporation compensation factor (ESCO), plant uptake compensation factor (EPCO), maximum canopy water storage (CANMX) (mm H_2O), percolation coefficient (PERCO), lateral flow travel time (LAT_TTIME) (days), baseflow recession constant (ALPHA) (days), and saturated hydraulic conductivity (K) (mm h^{-1}). It should be noted that most of the influential sensitivity parameters identified for model calibration, such as cn2, esco, perco and alpha (Table 3), are similar to those of other hydrological modelling studies [11, 43] conducted in watersheds with the same characteristics as the Chari-Logone watershed. They accurately reflect the dominant processes in a semi-arid tropical watershed [27]: surface runoff (cn2), soil evapotranspiration (esco), and groundwater-river exchanges (perco, alpha). Analysis of the performance parameter values in Table 3 shows that the fitted percolation coefficient (perco) value (0.9) is close to the maximum within a range of values between 0 and 1. This value indicates high deep percolation into the aquifer, based on the physical meaning of this parameter. This result is consistent with the geology of the Chari-Logone Basin, dominated by the permeable sedimentary formations of the Lake Chad Basin [3]. Modelling studies conducted in the same area (logone

catchment) by Nkiaka et al. [36] have also confirmed that SWAT parameter relaplayo groundwater plays an important role in the catchment hydrology. Furthermore, the calibrated value of the soil evaporation compensation factor (esco) is close to 0. This means that the model allows for maximum water extraction from the soil through evaporation from deeper layers, without compensation from the upper layers. However, this configuration physically reflects the conditions of very dry soil during the dry season, characteristic of the Sahel-Sudan region where evaporative demand far exceeds surface water availability. Similar results (esco = 0.02) were obtained by Odusanya et al. [38] for basins in southwestern Nigeria. Finally, the optimized values are physically interpretable and consistent with the literature for comparable basins.

Table 3. Performance parameter ratings for streamflow simulation in the catchment studied.

Rank	Name of sensitive parameters	Range	Fitted parameter value
1	cn2	35-95	45.16
2	esco	0.01-1	0.01
3	epco	0.01-1	0.38
4	canmx	0.01-1	0.21
5	perco	0-1	0.90
6	lat_ttime	0.5-180	59.65
7	alpha	0-1	0.21
8	k	0.0001-2000	171.63

3.2. Model Calibration, Validation and Uncertainty Assessment in Streamflow Prediction

Calibration and validation of the streamflow model are carried out at the outlet of the Chari-Logone catchment (N'Djamena TP gauging station). In this study, 31 years (from 1990 to 2023) of continuous monthly streamflow recorded data were used to evaluate model performance at the calibration and validation stage. The model calibration and validation procedures have been described in the preceding sections. Table 4 presents a summary of the model performance indicators (R^2, NSE, and PBIAS) obtained for both calibration and validation periods. During the calibration period (1993-2012), the comparison of observed and simulated streamflow at the catchment outlet revealed a satisfactory agreement between the two datasets, as illustrated in Figure 4. Furthermore, analysis of the hydrograph (Figure 4) indicates that the model accurately fit the seasonal dynamics of streamflow, with a good reproduction of the timing of rises and falls of flow dynamic associated with rainfall events. During the calibration step, the R^2, NSE and PBIAS are 0.76, 0.71, and 24.6%, respectively. These values fall within the good to very good category according to the classification of Moriasi et al. [34] showed in the Table 2, which confirms the ability of the SWAT+ model to reproduce monthly streamflows at the outlet of the Chari-Logone catchment. The NSE of 0.71 is comparable to those obtained in similar studies on large tropical African catchments. Schuol et al. [42] obtained NSE between 0.54 and 0.82 for several basins in sub-Saharan Africa. Rameshwaran et al. [39] shows that across West Africa, the medians of NSE is 0.62 by comparing observed and simulated daily river flows at 20 gauged locations across 10 countries including four major river basins Senegal, Volta, Niger, and Chad for a 30-year period. Conversely, Ezeckiel et al. [24] recently showed that the NSE could be improved using the HyMoLAP rainfall-runoff model, obtaining NSE values ranging from 0.997 to 0.921 in the Bonou catchment (Benin). Similar trends have been observed in North Africa (Chelif Basin) where the simulation yielded NSE values between 0.68 and 0.78 [51]. Although the SWAT model produced reliable results for the Chari-Logone catchment, the NSE value of 0.71 could be improved by addressing the challenges associated with data availability/data gaps, data quality, and SWAT model limitations [5]. For the validation period (2013-2023), the model also reproduces the general temporal variability of streamflow at the N'Djamena TP gauging station (Figure 5). Unlike the calibration phase, we observed that the model's performance decreased during the validation period, as expected. Although low, the obtained NSE value of 0.54 is acceptable according to Moriasi et al. [34]. However, the PBIAS of 25.5% is above the threshold of ±25% (Table 2). The R^2 value (R^2 = 0.82) is within the range of high performance (Table 2). The slight degradation in performance between calibration and validation is a classic phenomenon in hydrological modelling, linked to differences in hydro-climatic conditions between the two sub-periods. Several studies on basins with the same climatic context located

in Africa report similar decreases in NSE between calibration and validation [7]. Recently, a review study conducted by Admas et al. [4] reported that more than 50% of the studies have NSE values above 0.65 during the monthly validation period while the NSE had a median value of 0.68 at the calibration step. The discrepancy of NSE value during calibration and validation of the streamflow model could be reduced by better fit extreme peaks flow at the calibration step. Because the squared differences in the peak flow simulation will drastically diminish the performance of the model during the validation step [4].

Table 4. *Model performance results for the monthly measured and simulated streamflow calibration (1993-2012) and validation (2013-2023).*

Component	R^2	NSE	PBIAS
Calibration	0.76	0.71	24.6%
Validation	0.82	0.54	25.5%

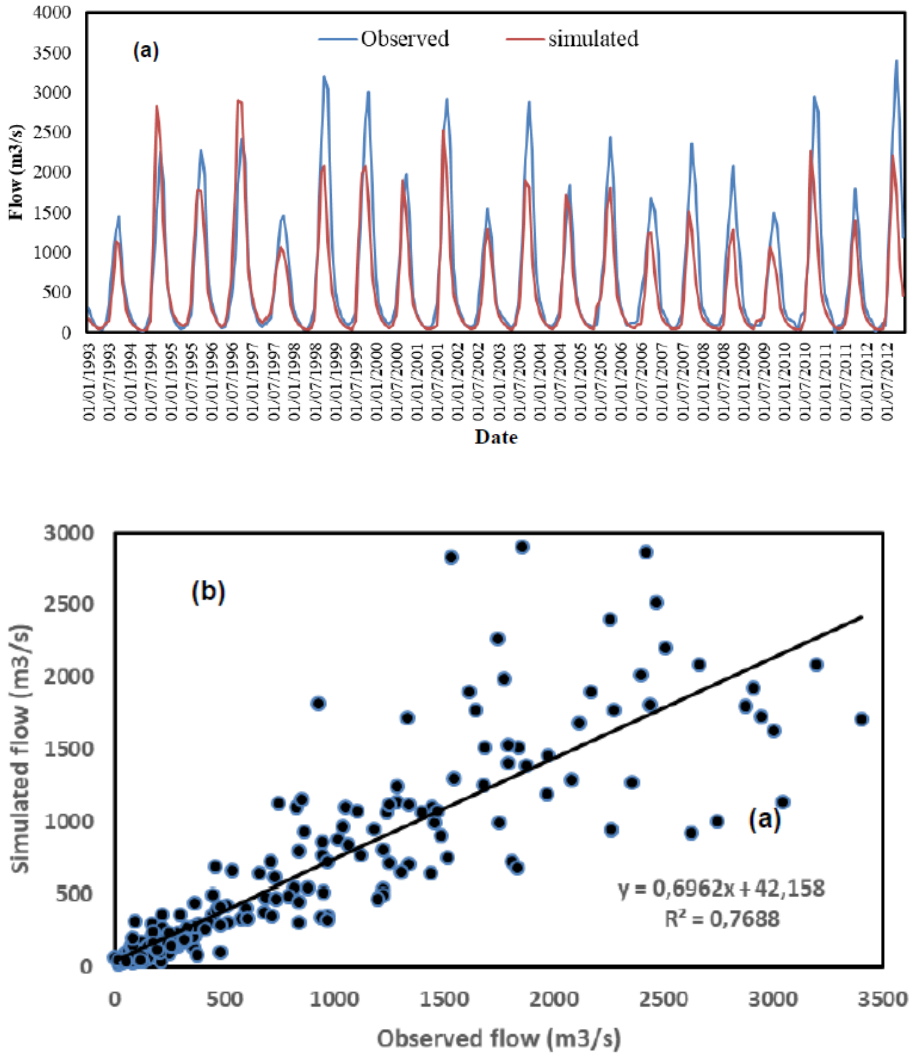


Figure 4. *(a) Time series of measured and simulated monthly flow calibration results at N'Djamena TP gauging station; (b) A scattergram comparison between measures and simulated monthly flow for calibration period at N'Djamena TP gauging station.*

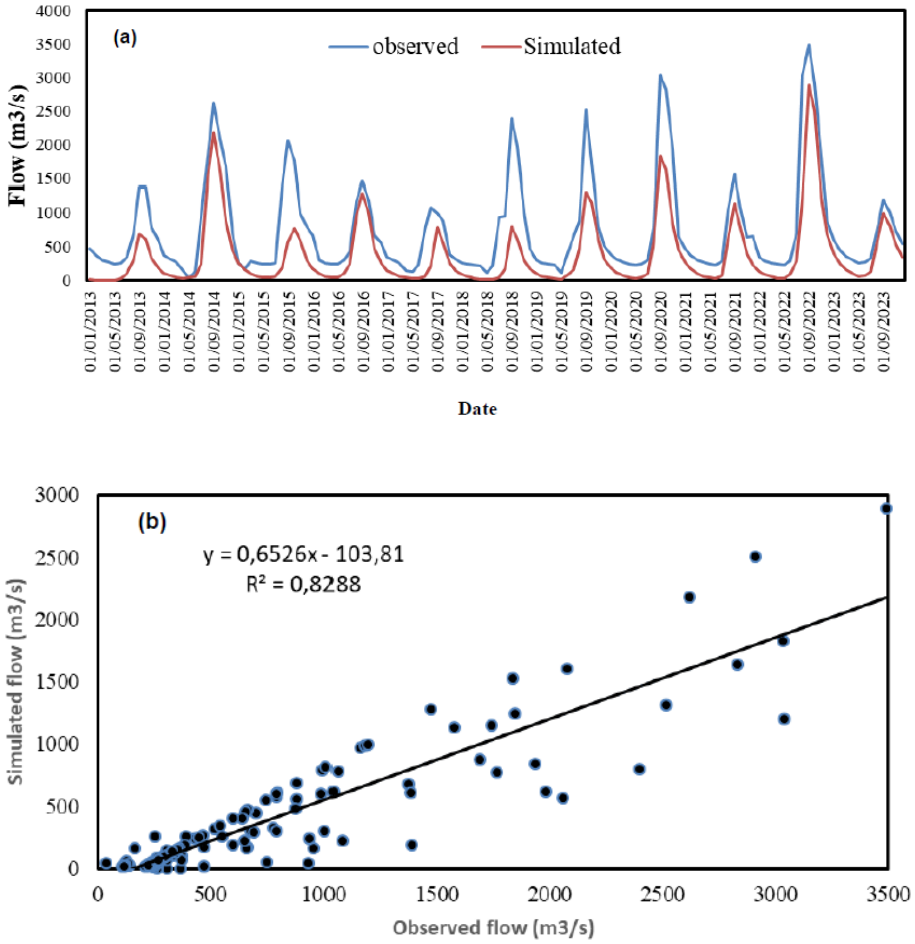


Figure 5. (a) Time series of measured and simulated monthly flow validation results at N'Djamena TP gauging station; (b) A scattergram comparison between measured and simulated monthly flow for validation period at N'Djamena TP gauging station.

3.3. Limitations and Uncertainties Associated to Streamflow Model Developed

Despite the good performance of the streamflow model developed and applied to this large-scale Chari-Logone catchment, some limitations and uncertainties associated with this model should be noted. First, the data availability and quality in the Chari-Logone catchment is the primary source of uncertainties in the model. There is a lack of dense meteorological networks and daily flow monitoring. For instance, in our study, we obtained missing rainfall data from CHIRPS databases; although reliable, these data remain limited in the context of high climatic variability observed in the basin. The impact of Land use and land cover (LULC) change in the Chari-logone catchment is not taking into account in this model and this parameter (LULC) represent a limitation that an effect on the goodness of calibration. Another limitation of the streamflow model developed is related to groundwater flow process in SWAT+ model. SWAT+ uses a simplified, and conceptual linear reservoir approach for groundwater flow modelling regardless of the aquifer type. In our case, this an important source of limitation given this complex large scale catchment and groundwater plays an important role in the catchment hydrology as stated previously.

4. Conclusions

Water resources management is fundamental due its multiple benefits in ecological stability and overall human well-being. Climate and rapid environmental change remains challenging because they strongly influence catchment water balance and hydrological regimes. To overcome these challenges, reliable hydrological models are needed. The main goal of this work was to develop, calibrate, and validate a first original hydrological model of the large-scale Chari-Logone catchment using SWAT+ model. This study highlighted the rainfall-runoff process behavior at the N'Djamena TP gauge station for 31 years (1993-2023). The SWAT+ model was successfully calibrated and validated for the Chari-Logone catchment. The comparison between observed and simulated streamflow at the catchment outlet, monitored at the N'Djamena TP gauging station, demonstrated satisfactory model performance. During the calibration period, the NSE and R^2 values were 0.71 and 0.76, respectively, while the validation period yielded corresponding values of 0.54 and 0.82. These findings are

satisfactory, and confirm the reliability and suitability of SWAT+ for the prediction of long-term streamflow behavior in this complex and large-scale catchment (613,000 km^2). Furthermore, the model capture well the seasonal dynamics of streamflow, with a good reproduction of its dynamic. Despite the goodness of the streamflow model at the calibration and validation stage, limitations and uncertainties related to the data availability and quality, the impact of Land use and land cover (LULC) change in the Chari-Logone catchment and groundwater flow modelling process in SWAT+ model applied to this model must be properly overcome to reach very good performance. Finally, the streamflow model developed can be used successfully to investigate the effect of climate and land use changes on streamflows at the catchment scale. As first SWAT+ model for the Chari-Logone basin, it will help further works to develop of early warning tools for flood control in the urban areas located around and within the basin.

Abbreviations

SWAT	Soil and Water Assessment Tool
HRU	Hydrologic Response Unit
DEM	Digital Elevation Model
SRTM	Shuttle Radar Topography Mission
FAO	Food and Agriculture Organization
HWSD	Harmonized World Soil Database
LULC	Land Use and Land Cover
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station Data

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Author Contributions

Tidjani Bahar: Conceptualization, Investigation, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing

NDari Linet: Data curation, Investigation, Writing – review & editing

Neinba Victoire: Data curation, Investigation, Writing – review & editing

Data Availability Statement

All relevant data are included in the paper or its Supplementary Information.

Conflicts of Interest

The authors declare no conflicts of interest.

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