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ORIGINAL RESEARCH ARTICLE

Assessment of Landuse -Landcover Change and its Impact on Runoff Depth in the River Kilange Catchment, Adamawa State, Nigeria

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ABSTRACT

This study assessed landuse/cover change and its impact on runoff depth in the River Kilange catchment for the period (1994 to 2024) using the Soil Conservation Service-Curve Number (SCS-CN) Model. The data used in the study are soil map from the Digital Soil Map of the World (DSMW) and Shuttle Radar Topography Mission-Digital Elevation Model-SRTM-DEM (2019). Other secondary data are Landsat TM and OLI imageries for the years 1994 and 2024 respectively. The digital data were processed in Arc-Hydro and Hec-GeoHMS GIS Extensions, and the SPSS-16 statistical package was used to carry out the analyses. The results of analyses were presented in tables, charts and maps. The Upper-Kilange sub-catchment recorded the highest rate of landcover transformation, with 390% of other landuse/cover types converted to bare/cropland category. Loko sub-catchment had relatively minimal landuse/cover change to bare/cropland with increase of 36.85 %. In the wood-forest landcover category, Lower-kilange had highest loss with 49.09 % decline, whereas Loko represents the least change with a decline of 11-39%. Runoff depth change in the study area during the study period follows the pattern of observed landuse/cover change. A 13.32% absolute increase in model-generated runoff was observed in the River Kilange catchment. Result of t-test, however, indicated the change difference between 1994 and 2024 was not statistically significant (P=0.68). This is likely due to high spatial variability among the sub-catchments considering the size of the study catchment, which is 5323 square kilometres. Increase in rock-outcrop and bare/cropland categories, and reduction in areas under wood forest, and shrub/grassland contributed to rise in runoff depth. This study recommends the regulation of fuel-wood exploitation to reduce the pressure on wood-forest. Afforestation measures can also reverse the current trend of landuse/landcover conversions that affect hydrological processes in the River Kilange catchment.

Introduction:
Human activities play a large role in influencing hydrologic processes. Land-use change accounts for about 50% of the change in global runoff over the last century (Wang *et al*, 2017). Natural landcovers are increasingly being converted into agriculture, which can negatively influence soil hydrological

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processes (Davari, *et al*. 2024). Landcover/landuse change have an impact on temperature, precipitation, evapotranspiration, water retention capacity of the soil, sediment loading, surface runoff potential, groundwater recharge and soil infiltration capacity of a catchment area (Dilnesa, 2018; Zhang, *et al*., 2014, Zhang, *et al*., 2025 and Sharma, *et al*. 2025). There is thus the need to investigate the impact of landcover change on runoff depth with a view to understanding the related environmental problems such as flooding, soil erosion and depletion of groundwater.

There is a growing level of concern prompted by an increase in the number of river catchment areas being affected by flooding and soil erosion (Nicandrou, 2010 and Hajji, *et al*. 2025). Land-use and land-cover change (LULCC), a process of modification of Earth's terrestrial surface affects biodiversity, climate change, watershed hydrology, and other processes on the earth. Increased runoff reduces groundwater recharge, thus lowering the water table and making droughts worse, especially for farmers and others who depend on the water wells (Alemu, 2010). The lowering of water tables would have implications for groundwater abstraction particularly in the semi-arid regions of Nigeria, where surface water is relatively scarce.

Apart from the Kiri dam constructed on the River Gongola and commissioned in the year 1980, primarily for irrigation purposes, there is no large water reservoir for domestic water supply in Adamawa state (James and Mustafa, 2005). Most of the water schemes in Adamawa State are from hand-dug wells, boreholes and tube wells, and the rate of groundwater exploitation has been on the increase. The realisation of the fact that increase in surface runoff culminates into reduction in groundwater reserve, which will have negative implications on the livelihood of the inhabitants of the study area makes research on surface runoff imperative.

The physical properties of soil can serve as indicators on the effects of landuse/landcover types on the soil's capability to take in water (Harssema, 2005). The change of the soil infiltration capacity due to inadequate land-management leads to deterioration of soil properties which results in negative impacts, such as faster runoff generation. The infiltration rate plays an important role in controlling the amount of water that will be available for surface runoff after rainfall event (Saowanee, 2007). A flat surface is better for water infiltration as it allows time for penetration, whereas a steep slope forces the water rapidly across the surface. Infiltration process affects surface runoff, soil erosion, and groundwater recharge (Tarek, 2011).

In Nigeria, some of the gauging stations operated by the expatriate workers during the colonial period are no longer functional. One of such obsolete gauging stations in the River Kilange catchment was located at Mbila-Song. This situation has caused paucity of hydrometric data making research in hydrology very difficult, because reliable data required for the analysis of the various hydrological parameters including runoff and sediment yield are not readily available. The inadequacy of historical data necessitates the development of methods that can be effectively used to investigate the catchment's management problems. The use of spatial technology techniques can overcome these difficulties. As postulated by Oshodi (2006), an approach is required to understand the area and the acquired knowledge base will help with watershed mapping, land cover change detection, hydrological analysis and modelling. The Curve Number-CN method, which is a popular method for computing surface runoff is, therefore, used in the current study.

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Materials and Methods

The Study Area

The River Kilange catchment is located in the north of Adamawa state, Nigeria. The study area is located between latitudes 9° 23´ 26´´ N to 10° 19´ 00´´ N and longitudes 12° 15´ 00´´ E to 13° 17´ 25´´E. The River Kilange catchment covers an area of 5,323 km² encompassing parts of Fufore, Girei, Gombi, Hong, Maiha, Mubi-North, Mubi-South and Song Local Government Areas (Fig. 1).

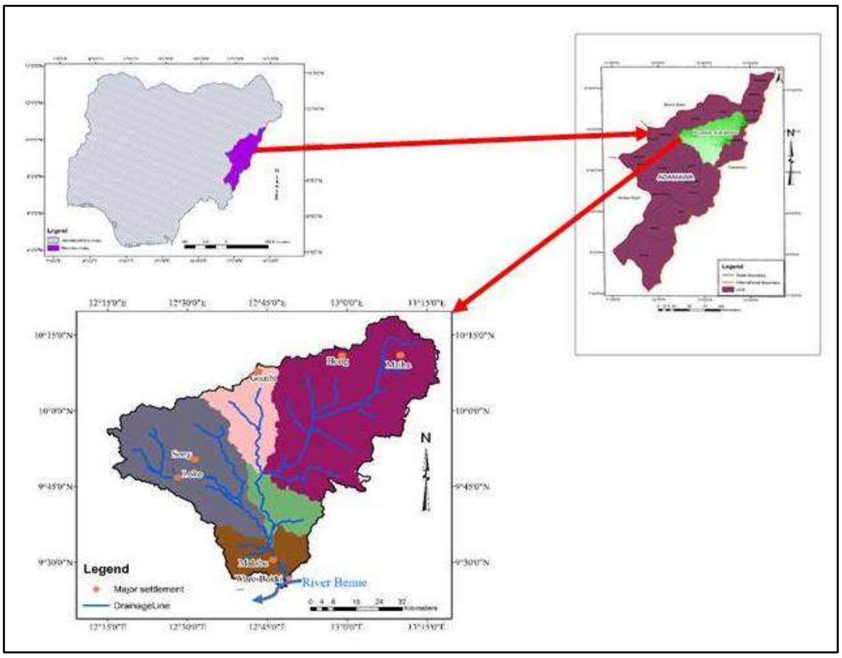

Figure 1: Location of the River Kilange Catchment in Adamawa State
Source: Adebayo and Tukur (1999)

Generally, the study area falls within the category of Basement Complex rocks of northern Nigeria. Chronologically, the granitic crystalline rocks of the Pre-Cambrian Basement Complex underlie the River Kilange catchment area. Overlying the older Basement Complex are the sedimentary and volcanic rocks of relatively younger age ranging from the upper Cretaceous to Quaternary periods (PFP-Nigeria, 1981).

The northern part of the study area comprises of high mountains, such as the ones at Pella and Zumo whose highest peaks are more than 1000 metres above mean sea level (Bawden, 1972; PFP-Nigeria, 1981). The Hudu range, bordering the northern extreme of the River Kilange catchment in Maiha Local Government Area belongs to the Wura-Wura and Pakka group of hills with peaks up to 1200 metres above mean sea level (Adebayo and Dayya, 2004). The Gurkusa Hills constitute the major relief feature in the north-western part of the study area. This group comprises of ranges of hills whose peaks constitute the catchment divide between the Hawul and Kilange catchments. The southern portion of the study area is characterised by low relief although there are areas with isolated domes and inselbergs that dot the plains.

The drainage system in the River Kilange catchment is closely related to the relief. The major drainage feature in the study area is the River Kilange, which originates from the northern segment of the River Kilange catchment. Major tributaries of River Kilange are the Rivers Loko and Song. These two rivers drain the western portion of the

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watershed, while Rivers Mayo-Nguli and Giraba drain the eastern parts. River Sangannare originating from the catchment divide between the Hawul and Kilange systems drain the north-central part of the study area. The River Kilange drains into the River Benue at an outlet near Wuro-Bokki, a settlement located some 45 kilometres upstream of the bridge at Jimeta (Pell, Frischmann & Partners-PFP Nigeria, 1981).

The River Kilange catchment lies in the Sub-Sudan climatic zone. The months from May to October constitute the rainy season, while the months from November to April make up the dry season period. Some spatial variation in the distribution of rainfall resulting from orographic effects in response to the south-westerly winds can be observed in the study area (PFP-Nigeria, 1981). The highland areas therefore, experience relief rainfall and receive rainfall amounts that are slightly higher than the lowland areas. The north east of the study area receive the highest annual mean rainfall owing to orographic lift around the Mandara Mountains. Mean annual rainfall in the study area ranges from 1050mm to 910 mm in the northern and southern extremes respectively (Adebayo, 1999).

Temperature in the study area is characterised by little diurnal, monthly and seasonal variations. Daytime temperatures are generally high except for cloudy days in the rainy season and the dusty Harmattan period between November and February. The hottest period in the year is in the month of April, with temperatures rising to 37^{o} C and 39.6^{o} C in the northern and southern extremes of the study area respectively (Adebayo and Dayya, 2004). December and January constitute the coldest months when temperatures drop to 15.3^{o} C and 18.3^{o} C in the northern and southern extremes of the study area respectively (Adebayo and Dayya, 2004).

Soils in the River Kilange catchment are closely related to the parent material, which are mainly the Basement Complex rocks. The area falls within the ferruginous tropical soil zone of northern Nigeria. The dominant soil types in the River Kilange catchment are sandy loam to sandy clay with or without concretionary iron pan. (Bawden, (1972).

The vegetation cover of the study area follows the pattern of climatic conditions. Adamawa State and River Kilange catchment inclusive is located within the Sudan Savannah belt of Nigeria (Adefioye, 2013). The natural vegetation in the study area is characterised by woody trees and grasses of varied heights. The natural vegetation of River Kilange catchment is wood-forest characterized by sparse, relatively short 5-10 metre semi-deciduous trees with shrubs and grasses constituting the dominant cover (PFP-Nigeria, 1981).

The major occupation of the people in River Kilange catchment as reflected in their notable vegetation zone, which is the fertile Sudan savannah is farming. Two basic patterns of rain-fed agriculture are practiced in relation to the two fundamental soil types in the River Kilange catchment. The first is the residual upland pediment soils found on hill slopes mainly in the north and central parts of the study area. The second is the alluvial floodplain soils, which are more fertile than the upland soils and are, therefore more productive (PFP- Nigeria, 1981).

Communities living on the banks of rivers engage in fishing, while the pastoralist communities keep large herds of cattle (National Bureau of Statistics, 2014; Akinbile and Ndaghu, 2005). Pastoral activities are a major contributor to the livelihood of the population, where livestock such as cattle, goats and sheep are kept. Open grazing is the main practice, where herds are moved alternately between the upland pediments and

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the floodplain areas during the rainy and dry season periods respectively.

The Curve-Number Method

The Curve Number model incorporates the factors influencing the ability of the earth surface to take in rainwater such as soil texture, land cover, slope gradient and the prevailing moisture condition or Antecedent Moisture Condition-AMC. Curve number values indicate the level of landscape's capability to take in water after rainfall event. Loose soil for example, sand can readily absorb large amount of water after rainfall event when the ground is not under saturated condition. Sandy soils are therefore associated with low curve number values and low runoff potentials. Conversely, crystalline rock surfaces have near impervious surfaces and absorb little or no rainwater after rainstorms, hence are characterized by high curve number values and high runoff potentials. Similarly, areas covered with vegetation have lower curve number values than bare surfaces, because vegetation can hold rainwater and slow down lateral flow thereby facilitating the percolation of water into the ground. The curve number method was, therefore, used to compute runoff depth under the 1994 and 2024 land cover scenarios in the River Kilange catchment.

In this study, the methodology involves the integration of Remote Sensing, Geographic Information System and Hydrological Modelling. The spatial information, such as climate data and Landsat images were derived from remotely sensed sources via the Internet. Some hardcopy maps and historical discharge data acquired from the Upper Benue River Basin Development Authority (UBRBDA) were used to complement the Internet-based datasets.

The differences between runoff response before and after LULC changes in the River Kilange catchment were examined under similar precipitation conditions by using the Curve Number-CN method. For the computation of runoff, maps of the study area depicting land use/land cover for the 1994 and 2024 years were prepared in ArcGIS. The procedure for the modelling has been divided into 6 parts:

1. DEM processing was done in Arch-Hydro (Version 2.0) Extension of ArcGIS.
2. Soil map was processed in Arc-GIS to extract Hydrological Soil Groups (HSG).
3. Precipitation and river discharge data were processed in Microsoft Excel.
4. Satellite images were classified in ArcGIS to produce LULC maps for the years; 1994 and 2024.
5. Land use, soil and slope map polygons were intersected in ArcGIS
6. Curve Number maps were generated in Hec-GeoHMS.

The methodology for computing runoff depth through the curve number-CN method is illustrated in Figure 2.

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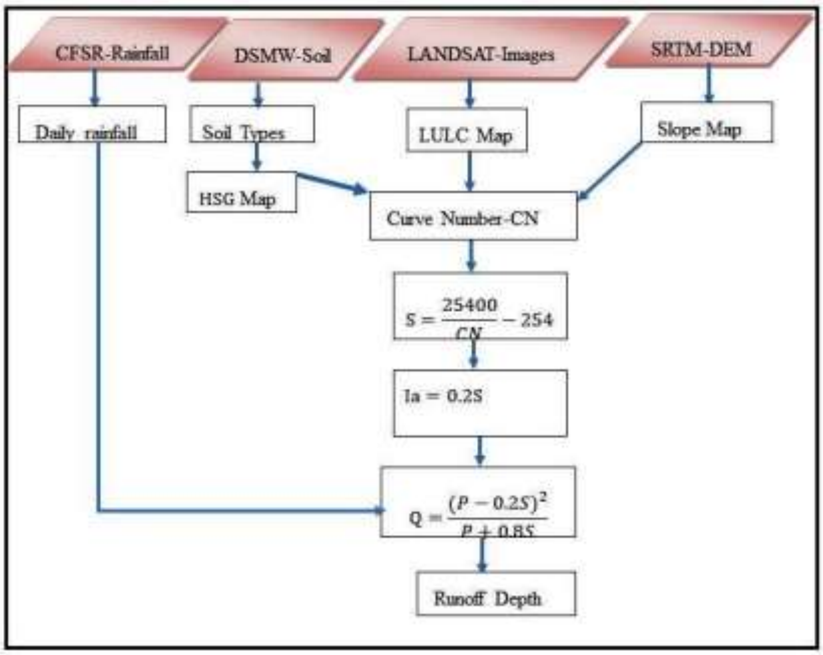

Figure 2: Procedure for Computing Runoff Depth.
(Modified) Shadeed, S. and Almasri, M.2010)

Creating Landuse Grid

In processing land use grid, the classified landuse raster layer was converted into polygon. The landuse polygons were later intersected with soil polygon in ArcGIS to produce landuse/soil complex.

Creating Soil Grid

Hydrologic classification of soils considers particle size, infiltration rate and effective depth for grouping the soils into classes. Group 'A' soils are highly permeable soils indicating low runoff potential while, Group 'D' soils have high runoff potential when thoroughly wet. Water movement through group D soils are very restricted as they have clayey textures. Soils in groups B and C have intermediate runoff potentials. The soil units of the study area delineated from the World Soil Map were grouped following the textural classes shown in Table 1. Based on the criteria (Table 1) the Hydrologic Soil Groups (HSGs) B and C were identified in the River Kilange catchment.

Table 1: Area Coverage of Major Soil Units in the Study Area

Type	Coverage (km^2)	Texture	HSG
Lithosols	1084	Skeletal rocky/gravelly sand	C
Plinthic luvisols	674	Loamy Sand	B
Eutric regosols	1882	Sandy loam	B
Ferric luvisols	1373	Sandy loam	B
Pellic vertisols	310	Clay loam	C
Total	5323		

Source: Harmonized World Soil Database-HWSD (version 1.2) FAO, (2012)

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Generating Curve Number Grid

Hydrological soil group and landuse/landcover maps were intersected (union) in ArcGIS to produce the landuse/soil polygons. With information from landuse classes, Hydrological Soil Group and the Soil Conservation Service Technical Report-TR55, which is a standard reference table, curve number look-up table for the study area was created using the create table tool in ArcGIS. The curve numbers were generated in the Hydrological Engineering Centre-Geospatial Hydrological Modelling System (HEC-GeoHMS) Extension for ArcGIS 10. Curve numbers at the River Kilange for different combinations of hydrologic soil groups and land uses were created as shown in Table 2. The Antecedent Moisture Condition II (AMC II) was chosen for the analysis because it produces sufficient rainfall that can generate runoff. This is because any rainfall depth less than the initial abstraction will not generate runoff since all the rainwater would be lost through infiltration, filling of depressions and other related losses before runoff begins. The curve number-CN map of the River Kilange catchment was generated by combining landuse/soil map, Hydro-Dem and the CN look-up table in Hec-GeoHMS. The mean curve number at the study catchment ranged from a low of 66 to a high of 98 for Hydrological soil Groups B and C (Table 2).

Table 2: CN Look-up Table for the AMC II Condition in River Kilange Catchment

ID	LUvalue	Description	Curve numbers for HSG			
			A	**B**	**C**	D
1	1	Rock-outcrop	98	**98**	**98**	98
2	27	Wood-forest	45	**66**	**77**	83
3	83	Grass/shrubland	49	**69**	**79**	84
4	144	Crop/bareland	60	**72**	**80**	84

Source: United States Geological Survey/Global Visualisation-USGS/GloVis, (2019)

Computation of Runoff (Q)

The Curve numbers for the years 1994 and 2024 were used to compute Potential Maximum Retention *S* (Equation 1):

$$S = \frac{25400}{CN} - 254 \qquad (1)$$

The Potential Maximum Retention *S* was substituted in (Equation 1) to derive the value of initial abstraction (*Ia*).

$$Ia = 0.2S \qquad (2)$$

Rainfall *P* value of a selected rainfall event and *S* as calculated in (Equation 2) were used to calculate runoff *Q* in millimetres (Equation 3)

$$Q = \frac{(P-0.2S)^2}{P+0.8S} \qquad (3)$$

The value of the selected rainfall event must be more than the product of potential maximum retention and the initial abstraction (0.2S). The derived *S* and *P* values were substituted in (Equation 3) to get the *Q*, which is the runoff depth for the study catchment.

The generated *CN* values and the Potential Maximum Retention-*S* were used to compute runoff depth for the years 1994 and 2024. Rainfall events with records of 102 mm in the month of August for the years 1994 and 2024 were selected for the computing runoff depth. These rainfall events were selected because their intensities were more than the product of potential maximum retention and initial abstraction at the Malabu station in these two periods. Since the same rainfall depth was used for the computation of runoff in years 1994 and 2024, any resultant change in runoff depth emanated from landcover change. In other words, all other parameters used for the computation of runoff, particularly rainfall were kept constant except landcover

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conditions. The calculated retention parameters (S) and runoff depth (Q) for the years 1994 and 2024 were compared to determine the impact of LULCC on runoff depth.

Results and Discussions

Landuse/ landcover Change in the Sub-catchments

Both spatial and temporal variations in the pattern of landuse/cover change took place in the study area during the study period. From Table 3, bare/cropland represent the highest percentage landuse/cover change in all the sub-basins, where the Upper-Kilange recoded an increase of 390% while Loko recorded the lowest increase of 36.85 % between the years 1994 and 2024. Secondly, the wood-forest landcover category witnessed highest decrease in all the sub-catchments as Lower-kilange leads with 49.09 %, whereas Loko represents the least change with a decline of 11.39%. Meanwhile, the Rock-outcrop landcover recorded the highest increase in the Upper-kilange sub-catchment with change of 31.52% while Loko with a decline of (2.7%) having the lowest change. Grass/shrubland witnessed relatively minimal landuse/landcover change during the study period, with the highest decrease in the Upper-Kilange (11.32 %) and lowest in Sanganare (6.51 %).

According Table 3, the direction of LULC in the River Kilange catchment from 1994 to 2024 is inclined towards increasing runoff depth potentials. Areas under both Wood-forest and grass/shubland declined, while rock-outcrops and bare/cropland expanded respectively in all the sub-catchments.

Table 3: Landuse/ landcover Transformation in the Sub-catchments

	Percentage landcover change 1994-2024			
Sub-catchment	Rock-outcrop	Wood-forest	Grass/shrubland	Bare/cropland
Upper-kilange	31.52	-38.83	-11.32	390.74
Sanganare	10	-18.47	-6.51	84.38
Loko	2.7	-11.39	-7.44	26.85
Giraba	10.53	-32.82	-11.11	69.62
Lower-kilange	20.00	-49.09	-8.8	82.22

The Upper-kilange located in the northern part of the River Kilange catchment experienced the highest rate of landcover transformation partly due to its proximity to large urban centres with very high population, prominent among which are Mubi, Hong, Maiha and Gombi. Pressure from these settlements in form of human activities such as fuelwood extraction, expansion in farmlands, human settlements and overgrazing are responsible for the high rate of land conversion in the Upper-kilange sub-catchment.

The trend of landcover change in the River Kilange catchment, particularly in the northern segment where landcover transformation is intense are similar to the pattern reported by Ariti, *et al.* (2015). The trio explored the undesired LULC changes in two districts of the Central Rift Valley of Ethiopia. The result of their study showed that between 1973 and 2014, cropland expanded at the expense of all other land-cover types. The area covered with forest, woodlands, grasslands and water have declined from 10.0%, 33.0%, 30.0% and 16.0% to 4.4%, 18.3%, 17.2% and 13.4% of the total study area, respectively, while the area cover for cropland increased from 11.0% to 46.7%. Population growth was one of the major drivers underlying these changes. They further opined that drought, decline in productivity, loss of wildlife and birds, and land degradation are the most

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widely perceived impacts of these LULC changes.

The drivers of landuse/landcover change in the River Kilange catchment are similar to the factors identified by Kindu, *et al.* (2015). They asserted that population growth, expansion of cultivated lands and settlements, livestock ranching, cutting of woody species for fuelwood, and charcoal making were the top six important drivers of LULC change in Munessa-Shashemene landscape of the south-central highlands of Ethiopia.

Trends and rates of landcover transformation in the Upper-Kilange sub-catchment portend negative effects on hydrological processes. Proportional increase in areas covered by bare/cropland and rock-outcrop create impervious surfaces that reduces infiltration rates of the soil, thereby accelerating the process of surface runoff.

Effects of Landcover Change on Runoff Depth in the Sub-catchments

The highest increase in runoff depth in the River Kilange catchment was 27 percent recorded in the Upper-kilange sub-catchment as shown in Table 4. Sanganare sub-catchment had the lowest increase in runoff depth with only 0.22 percent. The increase in runoff depth over the study period (1994 to 2024) was 13.33 Percent for all the five sub-catchments in the River Kilange.

Table 4: Runoff Depth Change in the River Kilange Catchment (1994 to 2024)

Sub-catchment	1994	2024	Percentage Change
	Runoff Depth-Q (mm)	Runoff Depth-Q (mm)	
Upper-Kilange	4.22	5.36	27.01
Sanganare	4.51	4.52	0.22
Loko	3.28	3.61	10.06
Giraba	3.58	4.11	14.80
Lower-Kilange	4.32	4.95	14.58
Mean	3.98	4.51	13.33

Student's t-test was used to compare the computed values of runoff depth for the years 1994 and 2024. The result of the t-test indicates that there was no statistically significant difference in runoff depth in the River Kilange catchment between the two periods, because the computed P-Value was 0.68 at 95 % confidence level. Although result of Student's t-test is not statistically significant, outcome of this analysis can be attributed to the spatial variation in the study catchment, considering its large size of 5323 square kilometres. Empirical studies using similar methodologies abound worldwide some of which are highlighted below.

Weng (2010) used similar methodology to examine the impacts of LULC change on surface runoff in the Zhujiang Delta by comparing predicted runoff volumes in 1989 with those in 1997. The result of his study indicated that the annual runoff volume had increased by 8.10 mm during the 8-year period owing to LULC changes.

Olang and Kundu (2011) reported a related work on the effects of land use changes on the characteristics of floods in the Nyando River basin in Lake Victoria Development Basin - LVDB of Kenya. The results of their study indicated over the study period (1973 to 2008), the peak discharges increased by 16% in all of the 14 sub-catchments in the basin.

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In a related manner, Guzha, *et al*., (2018) evaluated the impacts of land use and land cover changes in East Africa. Their study revealed that forest cover loss increased annual surface runoff by 14%. Weak correlations were observed between forest cover and runoff ($r=0.42$, $p<0.05$), indicating that forest cover alone is not an accurate predictor of hydrological change in East African catchments. The study revealed that variability in these results supports the need for long-term field monitoring to understand catchment responses better and to include more landcover classes in addition to forest cover in the analysis. This was done in the current study by including more landuse/landcover classes such as bare surface, rock-outcrop and grassland. The period of study of three decades is also sufficient time for changes to occur in the study area.

Alfa, *et al*. (2018) conducted a similar study to examine the effect of changes in land cover on the total runoff from Ofu River Catchment in Nigeria. The average change in runoff depth was 48.09% for the period between the years 1987 and 2016.The study concluded that the changes in LULC of the catchment had significant effect on the runoff from the catchment. The percentage change in runoff depth in the Ofu River catchment is higher than the values in the River Kilange catchment. The variations in catchment characteristics account for the difference since the two study areas are located in different ecological zones of Nigeria.

Hu, *et al*. (2020) assess the effect of landuse change on surface runoff in Beijing Central Area, report similar result. Their study showed that change in surface runoff had positive correlation with change in impervious land area, having correlation coefficient of 0.92. Conversely, change in surface runoff had negative correlation with woodland, grassland and farmland having correlation coefficients of -0.91, -0.70 and -0.57 respectively. They concluded that impervious area change is the predominant driver of surface runoff change in the study area for the whole period.

Ohana, *et al.* (2015) also estimated the effects of 20 years of LCCs on rainfall-runoff relations in an extreme rainfall event. A strong relationship was detected between vegetation cover and the runoff volume. The LCCs with most pronounced effects on runoff volumes were related to urbanization and vegetation removal.

Results of these studies show that change in runoff depth had direct or positive relationship with bare/cropland and rock-outcrop. Conversely, runoff depth change had negative correlation with change in grass/shrubland and wood-forest. In other words, increase in areas covered by rock-outcrop and bare/cropland cause increase in runoff depth, while decrease in the proportion of land under wood-forest and grass/shrubland cause increase in runoff depth. The rock-outcrop landuse/landcover change was the most critical factor driving runoff depth change in the River Kilange catchment for the study period.

Conclusion

Hydrologic modelling provided an alternative to traditional empirical observations and analysis using in situ (field) data for environmental studies. Landuse/landcover change in the River Kilange catchment had considerable impact on the hydrological processes. The changes in landuse/landcover over the period 1994–2024, created impervious surfaces on the landscape hence increased runoff. With climatic inputs held constant between the years 1994 and 2024, land-cover change accounted for the increase of runoff depth in the River Kilange catchment. The results of the study indicate rapid landcover transformation in the Upper-kilange sub-catchment in particular and the consequent increase in runoff depth constitute a serious threat to the ecological balance of the catchment.

For proper understanding of the global change phenomena, there is the need to take into account the impact of landcover change on runoff depth in particular and hydrological processes in general. Change in catchment's runoff response to landuse/landcover variability can occur particularly at a localized scale causing environmental problems such as soil erosion, flooding and sedimentation of river channels.

If the trend of landcover change in the study area persists, environmental problems like soil erosion, flooding, sedimentation of river/stream courses and depletion of groundwater resources will become common phenomena. There is thus the need to reverse the trend of landcover change through mitigation measures such as afforestation and regulation of fuelwood exploitation in the River Kilange catchment of Adamawa State, Nigeria.

References

Adebayo, A. A. (1999) *Climate*: In A. A. Adebayo and A. L. Tukur (Eds). *Adamawa State in Maps*, Paraclete Publishers, Yola

Adebayo, A. A. and Dayya, S. V, (2004) *Geology, Relief and Drainage*: In A. A. Adebayo (Ed), The Mubi Region-A Geographical Synthesis, Paraclete Publishers, Yola

Adefioye, S. A. (2013). *Analysis of Land Use/Land Cover Pattern along the River Benue Channel in Adamawa State, Nigeria,* Academic Journal of Interdisciplinary Studies; Volume 2 No.5, Published by MCSER-CEMAS-Sapienza University of Rome

Akinbile, L.A. and Ndaghu A.A.T. (2005) *Access to Extension and Poverty Alleviating Strategies of Farm Families in Adamawa State, Nigeria, Journal of Agricultural Extension,* Vol. 8, 2005, Accessed 13 December 2025

Alemu, B. (2010) *GIS and Remote Sensing Based Assessment of Causes and Risk nalysis of Flood Hazard in Iresha Watershed, Meskan Wereda, SNNPR, Ethiopia,* M. Sc. Dissertation, College of Natural Sciences Environmental Science Program, Addis Ababa University, Ethiopia

Alfa, M. I., Ajibike, M. A., Adie, D. B. and Mudiare, O. J. (2018) *Assessment of the Effect of Landuse /land cover Changes on total Runoff from Ofu River catchment in Nigeria.* Journal of Degraded and Mining Land Management 5 (3):1161-1169,

Ariti, A. T., van Vliet, J., and Verburg, P. H. (2015) *Land-use and land-cover changes in the Central Rift Valley of Ethiopia: Assessment of perception and adaptation of stakeholders,* Applied Geography, 65, 28–37.

Bawden, M.G. (1972). Physiography, Geology, Geomorphology and Hydrology. In: Tuley, P. (Ed.), Land Resources of North East Nigeria. The Environment: Land Resource Study No.9. Surrey, England. Land Resources Division/Overseas Development.

Davari, M., Saeidpoor, B., Khaleghpanah, N. *et al.* (2024) Impacts of land use/cover change on soil hydrological properties, runoff, and erosion: results from micro-plots in Western Iran. *Environ Earth Sci* **83**, 508 https://doi.org/10.1007/s12665-024-11813-w

Dilnesa, W. (2018) *Assessing the Impacts of Land use/cover Change on the Hydrological Response of Temcha watershed, upper Blue Nile basin,* Ethiopia International Journal of Scientific Research in Civil Engineering, IJSRCE | Volume 2 | Issue 5 | ISSN : 2456-6667

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FAO/IIASA/ISRIC/ISSCAS/JRC (2012) *Harmonized World Soil Database (version 1.2).* FAO, Rome, Italy and IIASA, Laxenburg, Austria

Guzha, A. C., M. C. Rufino, S. Okoth, S. Jacobs, and R. L. B. Nóbrega (2018) *"Impacts of Land Use and Land Cover Change on Surface Runoff, Discharge and Low Flows: Evidence from East Africa." Journal of Hydrology: Regional Studies* 15:49–67

Hajji, S., Boudhar, A., Elaloui, A. *et al.* (2025) A review of the literature on spatial prediction of Floods using machine learning models. *J Coast Conserv* **29**, 85 https://doi.org/10.1007/s11852-025-01158-2

Harssema, S. (2005*) GIS- Based Surface Runoff Modelling and Analysis of Contributing Factors: A Case Study of the Nam Chun Watershed, Thailand,* M. Sc. Dissertation, International Institute for Geo-|Information Science and Earth Observation, Enschede,The Netherlands

Hu, S., Fan, Y. and Zhang, T. (2020) Assessing the Effect of Landuse Change on Surface Runoff in a Rapidly Urbanised City: A Case Study of Beijing Central Area. Land, MDPI

James, T. and Mustafa, S. (2005) *Study on Water Supply Pattern in Some North-eastern States of Nigeria,* Technology and Development (A Journal of scientific and Technological Research), Federal University of Technology, Yola 45-55

Kindu, M., Schneider, T., Teketay, D., & Knoke, T. (2015) *Drivers of land use/land cover changes in Munessa-Shashemene landscape of the south-central highlands of Ethiopia,Environmental Monitoring and Assessment, 187* (7), 452.

National Bureau of Statistics- NBS (2010) *Annual Abstract of Statistics*, Federal Republic of Nigeria 2010, Accessed 12 December 2015 National Bureau of Statistics-NBS (2014) *Adamawa State Information,* Accessed 13 December 2025

Nicandrou, A. (2010) Hydrological ***Assessment*** *and Modelling of the River Fani Catchment,* Albania, Ph. D. Thesis, Faculty of Advanced Technology**,** Azaaz University of Glamorgan, Accessed, 5 April, 2026

Ohana-Levi, N., Karnieli, A., Egozi, R., Givati, A. and Peeters, A. (2015) *Modeling the Effects of Land-Cover Change on Rainfall-Runoff Relationships in a Semiarid, Eastern Mediterranean Watershed* [Research article]. https://doi.org/ 10.1155/2015/ 838070

Olang, L. O. and Kundu, P. M (2011) *The Impact of Land use Change on Runoff and Peak Flood Discharges for the Nyando River in Lake Victoria Drainage Basin, Kenya,* WIT Transactions on Ecology and The Environment, Vol 153,© 2011 WIT Press

Oshodi, K.S. (2006) *Hydrological Study of Nigeria, GIS Term Project* , University of Texas, USA, http://www.crwr.utexas.edu/gis/gishydro06/, Retrieved 3 July. 2025

Pell, Frischmann and Partners-PFP Nigeria (1981) *Kilange River Basin Feasibility Study, Volume IV,* Upper Benue River Basin Development Authority, Federal Government of Nigeria

Saowanee, P. (2007) *Analysis of Soil and Landcover Parameters for Flood HazAssessment, A Case Study of the Nam Chun Watershed, Phetchabun, Thailand, M.Sc. Dissertation in Geo-information Science and Earth Observation*, International Institute for Geo-Information Science and Earth Observation, Enschede, The Netherlands

Shadeed, S. and Almasri, M. (2010) *Application of GIS-based SCS-CN method in West Bank catchments, Palestine, Water*

ISSN: 2705-1900 (Online); ISSN: 2251-0702 (Print)
Website: gjges.adsu.edu.ng *Email:* gjges@adsu.edu.ng *DOI:* https://doi.org/10.64290/gjges.v6i1.47

Science and Engineering, 3(1): 1-1, Accessed 12 Mach 2026

Sharma, A., Krishan, R., Kour, K., Nikam, B.R., Bagri, D.S. (2025). Insight into the Impact of Land Use/Land Cover Change on Runoff Incorporating Hydrological Modelling to Analyse Their Impact on the Water Regime. In: Nanda, A., Gupta, P.K., Gupta, V., Jha, P.K., Dubey, S.K. (eds) Navigating the Nexus. Water Science and Technology Library, vol 102. Springer, Cham. https://doi.org/10.1007/978-3-031-76532-2_4

Tarek, S. (2011) *The Effect of Land use on Soil Infiltration Rate in a Heavy Clay Soil in Egypt,* VATTEN

Wang Fang, Ge Quansheng, Yu Qibiao, Wang Huaxin, Xu Xinliang, (2017) *Impacts of land-use and land-cover changes on river runoff in Yellow River Basin for period of 1956–2012. Chinese Geographical Science*, 27(1): 13–24.

Weng, Q. (2010) *Surface Runoff Modelling and Analysis-Remote Sensing and GIS Integration, Theories, Methods and Applications.* The McGraw-Hill Companies

Zhang, T., Zhang, X., Xia, D. and Liu, Y. (2014) *an Analysis of Land Use Change Dynamics and Its Impacts of Hydrological Processes in the Jialing River Basin Water*

Zhang, L., Li, W. Chen, Z, Hu, R., Yi, Z. Qin, C. & Li, X. (2025) Impacts and Predictions of Landuse/cover on Runoff in the Jinghe River Basin, China. Land14 (3) 6