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Application of GIS-based SCS-CN method for Runoff Estimation in the Kubanni Drainage Basin, Zaria, Nigeria

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Abstract

The problem of soil erosion and sedimentation of water courses is becoming widespread due to increasing unwholesome land use practices and population pressure on limited landscape. To ascertain the response of Kubanni drainage basin to natural and anthropogenic forcing, this study adopted SCS-CN and geospatial technology to estimate the runoff of the Kubanni drainage basin. Some of the unique contributions of this study include the determination of the HSG and SCS-CN for the Kubanni drainage basin as a precondition to estimate runoff in a GIS environment. Satellite images of Landsat OLI for December 2014 and 2018, rainfall data from 2014 to 2018, soil data and DEM of 30-meter resolution were utilized for the study. A maximum likelihood supervised classification method was adopted in processing the satellite images to determine the LULC classes for the Kubanni drainage basin landscape. The LULC classes for the study area include built up area, water, vegetation, farmland and bare land. The SCS-CN values for the sub basins of Goruba, Maigamo, Tukurwa and Malmo were discovered to be 79.724, 76.506, 71.470 and 66.004 respectively, while the average SCS-CN value was found to be 73.426. The volume of runoff for the year 2014, 2015, 2016, 2017 and 2018 were discovered to be 1,435,722.7m^3, 1,651,498.6m^3, 1,281,367.5m^3, 1,051,406.9m^3 and 1,592,346.9m^3 respectively, while the average runoff was found to be 1,402,406.52m^3 $year^{-1}$. The model of this study is empirically viable and demonstrates its applicability in investigating watershed runoff due to anthropogenic and climatic forcing.

Keywords: *Runoff, Infiltration excess, Saturation excess, Initial abstraction and Kubanni drainage basin.*

Application de la méthode SCS-CN basée sur le SIG pour l'estimation du ruissellement dans le bassin versant de Kubanni, Zaria, Nigéria

Resume

Le problème de l'érosion des sols et de la sédimentation des cours d'eau se généralise en raison de l'augmentation des pratiques malsaines d'utilisation des terres et de la pression démographique sur un paysage limité. Pour déterminer la réponse du bassin versant du Kubanni au forçage naturel et anthropique, cette étude a adopté la technologie SCS-CN et géospatiale pour estimer le ruissellement du bassin versant du Kubanni. Parmi les contributions uniques de cette étude, mentionnons la détermination du HSG et du SCS-CN pour le bassin versant de Kubanni comme condition préalable à l'estimation du ruissellement dans un environnement SIG. Des images satellites de Landsat OLI pour décembre 2014 et 2018, des données pluviométriques de 2014 à 2018, des données sur le sol et un DEM d'une résolution de 30 mètres ont été utilisés pour l'étude. Une méthode de classification supervisée de probabilité maximale a été adoptée lors du traitement des images satellites afin de déterminer les classes LULC pour le paysage du bassin versant de Kubanni. Les classes LULC pour la zone d'étude comprennent la zone bâtie, l'eau, la végétation, les terres agricoles et les terres nues. Les valeurs SCS-CN pour les sous-bassins de Goruba, Maigamo, Tukurwa et Malmö se sont révélées être de 79,724, 76,506, 71,470 et 66,004 respectivement, tandis que la valeur moyenne SCS-CN s'est avérée être de 73,426. Le volume de ruissellement pour les années 2014, 2015, 2016, 2017 et 2018 s'est avéré être de 1 435 722,7m^3, 1 651 498,6m^3, 1 281 367,5m^3, 1 051 406,9m^3 et 1 592 346,9m^3 respectivement, tandis que le ruissellement moyen a été constaté à 1,402,406.52m^3 $year^{-1}$. Le modèle de cette étude est empiriquement viable et démontre son applicabilité dans l'étude du ruissellement des bassins versants dû au forçage anthropique et climatique.

Mots-clés : *Ruissellement, Excès d'infiltration, Excès de saturation, Prélèvement initial et bassin versant de Kubanni.*

INTRODUCTION

Drainage basin is a unique physical feature of tremendous geomorphologic and hydrologic importance. Horton (1932), recognized the drainage basin as a fundamental geomorphological unit which is frequently used as the primary landscape unit for hydrological, water supply and ecological investigations and for land management activities. It is therefore a fundamental unit upon which runoff investigations are based. Scholarly efforts have been made to define the drainage basin system. Goudie (2004) defined drainage basin as an area of land that contributes water and sediment to a specific outlet point on a stream. The watershed plays a dominant role in the development of landforms and therefore, the study of drainage basin has a great significance in geomorphic studies (Abdulrahaman, Abdulajeez, Aruchamy & Jegankumar 2015). The abuse of the drainage basin by anthropogenic interference promotes degradation which exacerbates rainfall runoff. The impingement of rainfall on a drainage basin triggers processes which result into storm runoff generation, soil loss, sediment yield and erosion. Storm runoff generation refers to a suite of processes that produce and route flow from landscape segments to stream channels in response to rainfall event (Goudie 2004) thereby determining the magnitude of sediment transport in water erosion process. Runoff is facilitated by the composite influences of climatic and physiographic factors. The climatic factors which affect runoff include rainfall intensity, rainfall duration, rainfall distribution and direction of prevailing wind. In the same vein, the physiographic factors which influence surface runoff are size, shape, slope of drainage basin, land use and soil type (Fowler, et al., 2018; Lotz, et al., 2018 & Sharma, et al., 2019).

An understanding of the key mechanism for runoff generation whether infiltration excess or saturation excess is fundamental to identifying the runoff zones. Infiltration excess or Hortonian flow occurs when rainfall intensities exceed the rate at which water can infiltrate the soil. Contrastingly, the saturation excess runoff is generated when rain encounters soils that are nearly or fully saturated with water. Infiltration excess is considered the main mechanism for runoff in areas having semi-arid tropical climate where rainfall intensities are high and the soil infiltration capacities is reduced due to surface sealing (Vaezi, Bahrami, Sadeghi & Mahdian, 2010). High rainfall intensities see unconsolidated soil materials entrained in surface runoff which serve as a sediment transporting media of drainage basin. Runoff within drainage basin in semi-arid zones which exceed normal threshold have been observed to pose great danger to the integrity of soils (Yosef & Asmamaw, 2015), thus causing great concern to agriculturalists, geomorphologists and conservation experts. The nature of runoff in a drainage basin varies from high concentrations of suspended sediment load, solute conveyance to reservoir and dam siltation. The point of controversy in our present knowledge of runoff is the uncertainty as to whether the record of stream discharge can approximate runoff in a drainage basin landscape. The work of Bowale (2005) estimated the river discharge of the Kubanni drainage basin. Yusuf (2013) also estimated stream discharge within the Kubanni drainage basin landscape. But the problem here is that while Yusuf (2013) incorporated the land use and land cover (LULC) of the Kubanni basin, the scope of the work of Bowale (2005) did not include the incorporation of LULC in his studies. Moreover, both Bowale (2005) and Yusuf (2013) did not integrate data on soil conditions of the drainage basin in their work. The integration of LULC and soil data for the estimation of runoff peak discharge have been carried out in the Kubanni basin with success (Ezenwa, et al., 2022). The controversy therefore is the viability or otherwise of approximating stream discharge to runoff especially in the face of non-inclusion of data on soil conditions whereas the inclusion of soil data into runoff estimation algorithm has been practiced with success elsewhere (Majidi & Shahedi 2012; Viji, et al., 2015). Thus, a scientific study is required to sort out this uncertainty and controversy. Thus, this study attempted to estimate the runoff volume of the Kubanni drainage basin by Soil Conservation Service Curve Number (SCS-CN) method in a GIS environment. The SCS–CN method, developed by the Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA), is one of the most widely used methods in many hydrological studies, particularly for estimating surface runoff, accounting several factors such as soil, land use treatment, and topographical features, and incorporating these factors into a single SCS-CN parameter (Shrestha, et al., 2021).

The Study Area

The study site is situated in the Kubanni drainage basin in Zaria and occupies an area of landscape defined by Latitudes 11° 05′ 30″ N to 11° 10′ 30″ N and Longitudes 7° 35′ 15″ to 7° 38′ 45″ E. Taking its source from Kampaji Hill in Shika, near Zaria, Kubanni river dissects the study site and flows in a southeast direction through Ahmadu Bello University Main Campus, Samaru to empty into an impoundment — the Kubanni dam. The map of the study area is shown in (Figure 1). Geologically, Zaria is underlain by differential pre-Cambrian Basement complex formation which comprises igneous and metamorphic rocks (Wright & Mc Curry, 1970). The upper Kubanni is developed on the old granite while the downstream of the dam, the channel is incised into superficial materials and deeply weathered gneiss (Ololobou 1982).

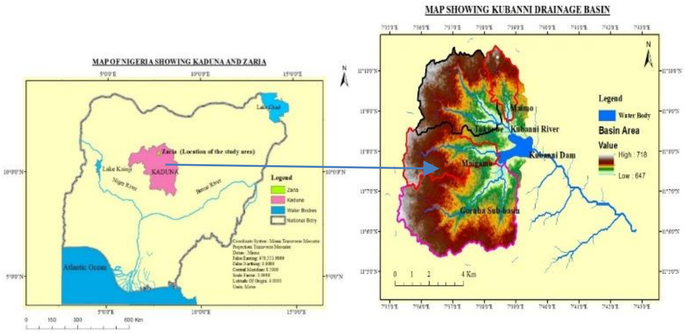

Figure. 1: Kubanni Drainage Basin in Zaria Kaduna

With the summits of the residual hills of Kufena and Kampaji at 820 meters and 708 meters respectively above sea levels, the Kubanni drainage basin which is our study area is characteristically enmeshed between these two prominent landmark features (Iguisi, 1996). The drainage system of the Kubanni River traces four tributaries upstream of the Kubanni impoundment reservoir, Ahmadu Bello University main campus, Samaru, Zaria. The Kubanni drainage basin landscape and its network are shown in Figure 1. From the perspective of geomorphology, Zaria landscape is characterized by thorough and deep chemical weathering which has developed thick lateritic regolith of varying degrees of induration (Bello, 1973). The study is characterized by strong seasonality in rainfall and temperature distributions (Oladipo, 1985). Seasonality in climatic conditions is caused by the oscillation over the study area of two air masses, the maritime tropical air mass (MTS) and the tropical continental air mass (CTS). The natural vegetation of the study area belongs to the northern Guinea savanna type which has been altered by human activities such as deforestation, construction, overgrazing, among others (Aminu, & Jaiyeoba, 2015). The dominant tree species found in the Zaria region are the *Isoberlinia doka, Terminalia* *avicennioides, Stereospermum kunthianum, Nauclea latifolia, Annona senegalensis and Dichrostachys cinerea* (Jackson, 1970). Most of the soils have a sandy loam texture (Jaiyeoba, 1995). The soil of the Kubanni drainage basin – our study area is mainly sandy-clayey-loam with poor infiltration capacity because of the high clay content (Iguisi, 1997).

MATERIAL AND METHODS

The data required for the estimation of the runoff volume of the Kubanni river basin were obtained from both primary and secondary sources. The primary data especially the geographic coordinates of the points in the study area from where soil samples were taken were obtained using GPS GARMIN 72H receiver. Soil samples were obtained with soil auger while rainfall data for the study area were obtained from the Institute of Agricultural Research, Ahmadu Bello University, Zaria. The secondary data on the study drainage basin was obtained from: (1) Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) with a spatial resolution of 30 m downloaded from USGS Earth Explorer. (2) Landsat OLI images (189/82) of December 2014 and 2018 were downloaded from the website of Global Land Cover Facility, www.glcf.com. The overview of the methods adopted in this study is shown in Figure 2.

The SRTM data was used to obtain the DEM of the study area. The morphometric parameters of the Kubanni basin landscape were extracted and the direction of flow from every cell in the raster was ascertained in ArcGIS 10.1 environment. The delineation of the basin boundary was carried out and the drainage boundary and size determined. A supervised image classification of the Landsat satellite images utilized in this study was carried out in ArcGIS 10.1 environment adopting the maximum likelihood classification technique. Subsequently, a reclassification operation was further carried out on the raster map data. Five land use classes emerged from the reclassification GIS operation which included built up area, water body, vegetation, farmland and bare land. The validation of all the supervised image classification was done using the confusion matrix as a tool for validation.

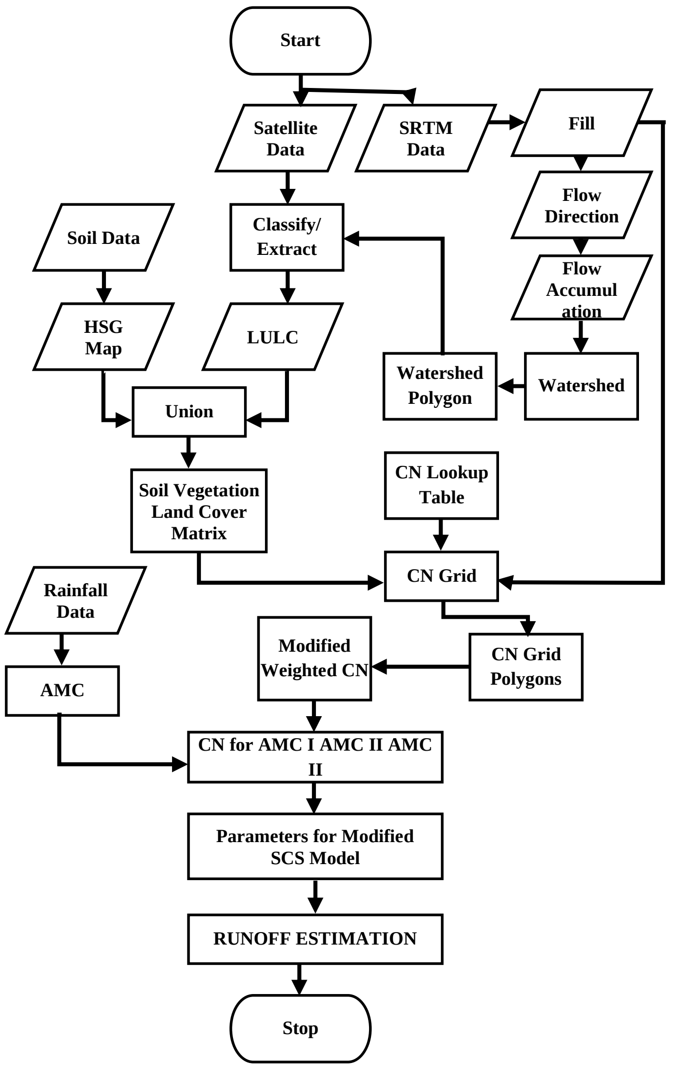

Figure 2: Schema for the Computation of Runoff in Kubanni Drainage Basin

Soil Conservation Service Curve Number Method

The SCS-CN method was originally developed by the SCS (US Department of Agriculture), to predict direct runoff volumes for rainfall events (SCS, 1964, 1972; USDA, 1986). The SCS runoff computation relation is given below:

$$Q = \frac{(P - I_a)^2}{(P - I) + S} \qquad (1)$$

Where Q represents runoff (mm), P represents rainfall (mm), S represents potential maximum retention after runoff begins (mm), and I_a represents initial abstraction (mm). Initial abstraction (I_a) denotes all losses before runoff begins in a watershed. The losses were incurred from the water retained in surface depression (surface detentions/detention storage, puddles or pools), water intercepted by vegetation, evaporation and infiltration I_a was highly variable and generally was correlated with vegetation cover parameters. The empirical relation used to approximate I_a is given as follows:

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

S as the potential maximum retention was calculated using the relation

$$S = \frac{25400}{CN} - 254 \qquad (3)$$

The SCS-CN (a parameter with a SI unit of measurement ranging from 0 to 100) was determined based on LULC, HSG and AMC. HSG is expressed in terms of four groups (A, B, C, D) according to the soil's infiltration rate. AMC is expressed in three levels (I, II and III), according to rainfall limits for dormant and growing seasons. SCS-CN value was adopted from Technical Release (TR-55). SCS-CN has been modified for application to larger watersheds by weighing curve numbers with respect to watershed/ land cover area. Equation of Weighted CN is given below.

$$CN_W = \frac{\sum(CN_i \times A_i)}{A} \qquad (4)$$

Where CN_W represents weighted curve number, CN_i represents curve number from 1 to any no and A_i represents area with curve number CN_i

Antecedent Moisture Condition (AMC)

The concept of AMC is generally used to gauge the moisture content of the soil of a watershed at any given time. The average levels of soil moisture content fluctuate on a daily basis. The AMC for this study was determined by computing the records of daily rainfall amounts for five consecutive days before a storm event (Hjelmfelt, et al., 1998). The SCS recognizes three antecedent soil moisture conditions and categorized them as AMC I, AMC II and AMC III in sync with soil, vegetation and land use characteristics. The determination of SCS-CN values for the Kubanni drainage basin landscape was predicated on rainfall limits and soil conditions for dormant and growing seasons in terms with Table 1 (McCuen, 1982).

The Kubanni Drainage Basin Model

The Kubanni drainage basin boundary was delineated and the drainage basin size determined. Similarly, the sub basins boundaries were delineated and the sub basin sizes determined. The Kubanni drainage basin model is shown in Figure 3.

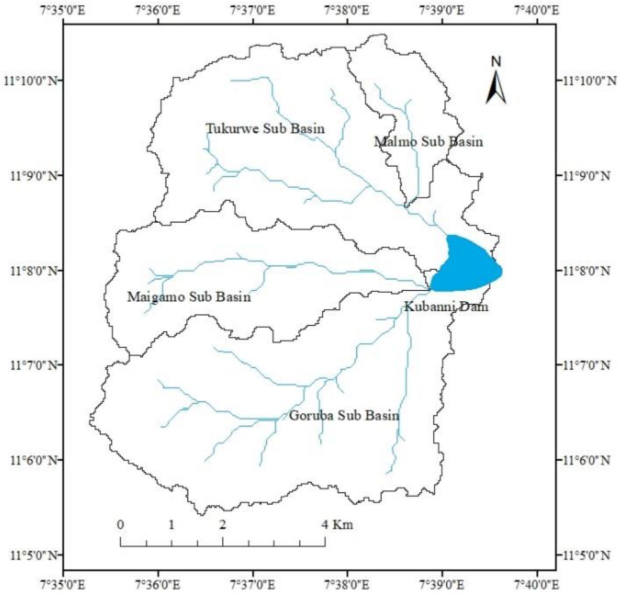

Figure 3: Kubanni basin model

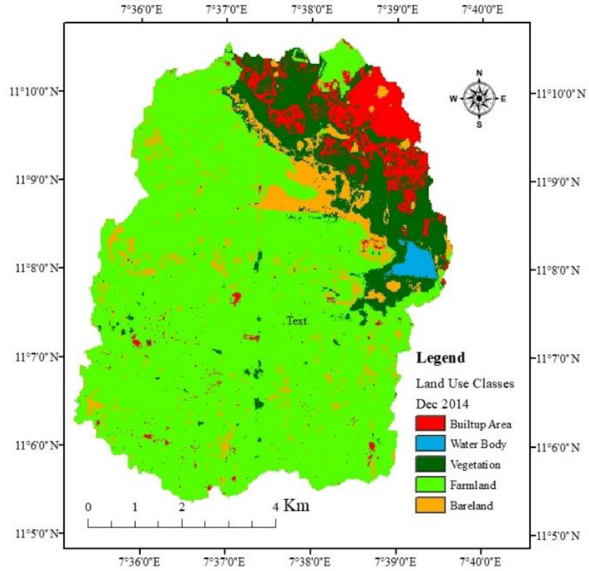

Figure 4a: LULC December 2014

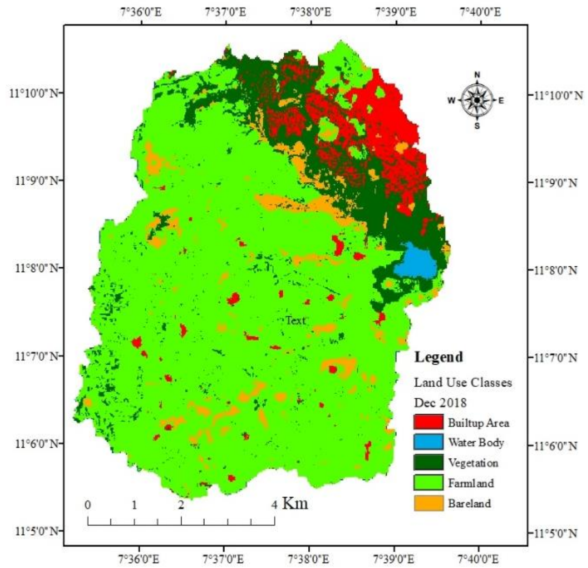

Figure 4b: LULC December 2018

Land Use and Land Cover Classification Maps

The LULC classification of the Kubanni drainage basin was realized adopting the maximum likelihood classification technique of the supervised image in ArcGIS 10.1 environment. Image classification operations returned five land use classes which included built up area, water body, vegetation, farmland and bare land as shown in Figure 4a and 4b.

Table 1: AMC for determination CN Values (McCuen, 1982)

AMC	Total Rain in Previous 5 days	
	Dormant Season	Growing Season
I	< 13	< 36
II	1 - 28	36 - 53
III	> 28	> 53

Source: (McCuen, 1982)

Hydrologic Soil Group Map

Soil classification system developed by SCS-CN has been followed while classifying soils into different hydrologic soil groups. In this study, soils are classified as A, B, C or D hydrologic soil group depending on their properties. The laboratory test conducted on the soil samples obtained from the Kubanni drainage basin landscape returned results which are indicative of the dominance of sandy loam soil in the Kubanni basin. The sandy loam soil falls under HSG A. Parts of the Kubanni basin is equally prevalent with loam soil, although sandy loam soil has preponderance over other soil types in the drainage basin. The loamy soil falls under HSG B. Figure 5 shows the map of the Kubanni basin HSG.

Curve Number Grid and Soil Vegetation Land Use Matrix

The generation of the soil SCS-CN grid for this study returned SCS-CN values for all the sub basins of the Kubanni drainage basin. The determination of the SCS-CN grid was preceded by the generation of the Kubanni HSG and Kubanni basin Soil Vegetation land use (SVL) matrix (See Figure 6). The SCS-CN Grid is shown in Figure 7 while the SCS-CN values for the basin is shown in Table 2.

Table 2: Curve Number for the Kubanni Basin

Basin	Soil Curve Number
Goruba Sub-basin	79.724091
Maigamo Sub-basin	76.505783
Tukurwa Sub-basin	71.469597
Malmo Sub-basin	66.003746
Kubanni Basin	73.4258043

Source: Author's Field Survey, 2019.

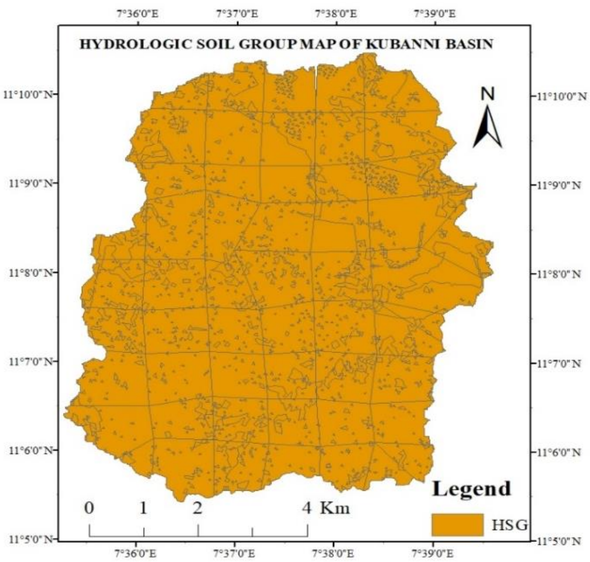

Figure 5: Kubanni Hydrologic Soil Group

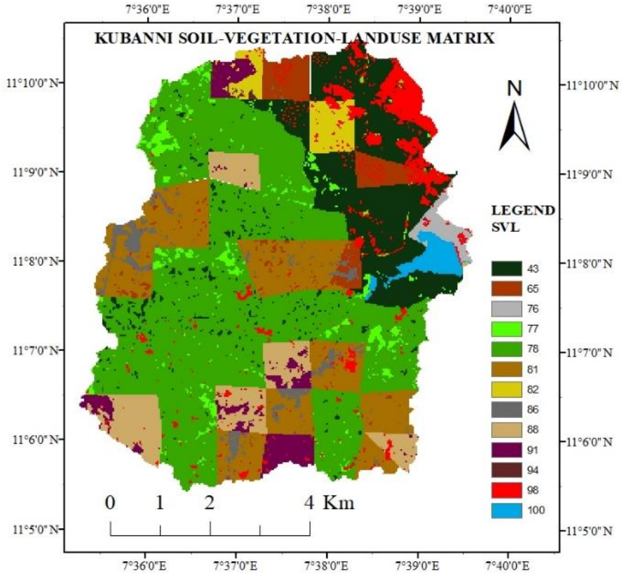

Figure 6: Soil-Vegetation-Land Use

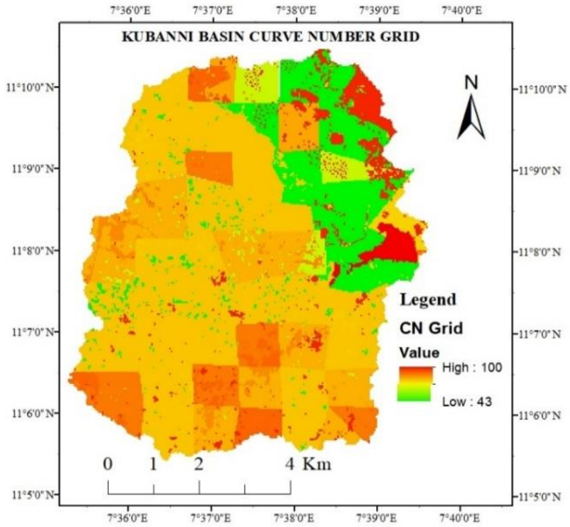

Figure 7: Kubanni Curve Number Grid Map

Runoff Estimation using the SCS Curve Number method.

The quantification of runoff for the Kubanni drainage basin was achieved through the utilization of HEC-HMS model version 4.2.1. HEC-HMS version 4.2.1 was hydrologic modeling software developed by the Hydrologic Engineering Center (HEC) of US Army Corps of Engineers (USACE, 2015). The HEC-HMS model which was an ArcGIS extension software recognizes the SCS runoff computation formula which has been factored into HEC-HMS programming language. The result of the Kubanni basin runoff estimation is shown in Table 3.

RESULTS AND DISCUSSION

The result of the estimation of the runoff profile of the kubanni drainage basin revealed that runoff volume in the year 2014 was $1,435,722.7\ m^3$ as indicated in Table 3. The runoff volumes for the years 2015, 2016, 2017 and 2018 were discovered to be 1,651,498.6m^3, 1,281,367.5m^3, 1,051,406.9 m^3 and 1,592,346.9 m^3 respectively. From Table 3, the year 2017 recorded the smallest rainfall runoff with $1,051,406.9\ m^3$ while year 2015 recorded the largest rainfall runoff volume with $1,651,498.6\ m^3$. The result of this study further revealed variations in runoff volumes which occur on an annual scale. This variation in runoff volumes is accounted for by the variation of annual rainfall amount recorded from year 2014 to 2018. It can be deduced from Table 3 that the volume of runoff in the Kubanni drainage basin relate with the annual rainfall amount recorded. For instance, the year 2015 which recorded the highest runoff volume of $1,651,498.6\ m^3$ correspondingly recorded the highest volume of annual rainfall amount of 1,227.7 mm. Similarly, the year 2015 which recorded the least runoff volume of $1,051,406.9\ m^3$ as shown in Table 3 correspondingly recorded the least volume of annual rainfall amount of 937.7 mm. The result of this study also discovered variations in runoff volumes recorded in respective sub basins. For instance, in year 2014, the runoff volume for the respective sub basins of Goruba, Maigamo, Tukurwa and Malmo was found to be 601,909.8m^3, 286,777.6m^3, 449,785.5m^3 and 97,275.3 m^3 respectively. The variations in runoff volumes between the sub basins can be attributed to the differences in the values of the SCS-CN for the respective sub basins of the Kubanni drainage basin. This assertion is collaborated by the discovery of the specific SCS-CN values for the sub basins. For instance, the SCS-CN values for the sub basins of Goruba, Maigamo, Tukurwa and Malmo were found to be 79.724, 76.506, 71.470 and 66.004 respectively. According to Al-Ghobari, et al., (2020), a high CN indicates low infiltration and high runoff while a low CN implies high infiltration and low runoff. It follows therefore from Table 3 that Goruba sub basin returned the highest CN value for this study while Malmo sub basin returned the least. As evidenced from Table 3, Goruba sub basin returned the largest runoff volumes in the years 2014, 2015, 2016, 2017 and 2018. High CN values and largest runoff volume for Goruba sub basin is imlicit with aggravated soil loss, sediment yield, sediment entrainment and dam sedimentation in the Kubanni drainage basin.

An empirical comparison of the results of this study with the studies of Majidi and Shahedi (2012); Nhamo and Chilonda, (2013) and Viji, et al., (2015) presents a mix of similarities and differences with respect to CN and runoff volumes. Nhamo and Chilonda, (2013) reported SCS-CN values of 79, 83 and 88 Tugwane Dam Catchment while Viji, et al., (2015) found SCS-CN values of 48, 68 and 83 for Kundahpalam watershed. The range of the SCS-CN values for Tugwane Dam Catchment share some similarities with that of this study. The reason for the observed similarity is the sandy loam soil type of the two basins which are moderately shallow with greyish brown colour and course grained sands. The range of the SCS-CN values for Kundahpalam watershed slightly differed from that discovered for this study. While the computed SCS-CN values for this study represented the SCS-CN profile of the respective sub basins of the Kubanni drainage basin, that of Kundahpalam watershed (SCS-CN 48, 68 and 83) were associated with AMC I, AMC II and AMC III for the entire watershed respectively. The result of this study compares favorably with that of Nhamo and Chilonda, (2013) who returned a runoff volume $6{,}850{,}000\ m^3/$ year in Tugwane Dam Catchment. Although, the runoff volume reported by Nhamo and Chilonda, (2013) contrasted with the runoff volume observed for this study, the two studies share similarity with respect to the integration of rainfall data and SCS-CN for runoff estimation. The difference in the volume of runoff generated can be attributed to the peculiarities of soil conditions, LULC, basin shape and basin size of the respective drainage basins.

Again, Shehu, et al., (2016) further collaborated the findings of this study notwithstanding that a total discharge value of $4{,}850{,}232\ m^3/yr$, mean discharge value of $0.2528\ m^3/s$ were a bit high and quite low respectively. The difference in the two results could be attributed to Shehu, et al., (2016) not taking cognizance of the influence of soil properties and associated infiltration matrix in their work. The findings of this study also mirrors a sharp contrast when compared with the results of Bowale (2005) who worked on the effect of the Kubanni dam on the morphology and hydraulics of the upper Kubanni river. While this study found the peak discharge for the Kubanni basin to be $995.7\ m^3/s$, $1{,}597.4\ m^3/s$, $532.1\ m^3/s$, $356.7\ m^3/s$ and $1{,}428.4\ m^3/s$ for the years 2014, 2015,2016, 2017 and 2018 respectively; Bowale (2005) found the river velocity and river discharge for Kubanni river as ranging between $0.0102\ ms^{-1}$ and $0.0389\ ms^{-1}$ and between $0.0034\ m^3\ s^{-1}$ and $0.0673\ m^3\ s^{-1}$ respectively. The contrast in the findings of these two studies can be attributed to temporal differences of data utilized in the studies. While this study relied on an annual data covering a five years' period from 2014 to 2018, Bowale (2005) collected the data for his study over a two weeks' period in November 2002.

Table 3: Runoff Regime for Kubanni Basin and Sub Basins

Year	Annual Rainfall Amount (mm)	Hydrologic Element	Area (Km^2)	Runoff Volume (m^3)
2014	1067.9	Goruba Sub-basin	23.82	601,909.8
		Maigamo Sub-basin	10.98	286,777.6
		Tukurwa Sub-basin	15.37	449,785.5
		Malmo Sub-basin	6.392	97,275.3
		Kubanni Basin	56.7	1,435,722.7
2015	1227.7	Goruba Sub-basin	23.82	690,708.9
		Maigamo Sub-basin	10.98	330,577.6
		Tukurwa Sub-basin	15.37	518,552.9
		Malmo Sub-basin	6.392	111,668.4
		Kubanni Basin	56.7	1,651,498.6
2016	958.5	Goruba Sub-basin	23.82	537,801.6
		Maigamo Sub-basin	10.98	257,357.6
		Tukurwa Sub-basin	15.37	400,080.6
		Malmo Sub-basin	6.392	86,127.1
		Kubanni Basin	56.7	1,281,367.5
2017	937.7	Goruba Sub-basin	23.82	526,905.8
		Maigamo Sub-basin	10.98	252,275.0
		Tukurwa Sub-basin	15.37	187,106.6
		Malmo Sub-basin	6.392	85,118.8
		Kubanni Basin	56.7	1,051,406.9
2018	1186.6	Goruba Sub-basin	23.82	665,988.4
		Maigamo Sub-basin	10.98	318,740.1
		Tukurwa Sub-basin	15.37	499,967.6
		Malmo Sub-basin	6.392	107,661.6
		Kubanni Basin	56.7	1,592,346.9

Source: Author's Field Survey, 2019.

Moreover, the methodological approaches adopted by the two studies were at variance. While this study adopted a remote sensing and GIS techniques as a methodological approach, Bowale (2005) adopted a manual methodological approach which was outside modern geospatial and GIS environment. With the foregoing comparative analysis, it can be deduced that the volume of runoff relates with the specific SCS-CN for a given sub basin within the Kubanni drainage. The variations in runoff volumes between the sub basins can be attributed to the differences in the values of the SCS-CN for the respective sub basins within the Kubanni drainage basin.

CONCLUSION

The results of the runoff estimation revealed that the values of SCS-CN for the Kubanni sub basins of Goruba, Maigamo, Tukurwa and Malmo were found to be 79.724, 76.506, 71.470 and 66.004 respectively. The volume of runoff for the Kubanni drainage basin in year 2014 was 1,435,722.7 m^3. The runoff volumes for the years 2015, 2016, 2017 and 2018 were discovered to be 1,651,498.6 m^3, 1,281,367.5 m^3, 1,051,406.9 m^3 and 1,592,346.9 m^3 respectively. Furthermore, the variations in runoff volumes for the sub basins in the year 2017 were discovered to be 526,906.8m^3, 252,275.0m^3, 187,106.6 m^3 and 85,118.8 m^3 for Goruba, Maigamo, Tukurwa and Malmo respectively. It has been established that, a high SCS-CN indicates low infiltration and high runoff while a low SCS-CN implies high infiltration and low runoff (Al-Ghobari, et al., 2020). It follows therefore that Goruba sub basin which returned the highest SCS-CN value for this study was more prone to soil erosion, soil loss, and sediment yield. As evidenced from Table 3, Goruba sub basin returned the largest runoff volumes in the years 2014, 2015, 2016, 2017 and 2018. High SCS-CN values and largest runoff volume for Goruba sub basin is implicit with aggravated soil loss, sediment yield, sediment entrainment and dam sedimentation in the Kubanni drainage basin. In this regard, this study has demonstrated that the runoff regime of a drainage basin can be investigated using satellite image products, rainfall records and soil data in the GIS environment. Therefore, this study has further shown that the runoff regime of the Kubanni drainage basin affected by factors such as LULC, AMC, rainfall receipts, Soil condition and SCS-CN with SCS-CN being the dominant influencing factors. In this respect, the study thus recommends that the Ahamdu Bello University authority should initiate a compressive monitoring of Goruba and Maigamo sub basins to curtail unwholesome agricultural practices which exacerbates soil removal and sediment yield. Furthermore, this study recommends that tree planting should be focused on Goruba and Maigamo sub basins to limit the amount of runoff generated thereby reducing the rate of water courses sedimentation from soil loss and sediment yield.

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