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A SCS-CN TECHNIQUE FOR GEOSPATIAL ESTIMATION OF RUNOFF PEAK DISCHARGE IN THE KUBANNI DRAINAGE BASIN, ZARIA, NIGERIA

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ABSTRACT

The problem of soil loss is becoming widespread due to increasing unwholesome land use practices and population pressure on limited landscape. This study employed the integration of satellite imageries, rainfall and soil data and modern GIS technology to estimate runoff peak discharge in the Kubanni drainage basin. Some of the contributions of this study include the determination of the Hydrologic Soil Group (HSG) and Soil Conservation Service Curve Number (SCS CN) for the Kubanni drainage basin with a view to investigating runoff peak discharge using geospatial technology. Satellite images of Landsat OLI for February, July and November 2019, rainfall data from 2014 to 2018, soil data and SRTM 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 Land Use and Land Cover (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 Goruba, Maigamo, Tukurwa and Malmo sub basins were discovered to be 79.72, 76.51, 71.47 and 66.00 respectively. The runoff peak discharges for the Kubanni drainage basin was found to be $995.7\ \mathrm{m^3s^{-2}}$, $1{,}597.4\ \mathrm{m^3s^{-2}}$, $532.1\ \mathrm{m^3s^{-2}}$, $356.7\ \mathrm{m^3s^{-2}}$ and $1{,}428.4\ \mathrm{m^3s^{-2}}$ for the years 2014, 2015, 2016, 2017 and 2018 respectively. The study has demonstrated the viability of adopting the SCS CN technique, satellite images, rainfall data and geospatial tools for the estimation of runoff peak discharge in the Kubanni drainage basin.

Keywords: Runoff, Peak Discharge, Infiltration, Abstraction

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 et al., 2015). The abuse of the drainage basin by anthropogenic interference promotes degradation which exacerbates rainfall runoff, soil erosion, soil loss and runoff peak discharge. The impact of rainfall on a drainage basin triggers processes which result into storm runoff generation, peak storm discharge, soil loss, sediment yield and channel 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 peak discharge is facilitated by the composite influences of climatic and physiographic factors. The climatic factors which affect runoff peak discharge 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.

An understanding of the key mechanism for runoff generation and runoff peak discharge whether infiltration excess or saturation excess is fundamental to identifying zones prone to high runoff intensity. 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 and 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 and Asmamaw, 2015) thus causing great concern to agriculturalists, geomorphologists and conservation experts. The nature of runoff peak discharge in a drainage basin varies from high concentrations of suspended sediment load, solute conveyance to reservoir and dam siltation. The key concern in the estimation of runoff peak discharge in the Kubanni drainage basin is the wisdom in the non-inclusion of soil conditions as a parameter for the estimation of runoff peak discharge. Bowale (2005) in his attempt to estimate the river discharge of the Kubanni drainage basin did not include data on the soil conditions of the drainage basin landscape. Another point of controversy in our present knowledge of runoff peak discharge is the uncertainty as to whether or not the records of runoff peak discharges reported by Bowale

(2005) compares or contrasts with results of runoff peak discharges obtained from studies which adopted geospatial techniques. 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 controversy therefore is the viability or otherwise of attempting to estimate stream discharge without the inclusion of data on soil conditions whereas the inclusion of soil data into runoff estimation algorithm has been practiced with success elsewhere (Majidi and Shahedi 2012; Viji, et al., 2015). Only the undertaking of a scientific study is required to sort out this uncertainty and controversy. Thus, this study will attempt to estimate the runoff peak discharge of the Kubanni drainage basin by adopting the Soil Conservation Service Curve Number (SCS CN) method using geospatial techniques.

Study Objective: The goal of this study is to estimate the runoff peak discharge of the Kubanni drainage basin from 2014 to 2018. The achievement of this goal entails the extraction of the map and the boundaries of Kubanni basin for the calculation of the drainage basin area, mapping the LULC and soil types of the watershed and converting the soil categories to Hydrologic Soil Groups and thereafter, computation of SCS CN and the runoff peak discharge for the Kubanni drainage basin.

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).

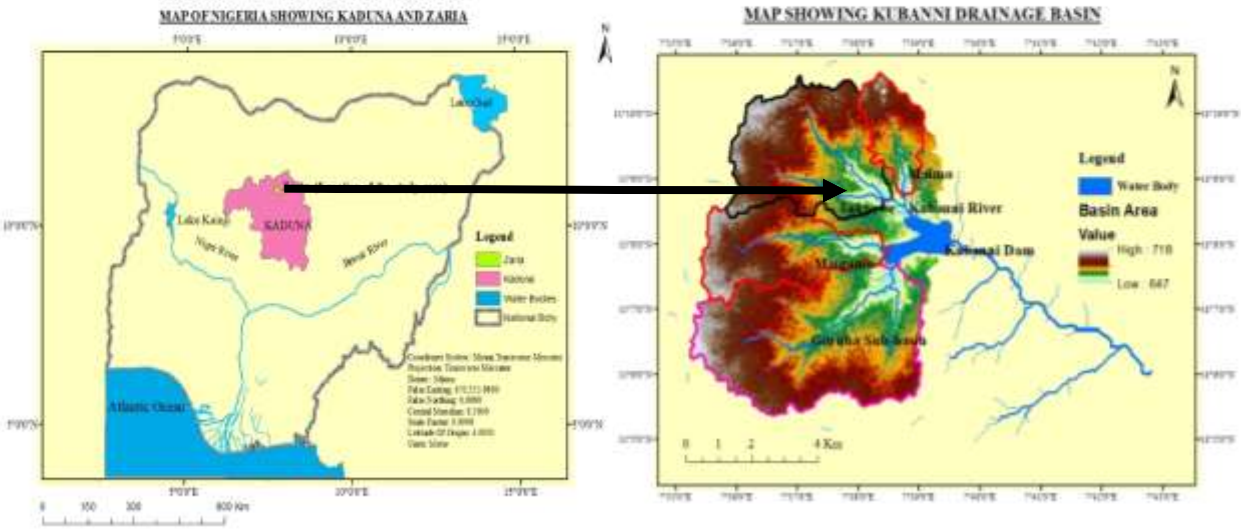

Figure. 1: Kubanni Drainage Basin in Zaria Kaduna State, Nigeria

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). With the summits of the residual hills of Kufena and Kampaji at 820 m and 708 m 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 is 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, and 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).

STUDY METHODS
The data required for the estimation of the runoff peak discharge 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 2019 images (189/82) of February, July and November 2019 were downloaded from the website of Global Land Cover Facility. The Flowchart of the procedures 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 ArcHydro 10.1 an ArcGIS software extension. 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. Thus, for all the output raster maps of the supervised image classification operation; the producer's accuracy, user's accuracy and the Kappa coefficient were determined. The Kappa coefficient was calculated using the equation below (Crnojevic et al., 2014, Leslie et al, 2017).

$$k = \frac{n \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i.} \times x_{.i})}{n - \sum_{i=1}^{r}(x_{i.} \times x_{.i})} \qquad (1)$$

where x_i denotes total observations in *i*th row, $x_{.i}$ denotes total observations in *i*th column x_{ii} denotes the number of major diagonal observations in *i*th row and *i*th column, *r* represents the number of rows in the error matrix, and *n* represents the total number of observations. (See Table 1).

Table 1: Validation matrix for July 2019 Landsat 8 Supervised Classification

Land Cover	Built up Area	Water	Vegetation	Farmland	Bare Land	Producer's Accuracy (%)	User's Accuracy (%)
Built up Area	44	0	4	1	1	91.7	88.0
Water	1	47	1	0	1	97.9	94.0
Vegetation	2	0	46	1	1	80.7	92.0
Farmland	0	1	3	44	2	93.6	88.0
Bare Land	1	0	3	1	45	90.0	90.0
Total	48	48	57	47	50		
Overall Classification Accuracy = 90.0%							
Overall Kappa Coefficient = 0.88							

Source: Author's Field Survey, 2019.

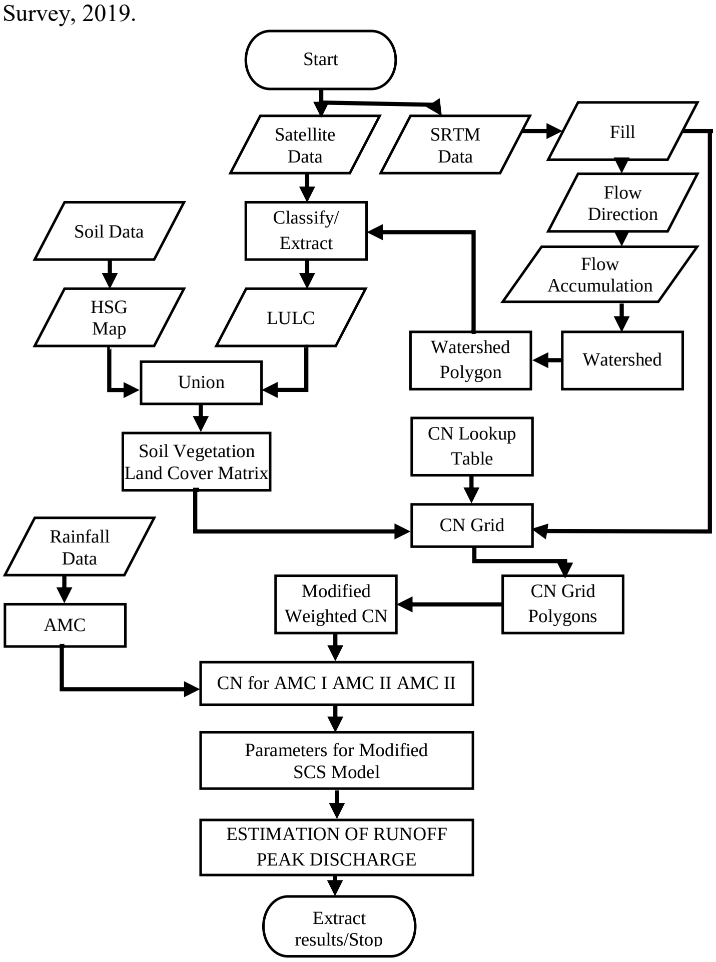

Figure 2: Flowchart for the Estimation of Runoff Peak Discharge in the Kubanni Drainage Basin Author's initiative based on theory.

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:

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

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:

$$I_a = 0.2S \qquad (3)$$

S as the potential maximum retention was calculated using the relation

$$S = \frac{25400}{CN} - 254 \qquad (4)$$

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 moderate to larger watersheds by weighing curve numbers with respect to watershed/land cover area. Equation of Weighted CN is given below.

$$CN_W = \frac{\sum(CN_i \times A_i)}{A} \qquad (5)$$

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 2 (McCuen, 1982).

The Kubanni Drainage Basin Model

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

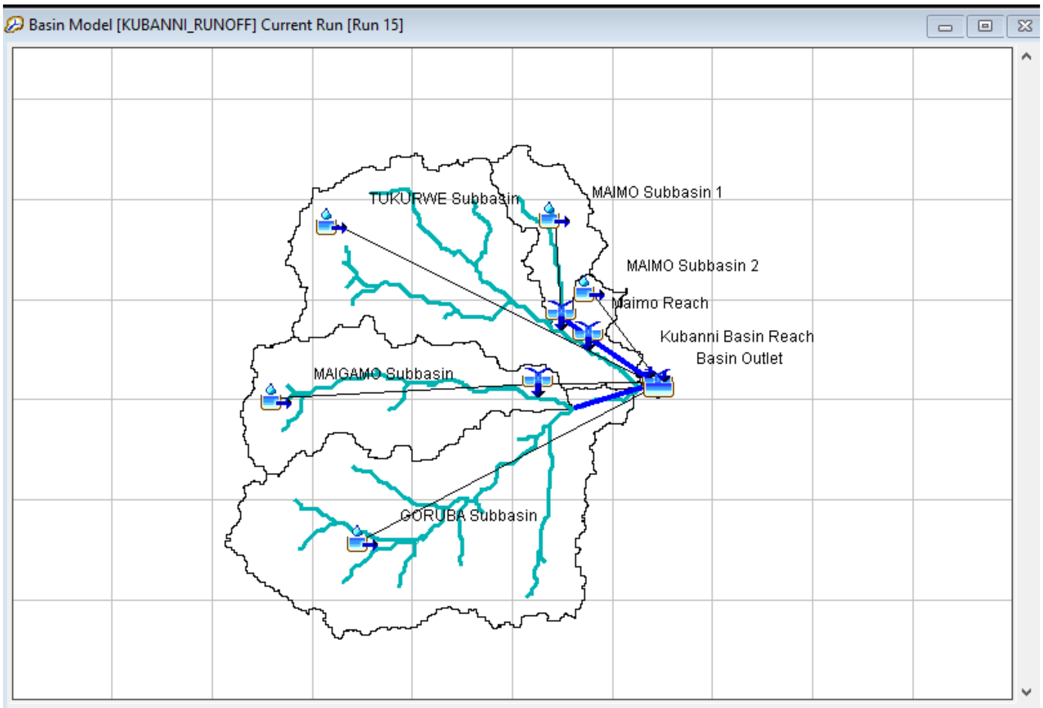

Figure 3: Kubanni basin model

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 4.

Table 2: AMC for determination CN Values (McCuen, 1982)

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

Source: (McCuen, 1982)

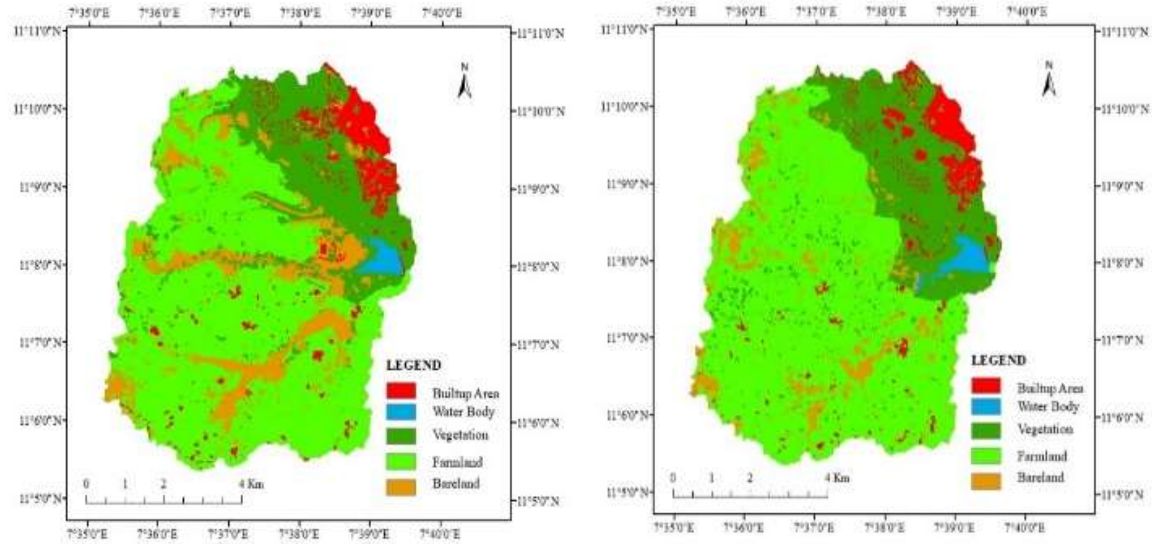

Figure 4: LULC February 2019 and LULC July 2019

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 3.

Runoff Peak Discharge Estimation using the SCS Curve Number method.

The quantification of runoff peak discharge 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 key benefit of adopting this geospatial approach for runoff peak discharge estimation is the fact that the connections between spatial entities and geographic features are stored in the geodatabase using unique identifiers in the attribute table, relationship classes and a geometric network (Li 2014; Ebb and Flow, 2012). The modelling approach adopted in this study is designed to simulate the rainfall-runoff processes in a dendritic watershed including a wide range of geographic areas from drainage basin systems and their water supply cum flood hydrology to small urban and natural watershed runoff (USACE, 2015). Details of the result of the Kubanni basin runoff peak discharge estimation is shown in Table 4.

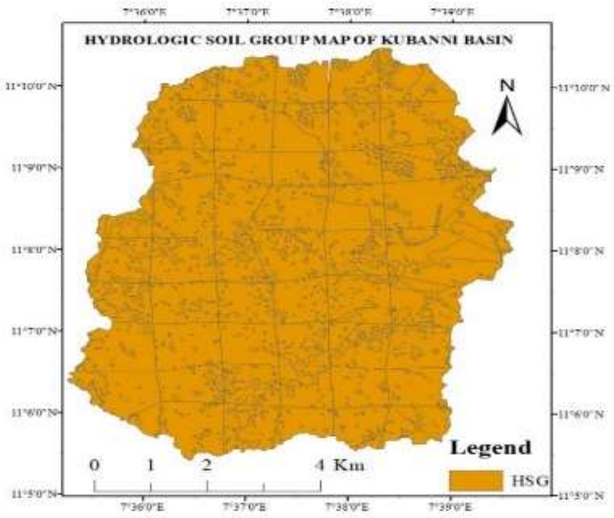

Figure 5: Kubanni Hydrologic Soil Group Map

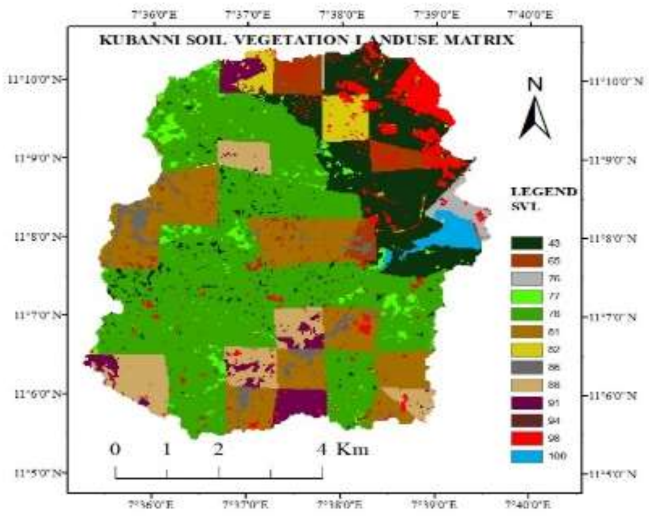

Figure 6: Soil-Vegetation-Land Use Map

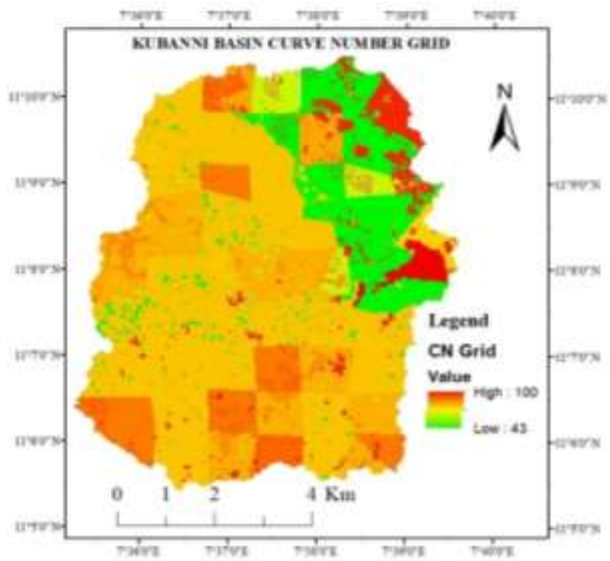

Figure 7: Kubanni Curve Number Grid Map

Table 3: Curve Number for the Kubanni Basin

Basin	Soil Curve Number
Goruba Sub-basin	79.72
Maigamo Sub-basin	76.51
Tukurwa Sub-basin	71.47
Malmo Sub-basin	66.00
Kubanni Basin	73.43

Source: Author's Field Survey, 2019.

DISCUSSION OF RESULTS

The results for the estimation of the runoff peak discharge revealed that the peak discharge for the Kubanni drainage basin was found to be $995.7\,m^3s^{-2}$, $1{,}597.4\,m^3s^{-2}$, $532.1\,m^3s^{-2}$, $356.7\,m^3s^{-2}$ and $1{,}428.4\,m^3s^{-2}$ for the years 2014, 2015, 2016, 2017 and 2018 respectively as indicated in Table 4. The year 2017 recorded the smallest runoff peak discharge volumes with $356.7\,m^3s^{-2}$ while year 2015 recorded the largest runoff peak discharge volume with $1{,}597.4\,m^3s^{-2}$. The result of this study further revealed variations in runoff peak discharge 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. For instance, the year 2015 which recorded the highest runoff peak discharge volume of $1{,}597.4\,m^3s^{-2}$ correspondingly recorded the highest volume of annual rainfall amount of 1,227.7 mm is shown in Table 4. The result of this study also discovered variations in runoff peak discharge volumes between the respective sub basins. For instance, in year 2014, the runoff peak discharge volume for the respective sub basins of Goruba, Maigamo, Tukurwa and Malmo was found $640.2\,m^3s^{-2}$, $306.5\,m^3s^{-2}$, $481.3\,m^3s^{-2}$ and $103.7\,m^3s^{-2}$ respectively. The variations in runoff peak discharge 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, Table 3 indicated that the SCS CN values for the sub basins of Goruba, Maigamo, Tukurwa and Malmo were found to be 79.72, 76.51, 71.47 and 66.00 respectively. 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 SCS CN. 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 the Kubanni drainage basin our study area. 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. Shehu, et al., (2016) further collaborated the findings of this study notwithstanding that a total discharge value of $4{,}850{,}232\ \mathrm{m^3\ yr^{-1}}$, mean discharge value of $0.2528\ \mathrm{m^3\ yr^{-1}}$ were a bit high and quite low respectively. The contrast in the two results could be attributed to fact that the work of Shehu, et al., (2016) did not incorporate data on soil conditions and its associated soil infiltration matrix. 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 $995.7\ \mathrm{m^3s^{-2}}$, $1{,}597.4\ \mathrm{m^3s^{-2}}$, $532.1\ \mathrm{m^3s^{-2}}$, $356.7\ \mathrm{m^3s^{-2}}$ and $1{,}428.4\ \mathrm{m^3s^{-2}}$ for the years 2014, 2015, 2016, 2017 and 2018 respectively; Bowale (2005) found the river discharge for Kubanni river as ranging between between $0.0034\ \mathrm{m^3\ s^{-1}}$ and $0.0673\ \mathrm{m^3\ s^{-1}}$. 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. Moreover, the methodological approaches adopted by the two studies differed one from the other. While this study adopted a SCS CN and remote sensing and GIS techniques as a methodological approach, Bowale (2005) adopted a manual methodological approach which was outside modern geospatial and GIS environment. Since SCS CN is derived using a combination of land use, soil condition, and antecedent moisture condition (AMC), then this result is in accord with Tailor and Shrimali, (2016) who found that variation in runoff and peak discharge potential correlates with different land use/land cover and with different soil conditions. Furthermore, a comparison of the runoff peak discharge volumes recorded in the respective sub basins and their corresponding areas reveal that the runoff peak discharge volume is directly proportional to the area of sub basin for any given sub basin. For instance, in the year 2016, the largest sub basin which is Goruba, with a spatial extent of $23.82\ \mathrm{Km^2}$ recorded the highest runoff peak discharge volume of $329.9\ \mathrm{m^3s^{-2}}$, while the smallest sub basin which is Malmo sub basin, with a spatial extent of $6.392\ \mathrm{Km^2}$ recorded the lowest runoff peak discharge volume of $53.4\ \mathrm{m^3s^{-2}}$.

Table 4: Runoff Regime for Kubanni Basin and Sub Basins

Year	Annual Rainfall Amount (mm)	Hydrologic Element	Area ($\mathrm{km^2}$)	Peak Discharge ($\mathrm{m^3/s}$)
2014	1067.9	Goruba Sub-basin	23.82	640.2
		Maigamo Sub-basin	10.98	306.5
		Tukurwa Sub-basin	15.37	481.3
		Malmo Sub-basin	6.392	103.7
		Kubanni Basin	56.7	995.7
2015	1227.7	Goruba Sub-basin	23.82	667.6
		Maigamo Sub-basin	10.98	319.7
		Tukurwa Sub-basin	15.37	501.9
		Malmo Sub-basin	6.392	101.2
		Kubanni Basin	56.7	1,597.4
2016	958.5	Goruba Sub-basin	23.82	329.9
		Maigamo Sub-basin	10.98	158.0
		Tukurwa Sub-basin	15.37	248.0
		Malmo Sub-basin	6.392	53.4
		Kubanni Basin	56.7	532.1

Table 4: Runoff Regime for Kubanni Basin and Sub Basins

Year	Annual Rainfall Amount (mm)	Hydrologic Element	Area ($\mathbf{km^2}$)	Peak Discharge ($\mathbf{m^3/s}$)
2017	937.7	Goruba Sub-basin	23.82	307.0
		Maigamo Sub-basin	10.98	147.0
		Tukurwa Sub-basin	15.37	253.3
		Malmo Sub-basin	6.392	49.7
		Kubanni Basin	56.7	356.7
2018	1186.6	Goruba Sub-basin	23.82	597.0
		Maigamo Sub-basin	10.98	285.9
		Tukurwa Sub-basin	15.37	448.8
		Malmo Sub-basin	6.392	96.7
		Kubanni Basin	56.7	1428.4

Source: Author's Field Survey, 2019.

With the foregoing analysis, it is scientifically safe to draw the inference that the runoff peak discharge is directly proportional to the spatial size of sub basin for any given sub basin within the Kubanni drainage basin. This submission is in agreement with (Schwab et al. 1971) who submitted that basin or watershed characteristics such as size and shape exert influence on runoff in a catchment (Schwab et al. 1971). Thus, the submission of (Schwab et al. 1971) can be extrapolated to submit in this study that watershed characteristics such as spatial area (basin size) exert an influence on runoff peak discharge volume in a drainage basin.

SUMMARY AND CONCLUSION

This study applied the SCS CN technique to estimate drainage basin, Zaria, Nigeria between 2014 and 2018. The morphometric parameters of the Kubanni basin landscape were extracted and the direction of flow from every cell in the raster was ascertained in ArcHydro 10.1 an ESRI GIS software extension. Five land use classes of the study area was determined using a supervised image classification of the Landsat satellite images in ArcGIS 10.1 environment adopting the maximum likelihood classification technique. The SCS CN was determined based on LULC, HSG and AMC of the study area. The runoff peak discharge for the Kubanni drainage basin was realized through the utilization of HEC-HMS model version 4.2.1. The annual variations in runoff peak discharge was attributed to the variation of annual rainfall amount recorded from year 2014 to 2018. The variations in runoff peak discharge between the sub basins of Goruba, Maigamo, Tukurwa and Malmo was attributed to the differences in the values of the SCS CN for the respective sub basins of the Kubanni drainage basin. In this regard, this study has demonstrated that the runoff peak discharge of a drainage basin can be investigated using satellite image products, rainfall records and soil data in the GIS environment. In particular, the integration of data on soil conditions was found viable in the estimation of runoff peak discharge volumes for Kubanni basin as this gave consideration to AMC and infiltration status of the Kubanni basin landscape. In effect, this study has further shown that the runoff peak discharge of the Kubanni drainage basin affected by factors such as LULC, AMC, rainfall receipts, Soil condition and SCS CN with SCS CN and rainfall receipts being the dominant influencing factors. The contrasts between the results of previous studies on peak discharge and this study leaned on the non-inclusion of soil data and the manual techniques of study adopted by the previous studies. Thus, has demonstrated that the investigation of runoff peak discharge using SCS CN techniques, geospatial data and geospatial tools is a viable research approach. This study therefore recommends the inclusion of soil data in future studies on runoff peak discharge in drainage basins.

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