Original Research Article

MORPHOMETRIC ANALYSIS OF RIVER DONGA WATERSHED IN TARABA STATE USING REMEOTE SENSING AND GIS TECHNIQUES

ABSTRACT

As climate change infiltrate and influence every sphere of the globe, the continuous study of the drainage features and assessment of the drainage basin as a fundamental geomorphic unit in water resources development and management cannot be relegated. This work has considered the analytical description of the physical division of RDCA. The three domains of the morphometric parameters (linear, areal, and relief aspects of the basin) were considered for the analysis. Remote sensing and GIS techniques were adopted in the analysis of the data using hydrological and surface tool in ArcGIS 10.2. The acquired SRTM DEM was used to delineate the catchment area and major morphometric parameters were estimated. The results show that the basin is elongated with low leminiscate ratio. RDCA is a 7^{th}order drainage basin, with an area of 11,355km^2, having a length of about 164km^2. Value of drainage density indicates moderate runoff potentials. Stream frequency, bifurcation ratio and constant channel maintenance indicate medium permeability and that the basin produces a flatter peak of direct runoff for a longer duration. Channel encroachment, land use and land cover change seems the cause of perennial flooding in the region than change in drainage features. This study provides scientific database for further comprehensive hydrological investigation of RDCA around which Kashimbilla dam is located.

Keywords: Catchment area, GIS, morphometric parameters, River Donga, Water resources development and management

1 INTRODUCTION

Information on the morphometric parameters is pivotal to the management of water resources of any watershed. Watershed, catchment area, or drainage basins are often used interchangeable. Watershed is a contributing area from which all precipitation flow to a pour point. It is the upslope area servers of water flow to a common outlet as a concentrated drainage. Watershed provides platform within which physical processes pertinent to the general hydrology of the drainage basin may be considered (Encyclopedia, 2012). Information about the watershed is useful for many fields such as forestry, agriculture and regional planning. A Morphometric characteristic of hydrologic and geomorphophic processes gives the information about the watershed formation in different scale (Singh and Singh, 1997). Management of any watershed depends upon its accurate delineation and plays an important role in the determination of the stream flow. Systemic delineation of the geometric of a catchment and its stream channel requires measurement of linear aspects of the drainage network, areal aspects of the drainage basin, and relief aspect of the channel network and contributing ground slopes (Strahler 1964). Knowledge of how water flow across a drainage basin and how changes in that area with time may affect the flow are required for successful operation of water resources and environmental planning and management of the basin. It has long been observed that the maximum flood discharge per unit area is inversely related to the size of the basin. Swatantra, et al, (2015) added that the runoff of different catchment area and the geomorphologic structure are sensitive and its changing nature was controlled by runoff. However, quantitative information like these, especially, pertaining to drainage morphometric that influence flood (drainage density, drainage frequency, meandering ratio, stream order and bifurcation) germane to proper planning of a catchment especially on River Benue tributaries in the study area has not been carried out despite the fast opportunities GIS techniques avail.

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The data integration functions provided by GIS which allow the linking of information from different fields of studies have led to a much wider use of satellite imageries from remote sensing in mapping and morphometric analysis of river basins. In the past, drainage morphometric parameters were extracted from the topographical maps or field surveys. This type of study was characterized by inaccuracies and disparities. In short, one can now say that the advent of GIS and remote sensing techniques has rolled away the nineteen century's ache associated to non-conventional studies of the river basins into dungeon of forgetfulness. Research works on derivation of flood potential using morphometric characteristic and the shape indices using the integration functions by GIS has been carried out by a number of researchers in different environments and it has proven to be an accurate scientific tools for drainage basin characterization outside the nation (National Institute of Hydrology, 1993; Ward 2007; Pankaj and Kumar, 2009; Hajam et al., 2013; Rama, 2014).

In Nigeria, drainage and morphometric characteristics of some river basins have been studied using GIS and remote sensing techniques: Ogunpa and Oghere draiangda basin (Ajibade et al, 2010); Calabar river basin (Eze and Effiong 2010); Osun drainage basin (Ashaolu, 2016) river Oyun, Asa, Gongola, Kastina,(Sule and Bilewu, 2017). River Donga is one of the three major tributaries of River Benue in Taraba. Despite Its water resources potential vital for socio-economic development of the region and Taraba state at large (Adebayo and Bashir, 2005), there is no available literature regarding the characterization of this river in the State to aid in the development, management and sustainability of the basin. This research work attempts evaluation of the morphometric parameters of River Donga in Taraba State Using Geographical Information System (GIS) techniques.

2. STUDY AREA

River Donga is one of the promising tributaries of River Benue in Taraba State. This river transport rainwater with huge amounts of sediments through the town. Donga town is one of the oldest LGA in the State. It is roughly located between latitude 7^0 43^1 00^{11} N 10^0 03^1 00^{11} E and longitude 7.71667^0 10.05000^0E (Fig. 1) Its river basin covers an area of 11355km^2. River Donga is characterized by several minor catchments of about 1,135,498 hectares (Adelalu, 2018). These Sub Basins include among others Ntum, Luggungo, Mbasoand Ngo. Its sources are from Tsabga hill, which has an altitude range of 4,500 – 5,000 meters above sea level (Adebayo and Bashir, 2005). It flows southwest to other parts of the State with a volumetric flow remaining considerable even in the low water period (Adebayo and Bashir, 2005). This makes these area water resources potential for socio-economic development. However if not properly harness can boost vulnerability of such area to flooding (Adelalu, 2018).

The land surface is generally undulating with high altitude in the south-eastern part and low altitude in the north, west and southern parts of the catchment. The south-eastern part of the catchment is characterized by considerable doomed hills and intervening flat topped ridges. River Donga drains five local governments in Southern Taraba before emptying to River Benue at the Western part of the State. The LGA which are drained include Kurmi, Ussa, Takum, Wukari, and Donga. These areas are potential to flooding and again could be potent when impaired by encroachment through human activities along the bank (Adelalu, 2018). More so, the Donga system have several minor basins characterized by rising water volume which can cause back flow and consequently propel flooding of several places in the region (Adebayo and Bashir 2005). The average rainfall and runoff over the basin are 2102 mm and 1123 m^3 respectively. The land use pattern within the catchment area includes that of residential/settlements, built up areas, bare land/soil surfaces, farmlands, vegetation, rock outcrop and water bodies.The region is endowed with fertile land for cultivation of staple crops. Major crops popularly grown in this area among others include sugar cane, rice e.tc. However incessant flooding of farm land is a common challenge to rural farmers in this agrarian region. This is however not inevitable considering the pattern and stream networks of the region. To convert this resistance to resources, the federal government has embarked on dam construction in the region.

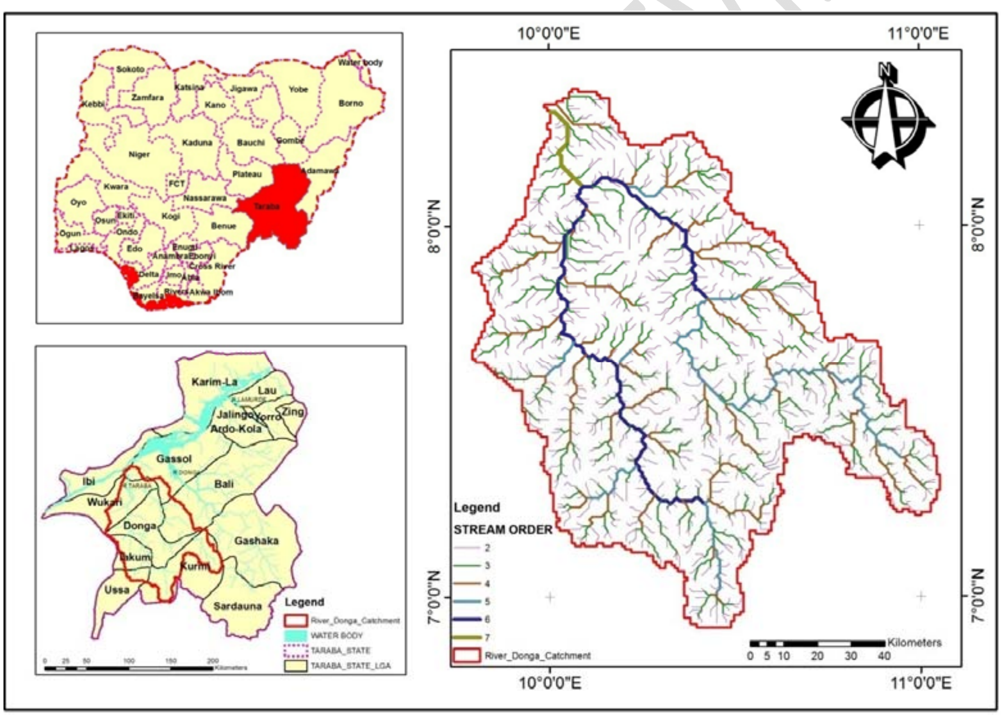

Fig.1. RDCA in Taraba State

3. MATERIALS AND METHODS

3.1 Materials

The data explored for the actualization of the objective of this work include: (i) 30 m resolution Digital Elevation Model (DEM) of the catchment area of Donga River. This was acquired from the Shuttle Radar Topographic Mission (SRTM) available for the globe and downloaded from http://srtm.usgs.gov/data/obtaing.html. (ii) Soil image was obtained from Digital soil map of the world (DSMW) from http://Worldmap.havard.edu/data/geonade.html (iii) The digital layer of geological condition of the catchment area were obtained from harmonization of the works from Federal surveys of 1959 and the Geological Survey of Nigeria in 1985 by digitizing 1: 50,000 toposheets: (194 & 195, 255 & 256) that capture the basin.

Table 1. Data used for the Study

S/N	Type	Format	Date	Source
1	Elevation Map	Digital	2015	SRTM DEM
2	Soil Map	Digital	2015	Worldmap.havard.edu/data/geonade.
3	Land-Sat 8 (Thematic Mapper)	Digital	2015	USGS Explorer
4	Slope Map	Digital	2015	SRTM
5	Drainage Map	Digital	2015	SRTM

Source: Compiled by the Authors

3.2 Methods

Importing the DEM of the study area into GIS environment, the generation of depression less DEM is the first task for morphometric analysis of a drainage basin (Swatantra, et al, 2015). Basin area derivatives such as basin area, basin perimeter, basin length, stream length and order were extracted directly from the DEM using hydrology tool under Spatial Analyst Tools in ArcGIS-10. Method for delineating the basin followed a series of these sequences: DEM, fill, flow direction, watershed, and stream order.From these, other domains of the morphometric parameters such as bifurcation ratio, stream frequency, drainage density, drainage texture, elongation ratio, circulatory ratio, leminiscate ratio, form factor among others were computed. The methodologies employed for the computation of all the morphometric parameters are tabulated in Table 1. The map obtained from Geological Survey of Nigeria that capture the

RDCA was georeferenced to WGS 1984 zone 31 and digitized. The shape file from the delineated basin of RDCA was then overlaid on the digitized map.

The soil image file from DSMW was loaded through Arc Catalog and Arc Map. The intention was to add the raster file of the DSMW. The raster soil map was projected to WGS 1984 and the soil attributes was added using the join command. The re class tool was used to reclass the new raster map. Other necessary steps were taken and at the end the catchment shape file was overlaid on the new raster that contain the soil texture to extract the soil of the study area. Basic infiltration rate for the various soil types and its influence on flood flow was considered following the Minnesota storm water manual prepared based on the review of about thirty guidance manuals and close to about two hundred published articles on infiltration rate. The soil infiltration rates suggested in the manual are as follows: clay, sandy clay loam, sandy loam, and loam sand has- 1.524mm/hr, 5.08 mm/hr, 20.32mm/hr and 20.32/mm respectively (Minnesota storm water manual , 2014).

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Table 2. Formulae used to compute morphometric parameters and their references

Morphometric Parameters	Methods	Reference
Linear Aspects		
Stream order (U)	Hierarchical rank	Strahler (1964)
Number of Streams (Nu)	Nu=N1+N2…….N_m	Horton (1945)
Stream length in km (Lu)	Lu=L1+L2………L_m	Horton (1945)
Mean stream Length (L_{um})	L_{um}= Lu/Nu	Strahler (1964)
Bifurcation Ratio (R_b)	R_b=Nu/Nu+1	Schumm (1956)
Stream length Ratio (R_L)	R_L= Lu/Lu-1	Horton (1945)
Areal Aspects		
Area in km^2 (A)	Area calculation	Schumm (1956)
Perimeter in km (P)	Perimeter calculation	Schumm (1956)

Length of the basin in km(L_b)	Length calculation	Schumm (1956)
Drainage density (D_d)	D_d= Lu/A	Horton (1932)
Stream frequency (F_s)	F_s= Nu/A	Horton (1932)
Circulatory ratio (R_c)	$R_c = 12.57*(A/P^2)$	Miller (1953)
Elongation ratio (R_e)	$R_e = 2/ Lb*\sqrt{(A/\lambda)}$	
Form factor (F_f)	$F_f = A/Lb^2$	Horton (1932)
Drainage intensity (I_d)	I_d = Fs/Dd	Faniran (1968)
Length of overland flow (L_o)	L_o = 1/Dd*0.5	Horton (1945)
Relief Aspects		
Basin relief in m (H)	H = Z - z	Strahler (1957)
Relief ratio (R_h)	R_h = H/Lb	Schumm (1956)
Relative Relief (R_{hp})	R_{hp} = H*100/P	Melton (1957)

Source: Compiled by the Authors

4.0 RESULTS AND DISCUSSION

4.1 Soil and Hydrology of RDCA

Information on the soil of the study area based on the textural composition from 0-30 cm depth, using the harmonized world soil database version 1.2 downloaded from http://Worldmap.havard.edu/data/geonade.html depicts five different soil types on the basin (Fig. 2). Among these are NumicNitosols, Lithosols, Fluvisols, Ferric Luvisols and Ferric Acrisols. From the digital map, more than half of the land areas of the study catchments support Acrisol. Acrisols form an old landscape, as classified by the Food and Agriculture Organization of the United Nation (FAO). Ferric Acrisols and Ferric Luvisol which form about 66% of the geologic basement are clay-rich and are associated with humid, tropical climates. The soil infiltration rate suggested in the Minnesota storm water manual (2014) for clay 1.524mm/hr. Minnesota storm water manual (2014) which was prepared based on the review of thirty guidance manuals and close to two hundred articles on infiltration rate hinged the inference for this study. The soil infiltration rates suggested in the manual are as follows: clay, sandy clay loam, sandy loam, and loam sand has- 1.524mm/hr, 5.08 mm/hr, 20.32mm/hrand 20.32/mm respectively. Next to this soil type as typified from the database is Lithosols. This is a shallow soil consisting partially weathered rock (parent material). Just like pave cement, it neither hold runoff nor support infiltration (Nicholas et al.2015), and this type of soil account for about 27% of the catchments terrain in the study area. This has implication on the hydrology of the basin of the study area. A soil with low infiltration rate with a region of continuous incremental torrents will produce flood events. A low rainfall rate and high infiltration extensive un-encroached basin may not produce any flooding event. The rate of infiltration and overland runoff are also influenced by other factors like land use and land cover, basin characteristics such as slope, drainage density, elongation ratio. Also rainfall characteristics such as intensity, amount and duration are factors of consideration for infiltration and overland flow discuss. Suffice to say that soil type/texture in isolation is not enough factor to explain the process of the basin hydrology. Figure 2 shows the soil map of RDCA.

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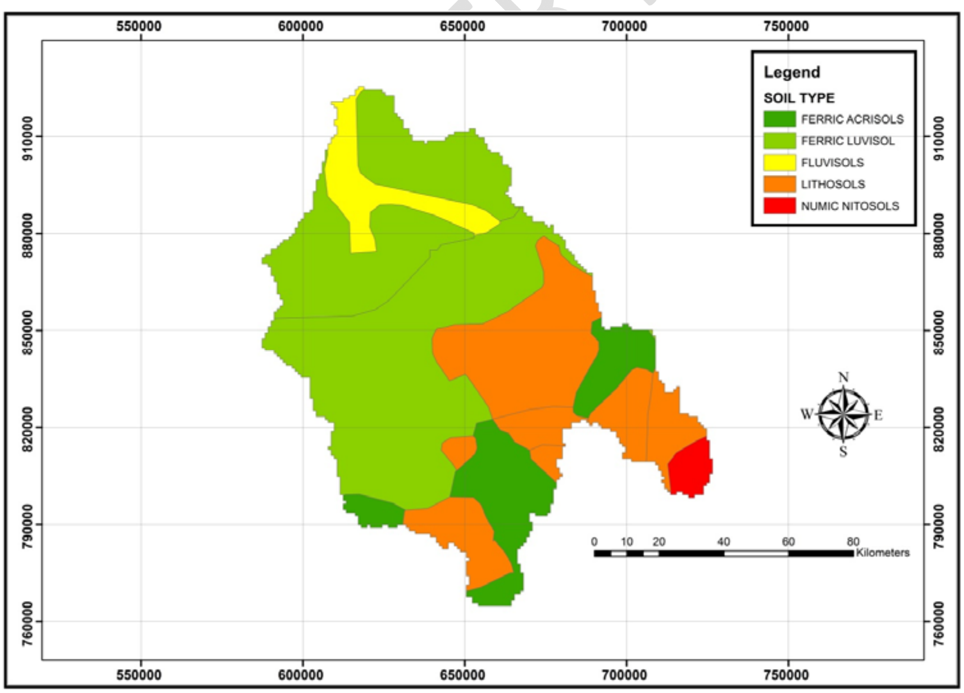

Fig. 2. River Donga Basin Soil

Table 3. Soil type and percentage covered in RDCA

SOIL TYPE	AREA (km2)	Percentage
FERRIC ACRISOLS	1377.674015	12.13
FERRIC LUVISOL	6096.982828	53.69
FLUVISOLS	671.959983	5.92
LITHOSOLS	3023.124682	26.62
'NUMIC NITOSOLS'	185.293719	1.63
TOTAL	11355.03523	100

4.2 Linear Features of RDCA

Linear feature is a measure of the axial divides, links and layout of the stream and the basin. The analyzed basin network of RDCA is presented in Fig. 2. Table 3 shows the results of the linear features of morphometric parameters.

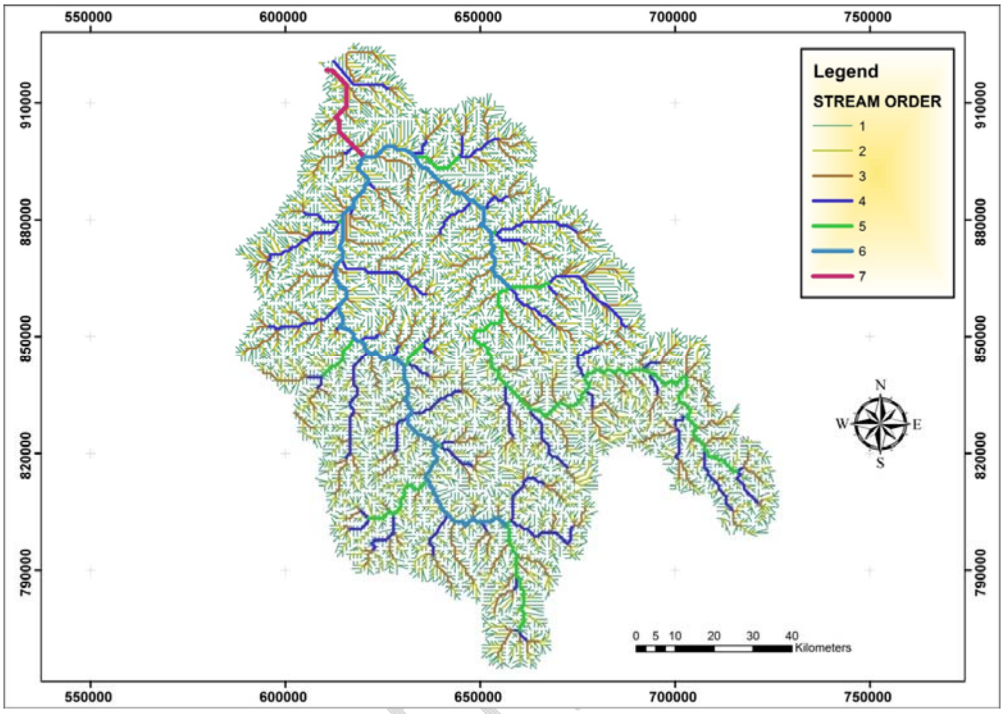

Fig. 3. Stream order of RDCA

4.2.1Stream Order, Stream Number (N_u)and Bifurcation ratio (R_b)

Subdivision of stream channel networks into individual lengths of channels and the hierarchical arrangement or order of magnitude of such is termed stream order (Ajaegbu and Faniran, 1992).There are many ways of stream ordering, but that proposed by Strahler, (1964) which is a modification of Horton's (1945) original method is adopted for this work. The highest order obtained using the DEM is 7^{th} order and hence the basin is designated as 7^{th} order drainage basin. In all, the total number of stream in the basin is five thousands eight hundred and seventeen (5817). The maximum number of streams (4762) was found in the first order. Also as earlier noted by pioneering researchers and generally observed in many studies today in the field of quantitative geomorphology, as the stream order increases, the number of streams decreases Table 3. Figure 2 shows different stream orders in the R DCA networking a total area of about 11,355km^2.

Bifurcation (**R_b**) is the ratio of the number of segments of a given order to that of the segments of the next higher order. The bifurcation ratio of (RDCA) ranges from 2 to 6.05, with an average of 4.33. Strahler, (1964) had earlier posited that bifurcation ratios ranging from 3 to 5 is an indication of a characteristic of a catchment area which have experienced minimum structural changes. It is an indication of anatural drainage basin system underlain with a homogenous rock (Kale and Gupta 2001). River Donga catchment area's bifurcation ratio shows that the region present drainage pattern is still somehow in the natural drainage system characterized with a homogenous rock that has not experienced serious structural changes. The bifurcation ratio of RDCA clearly can be grouped into low (stream order 7) and high (stream order 1-6). The **R_b** neither show increasing nor decreasing order from one order to the next order. These irregularities are associated to geological and lithological development (Strahler, 1964); or transitional zone of geological structure of the drainage basin (Cooray, 1984). Chorley et al. (1957) has observed that the lower the bifurcation ratio, the higher the risk of flooding, particularly of parts and not the entire basin. In the present study, stream order 7 has the lowest **R_b**. Google Earth search and ground truthing during the field work reveal two vulnerable wards along this stream order: Gyata Aure and Fada communities. This confirms the reason why Gyata Aure and Fada communities at the mouth of the basin suffer perennial flooding. However, the higher **R_b** values of the other parts of the catchment (3.69-6.05) and the presence of the elongated shape would give room for a lower and extended peak flow, which will curtail the risk of flooding in major parts of the catchment area of river Donga.

Table 4. Summary of the drainage basin parameter in the study area

Stream order (U)	No of Streams (Nu)	Total Stream Length (Lu) km	Mean Stream Length in Km (Lum)	Bifurcation Ratio (Rb)	Stream Length Ratio (	Length of overland flow
1	4762	9515.85	1.99	-	0.26	4.88
2	787	2513.44	3.19	6.05	0.47	
3	213	1050.11	4.93	3.69	0.52	
4	43	543.54	12.64	4.95	0.44	
5	9	239.55	26.62	4.78	0.87	

6	2	208.19	104.10	4.50	0.14	
7	1	29.43	29.43	2		
Total	5817	14099.76				

Source: Authors' Data Analysis

4.3 Areal Aspects of RDCA

The area (A) and the perimeter (P) of a basin are pivotal in quantitative geomorphology. Other areal aspects derivative of A and P include length of the basin (Lb), Drainage density (Dd), Stream frequency (Fs), Circulatory ratio (R_c), Elongation ratio (Re), Form factor (Ff), Length of overland flow (Lo) . The areal aspects values for River Donga Catchment area (RDCA) were calculated and the results are presented in Table 5. The area and the perimeter of Donga River Basin are 11355km^2 and 727km, respectively.

Table 5. Area features of RDCA

Basin Area (km^2)	Basin Perimeter (km)	Basin Length (Km)	Form Factor (Ff)	Drainage Density (Dd)	Stream Frequency (Fs)	Circulatory ratio (R_c)	Elongation ratio (Re)	Form factor (Ff)	Length of overland flow (km)
11355.04	727.40	164.0	0.42	1.24	0.51	0.27	0.73	0.42	4.88

Source: Authors' Data Analysis

The length of the basin (Lb) has been defined by many researchers in the field of geomorphology. Pioneer subscriber, Horton (1932), define basin length as the straight-line distance from a basin mouth to the point on the water divide intersected by the projection of the direction of the line through the source of the main stream. It is the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956). The calculated length of RDCA in accordance with the definition of Schumm (1956) was 164km.

Horton (1932) defined Drainage density (Dd) as the ratio of total length of streams of all orders within the basin to the basin area, which is expressed in km/km^2. He added that it is an indication of the closeness of spacing of channels. Dd can span from 1- 5km/km^2 in an area where slopes are gentle, where rainfall are low with present of permeable bedrock, to about 500km/km^2 in mountainous areas where slopes are steep, where rainfall total are high with impermeable rocks (Hugget, 2003). The Dd of the RDCA is 1.24km/km^2. This indicates a low Dd. Nag (1998) submitted that a low Dd resulted from a permeable land surface with less slope and good number of vegetation cover in the basin. As shown in Fig 4 .The results of the land use analysis performed for the basin revealed that the basin has 61% natural vegetation cover and 39% cultivated area and this provides the evidences for a low Dd value in the catchment area. Presence of good vegetation cover can influence drainage density. This creates biding force at the root zone thereby encouraging high infiltration capacity. High infiltration brings about slow respond to storm rainfall and as a result reducing the rate of overland flow consequently low Dd.

What factors then could be responsible for the perennial flooding in this region? It is clear that the area has no adequate documented climatic data especially rainfall. Available projected data downloaded from usgs.worldclim. and the record from the respondents in the work from Gabriel and Audu (2017) posited that in less than two decades, built- up and bare land have been increased by 4% (137.7021 km^2), and 12% (409.8324 km^2) while vegetation, water body and rock outcrop have decreased by16% (541.1142 km^2), 0.08% (2.5924 km^2) and 0.1% (3.8279 km^2) respectively. They added that even though only 8% of the respondents adduced flooding to change in land use and land cover, the analyzed imageries show that between the spaces of 16 years, the present built up area is fifth times of the capture in the year 2000 and that 16% of the vegetation cover has disappeared for other use. Based on the interview conducted, 93% of the respondents are attestants to the fact that flooding is on the increase and that 47 and 37% affirmed that increase in rainfall intensity and flood plain encroachment are the major cause respectively.

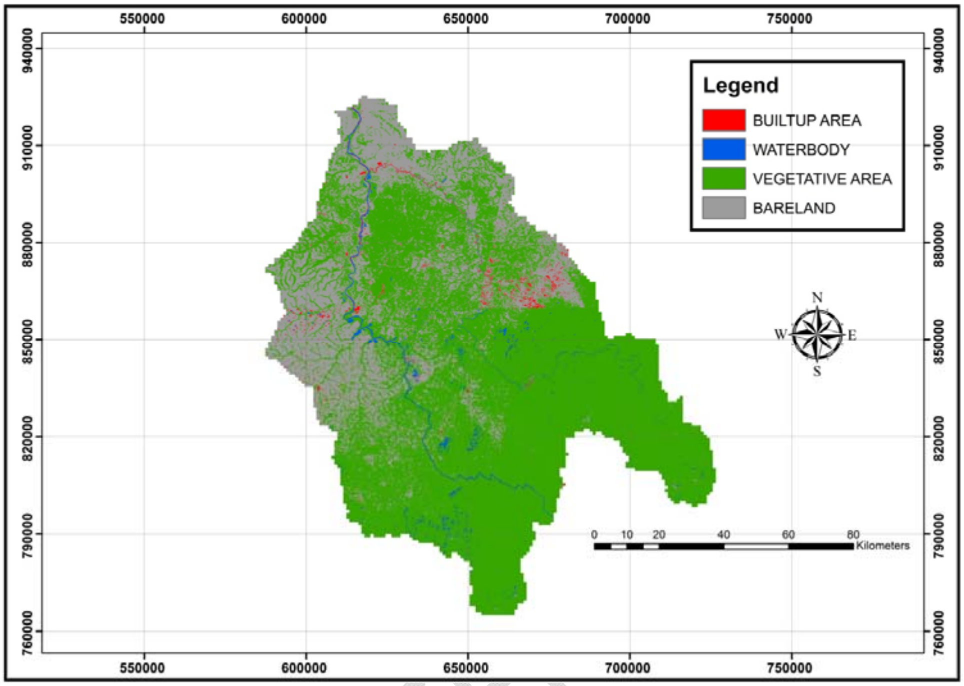

Fig. 4. Land use map of RDCA

Pioneering subscriber in the field of quantitative geomorphology, Horton, (1932), define Stream frequency (Fs) as the total number of stream segments of all orders within the basin per unit area. Fsis a suggestive of stream network distribution over the river basin. Its value may range from less than 1 to 6 or even more depending on the lithology of the basin (Kale and Guptha, 2001). In the present study, Fs of the catchment is 0.51 and it indicates a low value. This is an indication that the catchment possesses a low relief and almost a flat topography (Horton, 1932).

Circulatory ratio (R_c), is a quantitative measure to figure out the shape of the basin. It is expressed as the ratio of the basin area to the area of a circle having the same perimeter as the basin (Miller 1953). According to his finding, it is generally influenced by the length and frequency of streams, geological structures, climate, relief, slope, landuse/land cover of the basin. He described the R_c, of a basin to range from 0.4 to 0.5. Schumn, (1956) added that basin within this range of R_c value is an indication of a basin with strong elongated and highly permeable homogenous geologic base. The lower the value of R_c the less circular the shape of the basin and vice-versa. For this study, the R_c, of this catchment was derived using Miller, (1953) method. The value of R_c for RDCA is 0.269. It implies that the catchment is somehow less circular in shape, highly permeable and having low discharge of runoff. Possibility of low response to storm rainfall is associated to high storage potential. The hydrograph of the basin will show storage characteristics at first, but later response rapidly to excess rainfall.

Elongation ratio (R_e) is a paramount index in analysis of drainage basin geometry. It is the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin (Schumm 1956). Depending on the climatic and geologic types of the catchment of the basin, Re runs between 0.6 and 1.0 (Strahler, 1964). According to Withanage et al, (2014), analysis of elongation ratio indicated that the areas with higher elongation ratio values have high infiltration capacity and low runoff. R_e has been applied also to characterize relief of basin shape. Slope of river basin with elongation ratio (0.9-1.0) circular, (0.8-0.9) oval, (0.7-0.8) less elongated, (0.5-0.7) elongated, (less than 5) more elongated (Withanage, et al. 2014). R_e of river Donga is 0.73. R_e) values close to 1.0 are typical of regions of very low relief (Nageswara et al., 2010). The Re of 0.73 is an indicative of elongated basin with low relief.

Form factor (F_f) is defined as the ratio of the basin area to square of the basin length, which reflects the flow intensity of a basin for a defined area (Horton 1932). The values of the Form factor normally vary from zero (highly elongated) to unity (perfect circular shape) (Mishra et al., 2011). Singh et al., (2014) submitted that drainage basins with high form factor experience larger peak flows of shorter duration, while basins with low form factors experiences lower peak flow of longer duration. Ashaolu, (2016) re- affirmed (F_f) benchmark of a basin above which the basin flood flows may be ungovernable and management somewhat difficult. F_f) should be less than 0.7854. The form factor of River Donga is 0.422. This indicates that the shape of the catchment is elongated as depicted by the DEM image. It means flow of a lower peak with longer duration hence the basin discharge rate could be manageable.

4.4 Relief feature of RDCA

Relief feature of a basin is a measure of the basin relief, relief ratio, relative relief and ruggedness of a basin. The elevation difference between the highest and the lowest points on the catchment area is called the total basin relief. Schumm, (1956) define the relief ratio as the ratio of maximum basin relief to the horizontal distance along the longest dimension of the basin parallel to the principal drainage line. It is the expression of the overall steepness of a basin (Ashaolu, 2016), consequently determine the gravity of scouring of the basin and ease of flood flow. Table 6 shows that the maximum height of the RDCA is 1604 m and the lowest is 96 m. The basin relief of the catchment therefore is 1508 m. The maximum relief is found in the South-Eastern part of the basin close to the source by Tsabga hill. The portions where we have the minimum basin relief coincide with the northern part of the basin. Major areas include part of Wukari, part of Takum, cut across Donga especially GyataAure and Fada town. The relief map of the basin is presented in Figure 5.

Table 6. Relief aspect of RDCA

Maximum Height of the Basin (m)	Height of the basin Mouth (m)	Total Basin Relief (m)	Relief Ratio
1604	96	1508	9.78

Source: Authors' Data Analysis

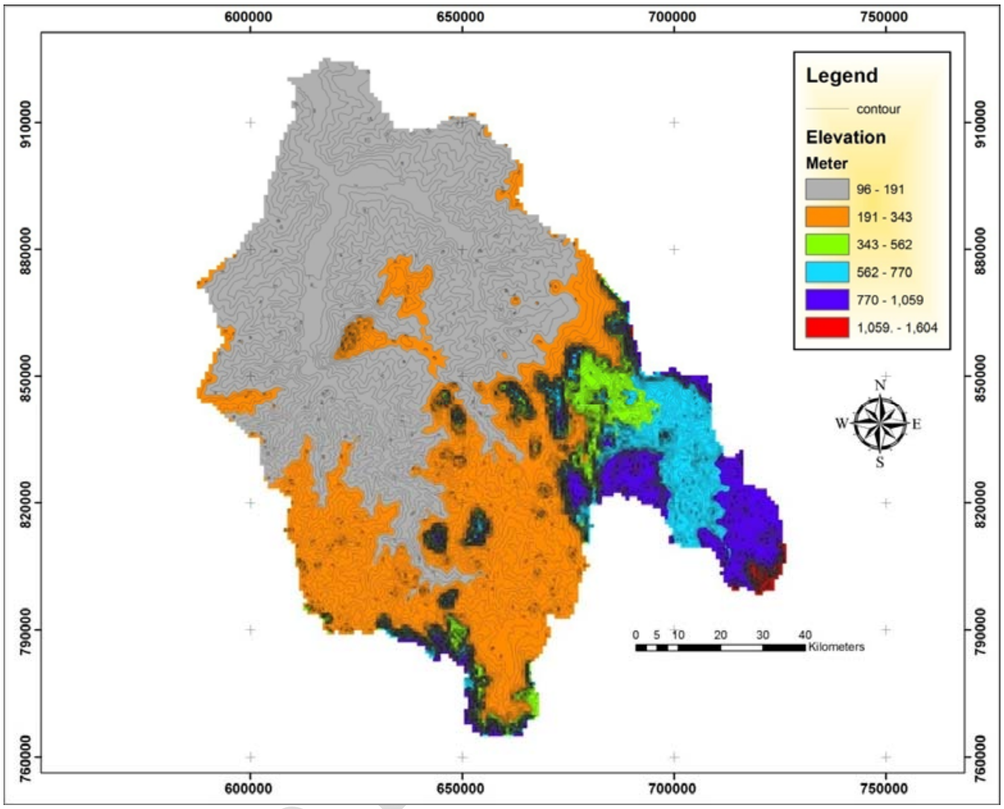

Fig5. Relief Map of RDCA

5.0 CONCLUSION AND RECOMMENDATION

This work has considered the analytical description of the physical division of RDCA. Morphometric parameters of the basin have been computed and analyzed using geo-processing technique of ArcGIS and remote sensing. GIS has proved helpful beyond reasonable doubt also in the field of geomorphology. In short, one can say that the advent of GIS and remote sensing techniques has rolled away the nineteen century's ache encountered in quantitative study of the river basin's characteristics into dungeon of forgetfulness. The morphometric analysis of the River Donga was carried on the SRTM-DEM with 30 meter spatial resolution. ArcGIS-10 software was used for analysis of the Perimeter (P), Basin Area (A), Basin length (Bl) and Stream Length (Lu). The Lu measure by using the ArcGIS software and Arc-Hydrology tool has been used for stream ordering. The studied basin has a dendritic drainage pattern with high drainage texture showing a 7th order stream network. The higher $\mathbf{R_b}$ values of the other parts of the catchment (3.69-6.05) and the presence of the elongated shape would give room for a lower and extended peak flow, which will curtail the risk of flooding in major part of the catchment area of river Donga. In summary, the findings of this study will serve as the scientific data base for further detailed hydrological investigation for sustainable water resources management of Kashimbilla dam on this catchment area of this river Donga.

In view of the water resource potential of the basin, which is capable of transforming the socio-economic status of the state, continuous study of the drainage features and assessment of the drainage basin as a fundamental geomorphic unit in water resources development and management cannot be relegated especially as climate change infiltrate and influence every sphere of the globe and sectors of the economy.

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