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DETERMINATION OF THE DRAINAGE DENSITY OF RIVER RIYADH BASIN IN AKKO LOCAL GOVERNMENT AREA OF GOMBE STATE, NIGERIA.

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ABSTRACT

This Study focused on determination of the drainage density of River Riyadh basin in Akko Local Government Area of Gombe State. The drainage morphometric parameters have been determined and measured after using the ASTER DEM (30 m) in ARC GIS 10.1. The result revealed that the basin covers an area of 8.23 square kilometer, the basin's circumference was determined as 16.61 km and the gradient (0.033). The stream orders obtained from the catchment showed 32, 7, 2, and 1 for 1st, 2nd, 3rd, and 4th orders respectively. The mean bifurcation ratio was determined as 3.36 therefore the basin is not liable to flood risk. The basin axial length is 8.35 km and is shorter than the length (8.58 km) The total length of streams within the basin was 25.510 km and the mean stream length in the basin was 0.607 km. The drainage density of the basin is 3.1 and it implies that the area is highly dissected. This study did not determine the Cross-profile of the river. The study recommended that further studies should be carried out on the Cross-profile of the river. It is also recommended that human activities such as cultivation and constructions should comply with international best practices that minimize geomorphological processes that could aggravate basin dissection.

Keywords: Determination**,** Drainage, Density, Riyadh and Basin

INTRODUCTION

Drainage density, a fundamental concept in hydrologic analysis, is defined as the average length of stream channel per unit area. The term was first used by Horton (1932), and it is calculated by dividing the sum of the lengths of all the streams in a drainage basin by the drainage area. A drainage basin with a high drainage density will have a highly dissected drainage area and a relatively quick hydrologic response to rainfall events. A drainage basin with a low drainage density will have a slow hydrologic response (Melton, 1957).

Numerous Digital Elevation Model (DEM)-derived geomorphic indexes have been created recently with the development of remote sensing and geographic information systems (GIS), and they are now widely used for quantitatively describing the size and shape of the Earth's landforms as well as for examining the geomorphic evolution and the surface process (Mahmood & Gloaguen, 2012; Radaideh & Mosar, 2019; Kumar & Singh, 2021). One of the many physiographic characteristics of basins considered as an index of surface processes and the fundamental parameter to control and influence the hydrological characteristics of any basin is the drainage density (Dd), defined as the ratio between the cumulative length of channels and the area of the drained basin (Horton, 1932). (Horton, 1945). It is still one of the most commonly used indices for the characterization of fluvially dissected landscapes (Spagnolo, 2002).

In recent years, studies on drainage density have been carried out in many parts of the world and achieved many research results; this includes the works of Melton (1958); Daniel (1981); Oguchi (1997); Schumm

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(1997); Osman (2002); Oyegoke & Ifeadi (2007); Giachetta, *et al*. (2014); Sangireddy et al., 2016; and Yan, *et al.* (2018) Liu et al., 2019; Radaideh and Mosar, 2019; Ayaz and Dhali, 2020; Kumar and Singh, 2021. The basins in their areas of study were classified as the case may be, and drainage basin morphometry were related to the processes that are prevalent in such areas. But no research has been carried out in Riyadh basin. Therefore, this study was undertaken to determine the drainage density of the River Riyadh basin in the Akko Local Government Area (LGA) of Gombe State, Nigeria.

Osman (2002) evaluated drainage density of Monongahela river basin in the United States of Americaand highlighted its impact on streamflow when researching, the study focused extensively on the hydraulics of stream flow and the amount of water a river discharges at a certain location. The study did not take into account how they would affect the growth of infrastructure. The importance of such studies cannot be overstated, especially when river basins are near or pass through urban areas (Wanah 2020).

Oyegoke & Ifeadi (2007) Examined the link between the River Gongola’s drainage basin area and stream length using Strahler’s system of ordering, having concentrated on drainage basin area and stream length, their work ignored their implications on structural developments such as agricultural, residential and transportation along and across the river in the light of the fact that river banks in Nigeria are inhabited by rapidly growing populations.

Riyadh River is located South of the Gombe Metropolis, where major human activities include farming, construction of residential dwellings and roads (Wanah & Abdullahi, 2018). Because Gombe, the capital of Gombe State, is nearby, a lot of people go through the catchment daily in search of basic raw materials like farm products and pasture for cattle, as well as engaging in other socioeconomic activities. Residential, commercial, and educational facilities are being built throughout the entire Riyadh drainage basin. This is endangering the basin's natural environment, the width and depth of the river's channel, as well as attracting more people into the area (Wanah, 2020). Although the basin's features have been depicted on topographical maps and town planning charts, the drainage density of the basin has never been addressed in the study of the channel’s landforms or its effects on development. Therefore, there is a gap in meeting the aspirations of the rapidly expanding population in the basin as well as those of academics, students, and land administrators for the Riyadh River's drainage density. The importance of such a study cannot be overstated because its findings will have applications in planning for structural development in the basin.

The study is aimed at determining the drainage density of the River Riyadh drainage basin in the Akko Local Government Area of Gombe State. The specific objectives are to;

i. determine the area of River Riyadh drainage basin
ii. establish the number of tributaries in the basin
iii. ascertain the total length of stream segments in the basin
iv. determine the drainage density of the basin

MATERIALS AND METHODS

The Study Area

Riyadh drainage basin is located in Akko Local Government Area (LGA) of Gombe State. Since the basin lies close to the state capital, it is considered part of Gombe metropolis. It is located between Latitudes 10° 14' 40” N to 10° 16' 52” N and

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Longitudes 11° 06' 05" E to 11° 12' 30" E. The study area consists of relatively flat dipping area towards the east (640 m to 440 m) above sea level. The area is made up of sedimentary rocks such as sandstone, which is underlain by crystalline complex rocks. These sedimentary formations of the late cretaceous have influenced topography of the area which characterized by dissected segments due to stream incision (Wanah, 2020).

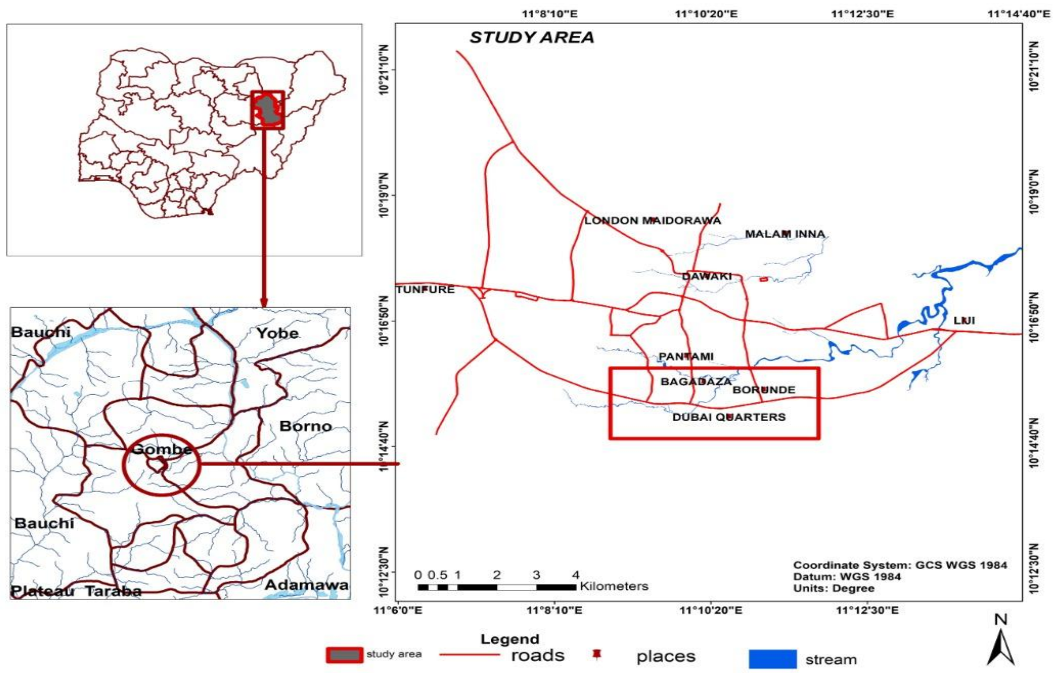

Figure 1; River Riyadh Drainage Basin

(Source; ArcGIS 10.1, 2021)

Methodology

Remote sensing and Geographic Information System have been used successfully to assess the various morphometric characteristics of surface features(Singh , Thakur & Singh , 2013). The data from the "Advanced Space-borne Thermal Emission and Refection Radiometer" (ASTER 30 m) that have been georeferenced with accurately orthorectified Global Digital Elevation Model (GDEM) were used for this work. The information was collected from the website of the United States Geologic Survey (USGS) 2021. The parameters of ASTER's GDEM are as follows:

i. Datum name: WGS 84.
ii. Spheroid name: WGS 84.
iii. Projection type: Universal Transverse Mercator (UTM).

The study region is located in UTM zone 32. The necessary region of the basinswere clipped and mosaicked using the ERDAS-IMAGINE 14 mosaic tools. The drainage system that was generated from the ASTER GDEM 30 m data were cross-verified using the Federal Survey of Nigeria (FSN 2021) subsequent topographical sheet, which were georeferenced. Using ASTER GDEM 30 m data and ArcGIS 10.1, the various morphometric parameters of the linear, relief, and areal aspects have been determined.

Extraction of Riyadh River watershed

The river basin of Riyadh was automatically extracted from the ASTER DEM (30 m) through the pour point identification with the various geo-processing tools of Arc GIS 10.1. The pour point was the user-defined cell of highest flow accumulation within DEM. The extracted drainage basin has been verified through FSN Topo sheet (1: 50,000).

Calculation of Riyadh Drainage Morphometry

The different drainage morphometric parameters (linear and areal) were extracted and calculated through a combination of geo-processing tools available in Arc GIS 10.1. First of all, the drainage network has been extracted through the Strahler's formula where segments with no tributaries identified as a first-order stream, when two 1st-order streams join form a 2nd-order stream and so on. The different aspects of drainage morphometry like bifurcation ratio (Rb), mean bifurcation ratio (Rbm), mean stream length (Lum), stream length ratio (Rl), drainage density (Dd) have been calculated through the standard formula shown Table 1.

Table 1: Morphometric parameters of a river basin

Morphometric Aspect	Parameters	Description	Formulae	References
Linear aspect	Stream order	Hierarchical rank	*u* has been calculated through the use of Strahler formula in Arc GIS 10.1	Strahler (1964)
	Stream number	N*u*= number of particular order '*u'*	*N* has been calculated for each order *(u)* through the use of Strahler formula in ArcGIS 10.1	Strahler (1964)
	Bifurcation ratio	R*b*=(*Nu/Nu*+1) were, *Nu* = number of a particular order '*u*', *Nu*+1 = Number of streams of next higher order	Rb has been calculated as the ratio of total number of streams in a given order to its next higher order	Schumm (1956)
	Mean bifurcation ratio	*Rbm* = mean of bifurcation ratios of all orders	*Rbm* has been calculated as the mean of*Rb* of all order	Schumm (1956)
	Stream length	*Lu* = total length of streams (km) of a particular order '*u*'	*Lu* has been calculated through the use of Horton formula in ArcGIS 10.1	Schumm (1956)
Areal aspect	Drainage density	*Dd* = *L/A;* where, *L* = length of streams (km), A = Basin area (km2).	*Dd* has been calculated as the length of stream channel per unit area of basin	Horton (1945)
Area	Area of Basin	*A*=Total area of the basin (Km square)	*A* has been calculated on ArcGIS 10.1	Horton (1945)

Source; Authors" compilation, 2023

RESULTS AND DISCUSSION

The drainage density and other morphometric properties of River Riyadh Drainage Basin are presented under the following sub-titles:

Area of River Riyadh Drainage Basin

Land area is one of the morphological properties of a basin, it is used in determining certain physical attributes of the basin as well as for analyzing the identified land use classes in the basin (Haghipour and Burg 2014). With respect to Riyadh drainage basin, the land

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area covers 8.23 square kilometers determined by the application of ArcGIS Software 10.1. The basin is characterized by short first, second and third order tributaries.

Circumference (Perimeter) of Riyadh Drainage Basin

Basin perimeter is used in delineating the land within a basin and is also used in describing the shape of the basin, that is whether it is elongated, rectangular, oval, or any other shape the basin might have taken (Wanah and Abdullahi 2018). The circumference of the Riyadh drainage basin which is distance along the basin divide was determined through the use of ArcGIS software. The length of the circumference determined is 16.61 km. In the case of Riyadh drainage Basin, the basin is elongated lying in a north west to south east alignment and generally dipping Eastward.

The Slope of Riyadh Basin

Channel gradient ratio can be defined as changes in vertical inclination in per unit area changes of horizontal distance. It is an indication of the potentiality for further erosion (Ibrahim and El-Tantawi 2012). The slope of Riyadh drainage basin was determined from the contour map of the basin (Figure 2) which shows the highest contour line on the crest of the basin was 640 m above sea level while lowest 440 m at the mouth of the river. The difference was 200 m. the horizontal distance between highest contour and that of the lowest contour, according to scale of the map is 6.6 km. In substituting the elevation and linear distance into the formula G = VI/HE the gradient of the basin was determined as 0.033. This is in agreement with the contour map of the basin as shown in Figure 2.

The gradient (0.033) of the Riyadh Drainage Basin implies that for every 1 unit of horizontal distance from the upper section of the basin towards the lowest, the land descends by 0.033 of the unit for every 1000 unit of the measure. This means that for 1 km distance from the highest part of the basin towards the lowest, the gradient of the land descends by 33 m. In other words, the vertical interval (rise) of the basin is 200 m over its entire stretch of 6.6 km. The contour map of Riyadh drainage basin shows vividly the degree of sloppiness of the basin. The gradient is sufficiently high to generate velocities of stream flows which together with the unconsolidated nature of material of the basin, and coupled with tropical storms, could account for the incision of water channels, and thus of streams in the basin. Furthermore, stream channels were widened through the slumping of the bank material.

Stream Orders of Riyadh Drainage Basin

Stream order (Nμ) treated as the first step of drainage analysis is based on the hierarchical ranking of streams. Horton (1945) model of ordering streams has been adapted for the present study. According to Horton's (1945), the smallest fingertip tributaries were numbered as 1st order. The 2nd order of stream forms where two 1st-order streams join. A 3rd-order stream forms when two 2nd-order streams join and so on. The main channel through which much of the water is discharged was marked as highest order stream of any particular drainage basin. This stream order depends on basin shape, size and relief characteristics of such basin (Haghipour and Burg 2014).

Horton's system of stream ordering was employed in establishing the stream orders in the basin and as shown in Figure 3. The orders obtained from the catchment are presented in Table 2 which shows that the first stream order has 32 streams; the second stream order has 7 while the third-stream order has two third stream orders which joined and formed the fourth order and the highest stream order of the basin. The

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implication of this is that Riyadh drainage basin is a Fourth order Drainage Basin.

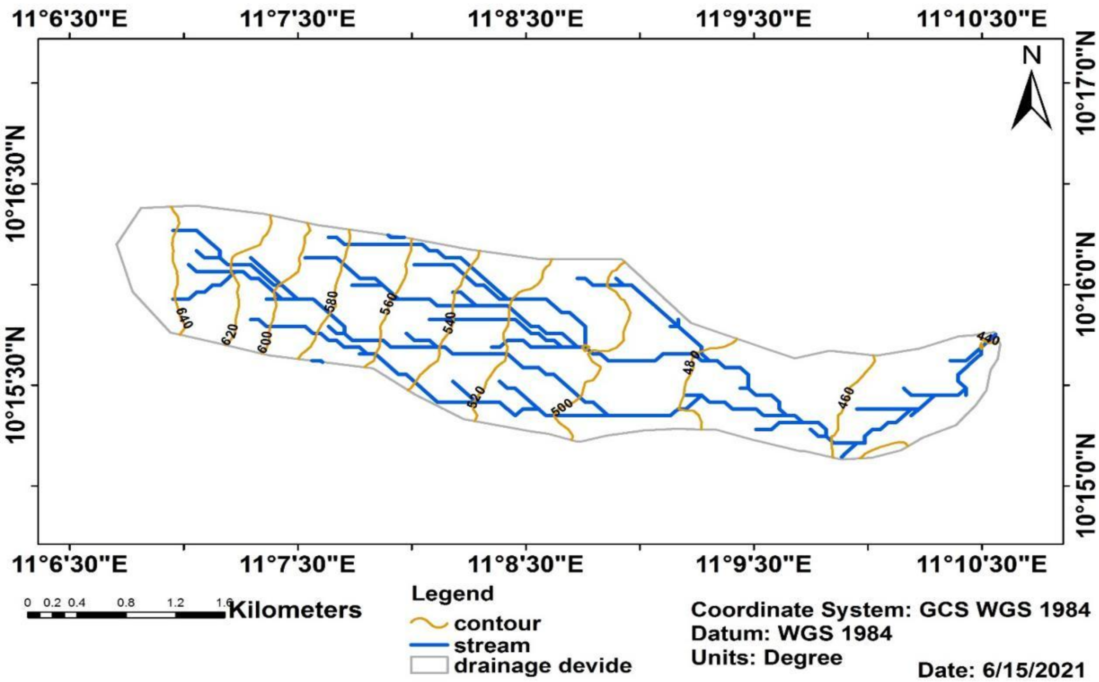

Figure 2; Contour map of Riyadh River basin

Source; ArcGIS 10.1, 2021.

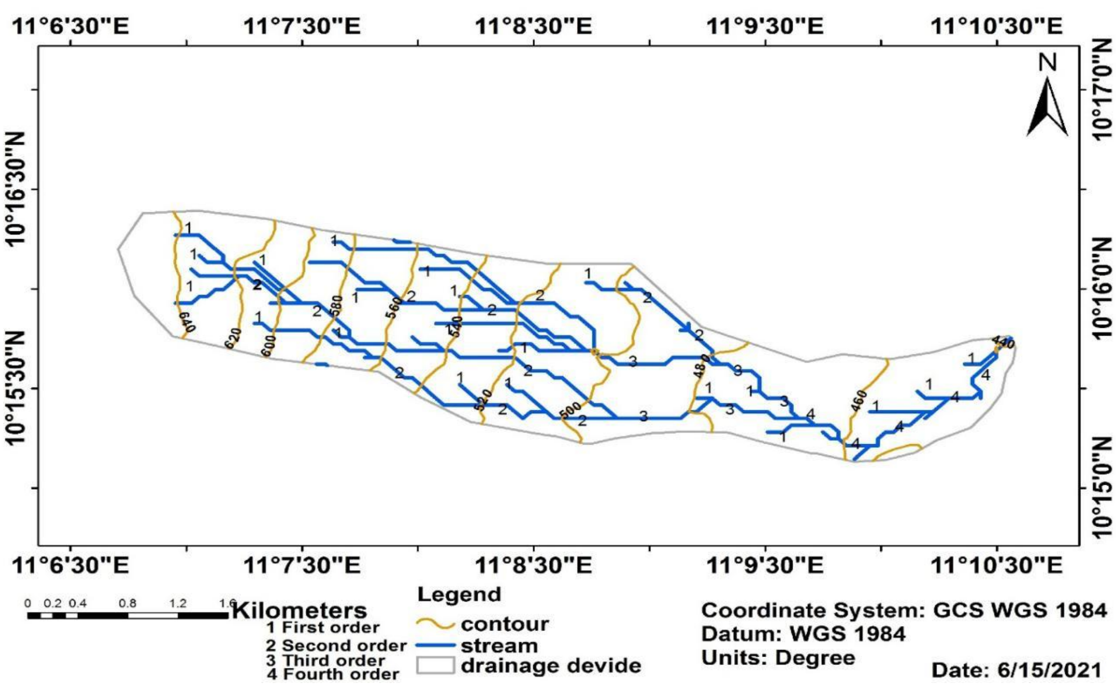

Figure 3: Stream order of River Riyadh Basin

Source; ArcGIS 10.1, 2021.

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Stream Number of Riyadh Drainage Basin

This refers to the total number of streams in a drainage basin and is an attribute of a basin that needs to be known. According to Ibrahim and Tantawi (2012), Wanah, *et al* (2018) stream number is computed by the formula (∑N) μ). The stream number of the Riyadh drainage basin was computed by the summation of the total number of streams in each stream order and the number obtained Riyadh was 42 as shown on Table 2, Stream number of a basin is of considerable importance and application in basin studies. It is employed in the study of various morphometric characteristics of a basin as noted in the works of Horton (1945), Gregory and Waning (1979). Waugh (1990), Strahler and Strahler (2002), and Ibrahim and El-Tantawi (2012), Wanah, *et al* (2018). For example, stream number is used in determining bifurcation ratio of drainage basins.

Table 2; Number of Stream Segments in River Riyadh Basin

S/N	Stream Order	Number of Streams	Percentage (%)
1	First order	32	76.19
2	Second order	7	16.67
3	Third order	2	4.76
4	Fourth order	1	2.38
5	**Total**	**42**	**100**

Source; Field work 2021

Bifurcation and Mean Bifurcation Ratios

Bifurcation ratio is the relationship between the number of Streams in one order and those of the next higher order (Waugh, 1990). It is obtained by dividing the number of streams in a lower order by the number of streams in the next higher order. Bifurcation ratio is thus obtained by the formula $Rb = N\mu / N\mu+1$. The Rb values Riyadh basin are 4.57 for 1st to 2nd, 3.50 for 2nd to 3rd, 2 for 3rd to 4th order streams as shown on Table 3.

A mean bifurcation ratio on the other hand, is the average of the bifurcation ratios in a basin, Wanah, *et al* (2017). It is used in predicting flood risk in drainage basins and is obtained by the application of the formula $Rbm = \sum N\mu / N\mu$ (Ibrahim and El Tantawi, 2012, Wanah, *et al* 2017). If mean bifurcation of a basin is less than 3, the flood risk of the basin is high. The lower the bifurcation ratio the higher the flood risk of the basin. In areas where the land surface is impermeable, slopes are steep, rainfall is heavy and prolonged, and vegetation cover is lacking, stream densities tend to be high thereby creating a situation that many streams are developed. In such a situation, mean bifurcation ratio will be greater than 3, This implies that the basin has less flood risk since the many streams in the basin would drain surface water thereby lessening the tendency of inundation or flooding. In addition, in areas where soils are sandy and permeability is high but rainfall is heavy, water channels are created thus raising stream density which implies that mean bifurcation ratio is greater than 3 (Wanah *et al* 2018).

In the case of Riyadh Drainage Basin, the bifurcation ratio is 3.36 (Table 3) and the basin is therefore not liable to flood risk. The sandy and permeable nature of the Kerri-Kerri Formation on which much of Riyadh basin lies, is expected that infiltration of rainwater will be high thereby reducing surface runoff and thus preventing stream channel development. But the situation in the basin is contrary to that expectation. Stream density in the basin and is associated with the heavy tropical storms during the rainy season accounting for surface runoff which creates the degree of dissection in the basin.

Besides, the sloppy terrain demonstrated by the contour map (Figure 2) facilitates rapid surface runoff thereby incising the landscape especially in the middle and lower parts of the basin. The impermeable surfaces in residential areas which are attributed to zincked roofs, cemented surfaces and tarred roads have further concentrated runoff thereby creating numerous stream channels. With a mean bifurcation ratio of 3.36, Riyadh Drainage Basin is not liable to flood incidences.

It was observed that the climatic and soil conditions under which Horton made his observations on flood risks in British rivers might not be similar with that of Riyadh in Gombe, Nigeria. This is because the two drainage basins lie in different climatic regions: temperate and tropical, and different geological formations. Application of mean bifurcation ratio in determining flood incidence as suggested may not be applicable for different climatic regions, the use of the presence of streams in a basin as an index for determining whether or not an area is liable to flooding cannot be dismissed as a significant ingredient in determining flood risks (Wanah, *et al* 2017).

However, the fact that landscape attributes vary from one geographical location to the other in terms of permeability, gradient, climatic conditions and anthropogenic activities, development of a single model for flood prediction might be challenged with questions that their solutions may be hard to arrive at. There is the need, therefore, of carrying out detailed studies to evolve a model for predicting flood risks that might be amenable to regions with different physical conditions. The prediction of flood risk in catchments is, however, a necessary knowledge (Wanah, *et al* 2017). Techniques of determining flood risks need to be evolved since floods are one of the most hazardous and common disasters on farm lands and in urban areas as it could cause enormous adverse impact on the environment, city infrastructure, human society and economy (Zhou, Leng and Huang, 2016).

Table 3; Bifurcation and Mean Bifurcation Ratios of Riyadh Basin

S/N	Stream Order	Number of Streams	Bifurcation
1	First order	32	4.57
2	Second order	7	3.50
3	Third order	2	2.00
4	Fourth order	1	
5	**Mean Rb**		**3.36**

Source; Field work 2021

Stream Length of Riyadh Drainage Basin

Stream length of a drainage basin is the length of the main stream of the basin. The stream length of Riyadh River from its farthest point on its longest source tributary through its meanders to its mouth was determined as 8.58 km. The distance was arrived at through the summation of the lengths of the segments of the main stream to its mouth. The distances that were summed up are shown on the stream segments in Figure 4. The length of each segment is the distance of the segment along the main stream from its first confluence with a tributary up-stream to the next confluence with another tributary down-stream (Wanah, *et al* 2017).

For the Riyadh River, there were 21 stream segments along the main river from its farthest point on its longest tributary through to its mouth. The distances shown are in meters, the sum of which is expressed in kilometers. Similarly, the stream length of

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each segment or tributary within the basin can be determined from Figure 4 by either reading off the length from the figure or by summing up the lengths of the segments that make up the tributary. This implies that the length of each first stream order can simply be read from Figure 4 whereas the lengths of any second, third and higher orders can be obtained through summing the distances of the segments that make up the stream order.

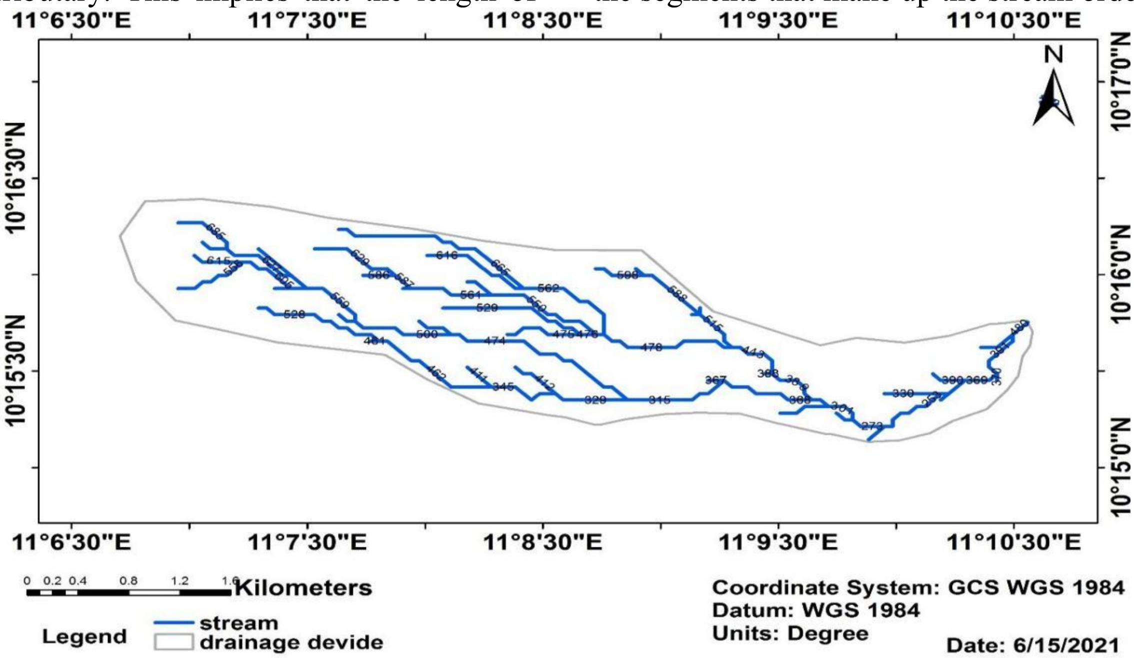

Figure. 4: Lengths of Stream Segments of Riyadh Drainage Basin
Source: ArcGIS 10.1, 2021

Total Length of Streams of Riyadh Drainage Basin

The distances or lengths of all streams of a basin are determined by summing the distances of the stream segments .in the basin. With respect to Riyadh Drainage Basin, the total length of all streams in the basin was determined by adding the lengths of all first order streams, second order streams, third order streams and so on to the highest stream order in the basin by inserting figures into formula $\sum Ln = L1 + L2 + \ldots Ln\mu$ (Ibrahim and El Tantawi 2012 and Wanah 2017). The total length of streams within the basin was 25.51 km. The summation of the total length in each stream order is presented on Table 4.

Table 4.: Total Length of streams in Riyadh Drainage Basin

S/N	Stream Order	Length of Streams (Km)	Percentage
1	First order	10.95	42.92
2	Second order	9.01	35.32
3	Third order	3.36	13.17
4	Fourth order	2.19	8.58
5	**Total**	**25.51**	**100 %**

Source: Field Work, 2021

Mean Stream Length of Riyadh River

Mean stream length *(Lsm)* is the characteristics property of drainage network and associated surface according to Strahler

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(Strahler 1964). It is an important dimension less morphometric characteristic calculated by dividing the total length of streams to the total number of streams. Most of the studies indicate low *L*sm value in mountain environment than plateau or plain morphology (Wanah, 2020). The mean stream length of Riyadh basin was obtained as 607.38 m, this implies the high erosion potentiality.

Riyadh Basin Axial Length

Basin axial length is the distance of the farthest point on the basin perimeter to the mouth of the main river in the drainage basin. In other words, basin axial length is a straight line (Crowfly) from the mouth of the main river to the farthest point on the crest of the basin (Wanah, *et al* 2018). The basin axial length of Riyadh is 8.35 km and is shorter than the length (8.58 km) of the Riyadh River. The difference (0.23 km or 230 m) of the length of the river to the axial length of the basin means that the distance covered by the river channel is longer and it could be attributed to the winding and meandering of the main stream channel.

Drainage Density of Riyadh Drainage Basin

Drainage Density (Dd) is the expression of the closeness or spacing of channels within a basin Horton (1945). As it provides a numerical measurement of runoff potentiality and landscape dissection, Dd is the important indicator of landform element. Dd measures as the ratio of the total length of streams irrespective of stream order to the unit area of the basin. Dd considers as an important parameter determining the travel time of water. The capability of any basin to drain is depended upon the drainage density of such area. Drainage density itself depends upon underlain geology, relief, climate, vegetation, among others. The amount and types of precipitation determined Dd value directly, Horton (1945).

With an area of 8.23 square kilometer and a total stream length of 25.51 km, the drainage density of the basin is 3.1. The drainage density of the basin means that for every one square unit of a linear measure on the map, stream density is 3.1 of that unit. With regard to Riyadh drainage basin, for every 1 km square of land within the basin there is 3.1 km of stream length and it implies that the area is highly dissected (Figure 5). The implication of this is that, the dissection of the land impedes human economic activities in the basin in several ways which include; high cost of constructing structural facilities such as roads, houses, and bridges, and most economics activities are situated far from the high stream density areas of the basin and less agricultural activity in the middle and lower sections of the basin. In addition, the degree of dissection in the basin may explain the slow rate of the development of housing projects in the basin in spite of the fact that there is high demand of houses in Gombe metropolitan area which is adjacent to the basin. There were very few roads developed across Riyadh River and its tributaries. The conspicuous absence of roads across and along the river is attributed to the difficulties of the terrain in infrastructural development.

In areas where the land surface is impermeable, slopes are steep, rainfall is heavy and prolonged, and vegetation cover is lacking, stream densities tend to be high thereby creating a situation that many streams are developed. In addition, where soils are sandy and permeability is high but rainfall is heavy, water channels are created thus raising stream the number of stream channels (Wanah, *et al* 2018).

In the case of Riyadh Drainage Basin, the drainage density is high in spite of the sandy nature of the Kerri-Kerri Formation on which

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the western part of the basin lies, it is expected that infiltration of rainwater is high and and thus it is expected to reduce surface runoff and therefore responsible for low stream density. But the situation in the basin is contrary to that expectation. Tropical storms during the rainy season account for surface runoff eroding the unconsolidated sandy Kerri-Kerri Formation creating the degree of dissection in the basin giving rise to high stream density in the basin. Besides, the sloppy terrain (Figure 2) of the basin facilitates rapid surface runoff thereby incising the landscape especially in the middle and lower parts of the basin. In addition, impermeable surfaces in residential areas which are attributed to zincked roofs, cemented surfaces and tarred roads have concentrated runoff thereby creating numerous stream channels.

It was observed that the climatic and soil conditions under which Horton (1945) made his observations on drainage analysis in British rivers might not be similar with that of Gombe, Nigeria. This is because the two drainage basins lie in different climatic regions: temperate and tropical, and different geological formations. However, the fact that landscape attributes vary from one geographical location to the other in terms of permeability, gradient, climatic conditions and anthropogenic activities, development of a single model for drainage studies might be challenged with questions that their solutions may be hard to arrive at. (Zhou, Leng and Huang, 2016.

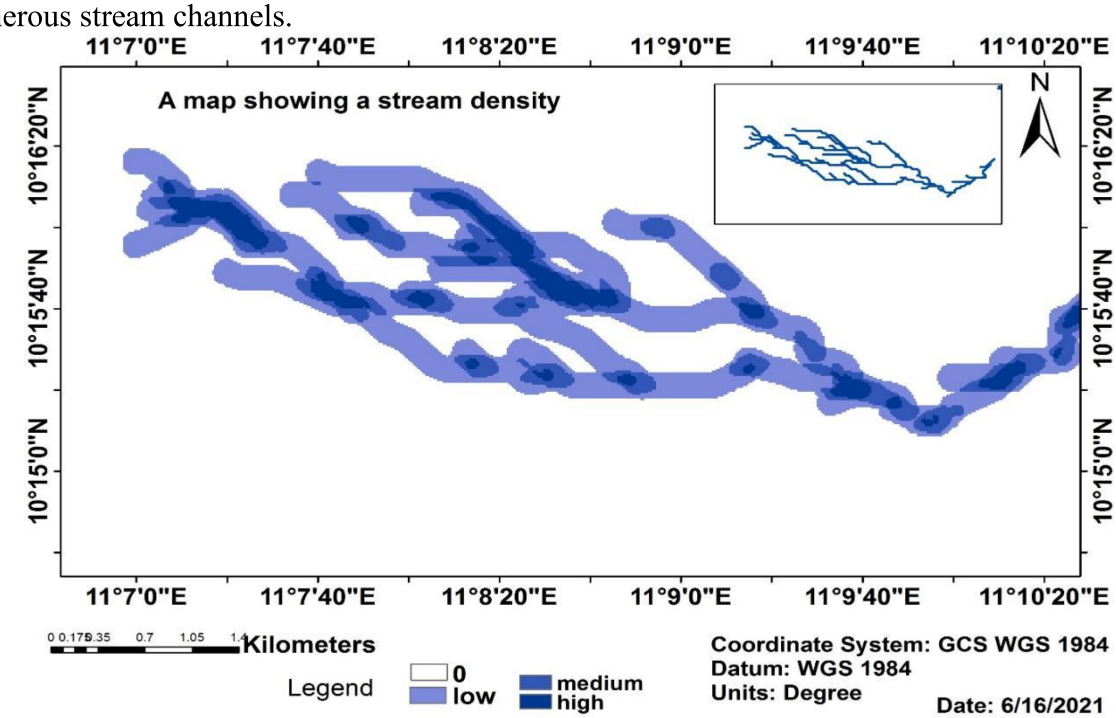

Figure 5: Drainage density of River Riyadh basin

Source; ArcGIS 10.1, 2021.

CONCLUSION

Drainage density is one of the many physiographic characteristics of river basins considered as an index of surface processes. It is the average length of stream per unit area of land in the basin, and it is a fundamental parameter for determining the flood risk of a basin. If drainage density is less than 3.0, the basin is liable to flooding. The mean bifurcation ratio of the Riyadh drainage basin was determined at 3.36, while Dd was 3.1. Therefore, it is concluded that the basin is not liable to flood risk. Dd also informs about the degree of dissection of the basin and the hydrological characteristics of any basin. With Dd of 3.1, the Riyadh basin is highly dissected, which may explain the slow rate of development of housing projects in the basin in spite of the fact that there is a high demand for houses in the Gombe metropolitan area, which is adjacent to the basin.

Recommendation

Based on the findings of this study the following recommendations are made.

1. The degree of dissection of the basin needs to be controlled through the planting of fast-growing plant species such as *Paniculatu and Pitadeniastrum africanum.*
2. Stone bags and concreting water courses should be embarked upon as well as planting Bermuda grasses on open surfaces by individuals and communal efforts.
3. The state government should stabilize the banks of the water channels in order to confine them, thereby protecting residential dwellings close to them.
4. Cultivation should be done such that ridges are plowed across the general gradient of the basin to minimize soil loss.
5. Enlightening the public on the effects of dissection.
6. Results of this research would be useful in formulating policies for controlling soil loss and dissection of the basin.

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