UP-TO-DATE GEOLOGICAL MAP OF LAKE CHAD IN CENTRAL AFRICA USING GEOSPATIAL APPROACH

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ABSTRACT: The Lake Chad area has witnessed many years of shrinkage for over 50 years in the region and also geological features played a vital role. This has led to the shortage of food supply and low level of economic activities which directly affect livelihoods of the inhabitant of the environment. For that reason, there is an urgent need for remediation and prevention of further devastation to the environment in the area. Hence, this requires extensive and comprehensive investigation. The research is aimed at investigating the impact of geological features of water surface area fluctuations using geospatial approach in Lake Chad, Central Africa. Likewise, all the relevant published maps and information from different data sources in respect to geological structures of the study area were considered with a view of providing an up to date map and all the map layers were collected to show diverse levels of details geographical features at various scales to enhance uses of the map. Map compilation, GIS digitisation and map production were performed for final map production. The results revealed that the geological map of the study area illustrates the area covered for each class in terms of percentage. Therefore, this percentage indicates the composition of geological types within the study area.

1. INTRODUCTION

The limited and less quality of relevant data is the major challenge in understanding the hydrogeology of full arid and semi-arid areas, for example, Lake Chad in Africa. The data is usually temporally inconsistent and spatially in nature. The availability of data for regional groundwater system often varies between zones because it comprises varied hydrogeological and geological zones (Candela *et al.*, 2014). Based on the past record, the Lake Chad Basin is situated in a tectonically active area with physical features that spread northwest to the Air Plateau and southwest towards the Benue trough. The positions of present-day rivers including Lagone, Chari and Kamadogu, and earlier streams are controlled by physical features. The western seashore of the current day lake, and the route of the perilacustrine ridge, match the known physical features (Durand, 1982). The extensional tectonic forces formed the Lake Chad Basin in the Cretaceous Period. It is situated between the basins, which is the Quaternary Chad Formation. It is the earliest geologic formation that comprises aquifers. Considering the southwest zone of the basin, the Chad establishment is comprising of 3 aquifers mentioned as the Upper, Middle and Lower Aquifers. Although, diverse in the study area, the Chad formation comprise of fine grained (argillaceous) sequences with coarse grained (arenaceous) horizons (Isiorho and Nkereuwem, 1996).

Therefore, posibility of ground water to penetrate the pore space in the rock is reffered to as rock pemeability. Further, low porosity is attributed to rocks with fine grain texture while high porosity is attributed to rocks with coarse grain texture. The definitions of particles, pores and permeability have been provided by a number of scholars, for example, wadell's. The wadell definitiion is highly sound due to the introduction of statistical concept. However, for the purpose of real-world application, the definition given by Wentworth (1922) is much more understandable and faster to use. Thus, the grade scale produced by Wentworth is the most commonly used, which can graphically quantify grain size within accuracy of the grade scale.

The different techniques for geospatial modelling have been extensively employed for predicting water surface zone in the last few years. Meanwhile, looking at the population growth and geological features that are evolving as the major factors triggering land cover and land use changes. Thus, it is essential to integrate such features into water surface modelling system for sustainable water development. Nevertheless, a number of attempts have been made to observe the water surface region in order to study how it affects land cover and land use in the present times (Elz *et al.*, 2015; Prieto-Amparán *et al.*, 2019). Thus, the employment of environmental factors including geological features with regards to water surfaces region is comparatively new. Therefore, there is a need to predict the impact of geological features on the current water surface region for some periods while putting different sustainable development constraints into consideration including water bodies and existing settlement (Hussaini *et al.*, 2019).

2. STUDY AREA

The study area of the research is presented considering the location and nature of the area. Lake Chad Basin is geographically located in West-Central part of Africa with latitudes of 5º22´ 46.42´´ and 25º43´ 11.11´´ to the north of the Equator and longitudes of 6º42´ 13.89´´ and 24º45´ 34.64´´ to the east of the Green Witch Meridian. The nature of the lake is continually dynamic due to the difference in precipitation and temperature that is obtainable due to its depth, size, and shape. A collection of natural regions, which are borders to the lake comprises mountains, desert, wetlands, savannahs and wood forest (Ovie *et al.*, 2012). There are 3 major drainage systems that offer the water namely, the Komadugu Yobe River situated in Nigeria, Chari Logone River situated in Central Africa Republic and Yedsaram/Ngadda River situated in Cameroon. Among the lakes that faces socio-political pressure issues, the Lake Chad Basin has been considered as one of them. For example, few years after 1960s the lake was considered to be massive in terms of size with up to 400,000km^2.Thus, previously it was recognized as Lake Mega Chad during the complete 20th century. Between 1960 and 1963, the lake was at its peak level of utilization. Furthermore, there is an insight that the state of the lake's bowl has worsened as it has reduced in size, up to 25,000km^2 that is, more than 90% reduction from 1960s to 2011 (Gao *et al.*, 2011). Meanwhile, conventional weather of the lake has been distinguished by its evapotranspiration of about 2,200mm/annum, solid breezes, high temperature and erratic precipitation patterns. There is yearly fluctuations of precipitate spatially from 1400mm across the southern poles to below 150mm near to the extreme northern (Okpara *et al.*, 2015). Figure 1 shows the location of the study area.

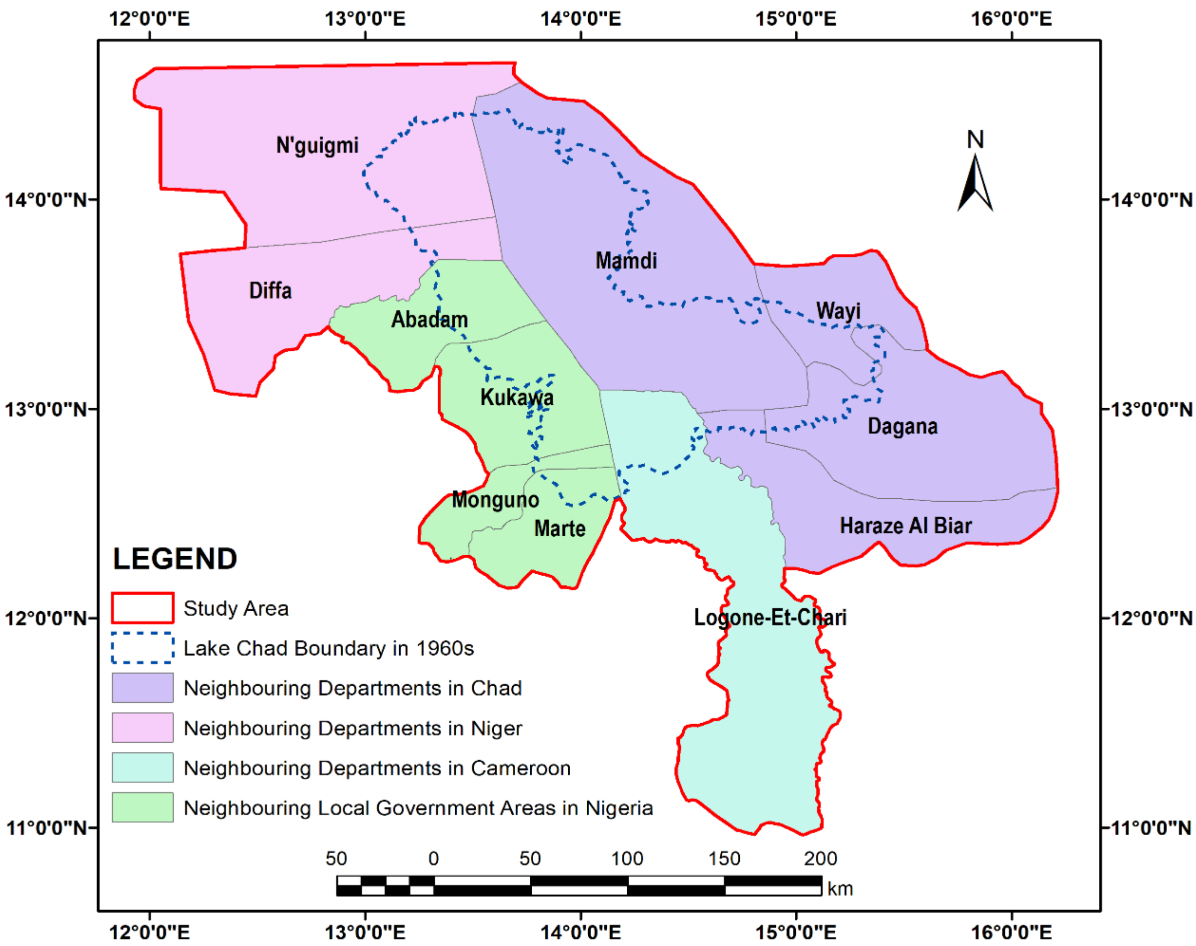

Figure 1: Study area.

3. MATERIAL AND METHODS

3.1 Data Collection

The study used various sets of data for the achievements of its objectives. Therefore, different sets of data were obtained and analysed in order to realise the study's aim and objectives. The data sources were utilized in this sort of study and this has to do with geological features of Lake Chad. The geological map was sourced from one famous commission formally known as Freshwater availability in the Lake Chad Basin/La Commission du Bassin Lac Tchad.

3.2 Software Used

The research were performed mainly with ArcGIS 10.3, the various information were collected by using common measurement scale and values based on their importance. This is a combination of datasets in order to get an up to date geological features.

3.3 Method of Data Analysis

Map Compilation, all the relevant published maps and information from different data sources, with respect to geological features of the study area were taken into consideration with a view to provide an up to date map. Map layers were collected to show diverse levels of detail of geographical features at various scales to enhance uses of map. The compilation enabled the cleaning of the map to allow for the visualization of all additional elements at different levels of detail. At first, the fresh information assembled from different data sources should be moved in broad details to stable transmission of information with metric grid and contrasted with the published geological maps. The data from geology were drawn as exactly as promising. Modification was made to line work where crucial, and explanation for such adjustment commented on the map. In view of that, the entire geological contacts were plotted by utilizing the standard geological signs as utilized on past map scale.

GIS Digitisation, after the compilation of all the published maps and information from different data sources, the next stage was the digitisation of map layers. The digitisation were carried out in Arc GIS software by scanning, storing and displaying all sort of dataset. The compiled maps and information from different data sources were digitized to level of details to reflect originality. Then, all the compiled analog maps were converted to digital format. On-screen digitising is an efficient method for editing and updating existing layers. However, this is typically done very slowly and meticulously to ensure free from error-prone process.

Map Production, Production is the subsequent and last stage for generating and updating of a map. Map production is the way of organising map components on a piece of paper in a manner that even with short words the normal individual can comprehend what it means. Maps are normally created for demonstrations and reports where the user or reader is a layman or a learner without proficient experience in GIS can understand better. In line with this, a map must be efficient in conveying spatial information. The common features of a map involves; key, scale bar, north arrow, map tittle, map body, acknowledgement and map frame. Once the digital information has been proved, a fundamental draft map is displayed in ArcGIS interface. All the map components, including geological signs, cover panel, map scale, key, credits, and geological descriptive notes were collected to set up a draft format. After examination, all inputs were considered and the map was corrected and checked. Thus, excellent care has been taken to guarantee high calibre/quality and exact production of the duplicate of a map. After this is accomplished throughout the procedure, then updated copy of a map was made accessible.

4. RESULTS AND DISCUSSION

4.1 Lake Chad and its Environs (LGAs and Departments)

The surrounded member countries within the lake were divided into departments and local government areas (LGAs). In Chad republic there are four (4) departments, Niger two (2) departments, and Cameroun one department and Nigeria four (4) local government areas, making the total number of eleven (11) LGAs/Depts. as depicted in Figure 2 below.

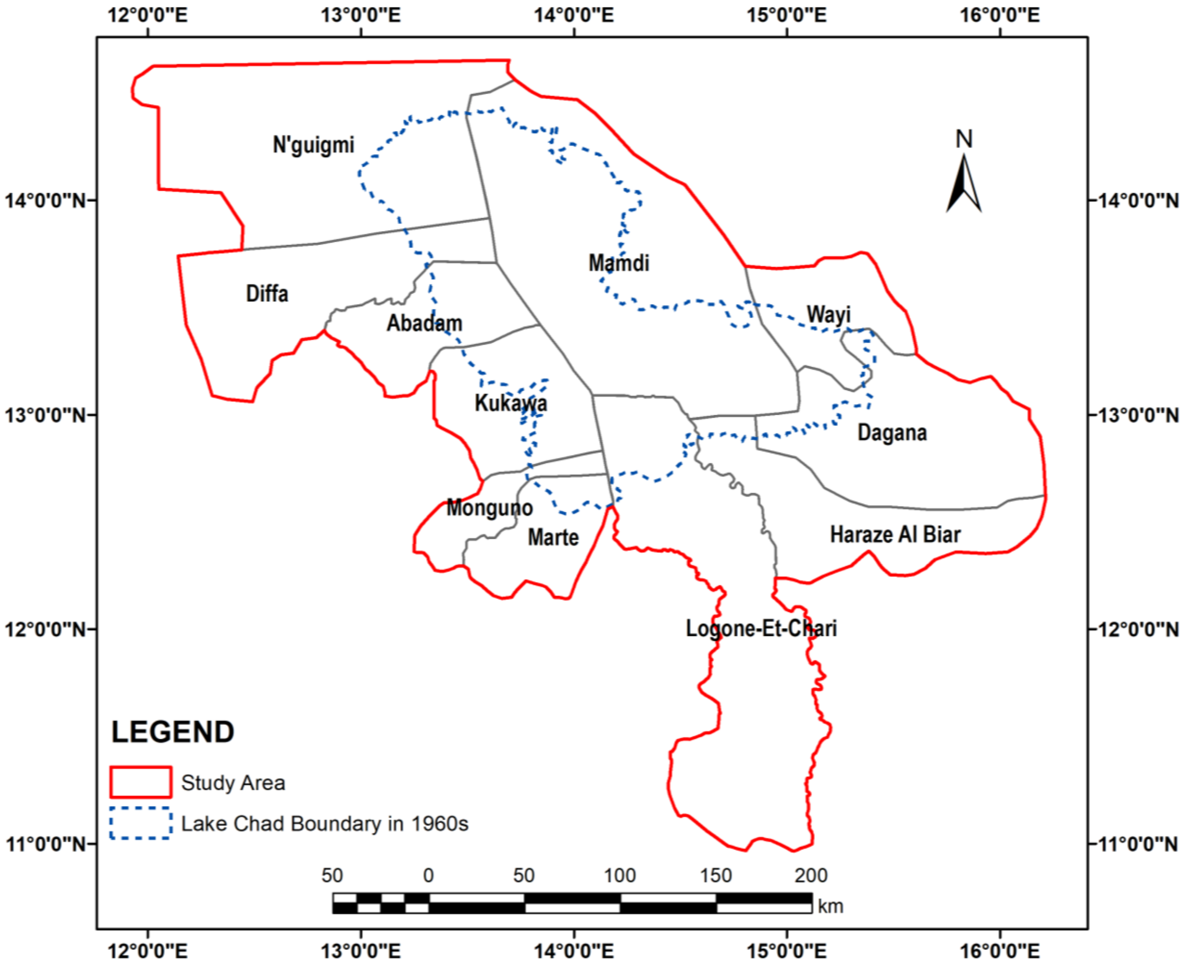

Figure 2: Neighboring LGAs and Departments.

4.2 Generation/Map out Geological Features

The main objective of the study is to identify and map out reclassified geological features in the Lake using geospatial approach. This objective has been clearly accomplished and the results are presented and discussed here. Generation of up to date geological features are very essentials, to mirror out and identify the various geological structures/features in the area which were serve as Figure 3 presented the geological features of the study area.

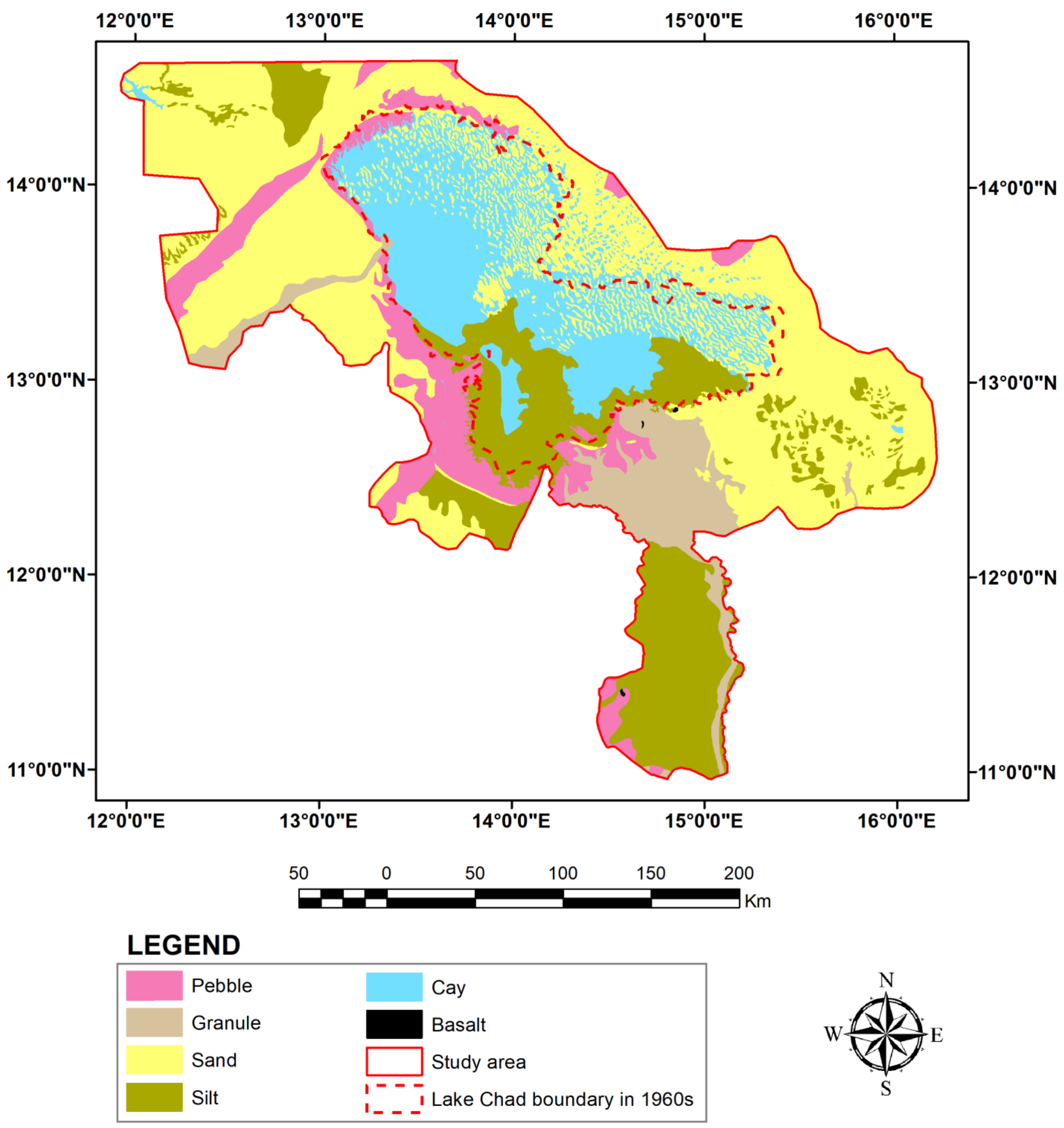

Figure 3: Geological Map of the study area

The geological map of the study area illustrates the area covered for each class in terms of percentage as shown in Figure 4. Therefore, this percentage indicates the composition of geological types within the study area.

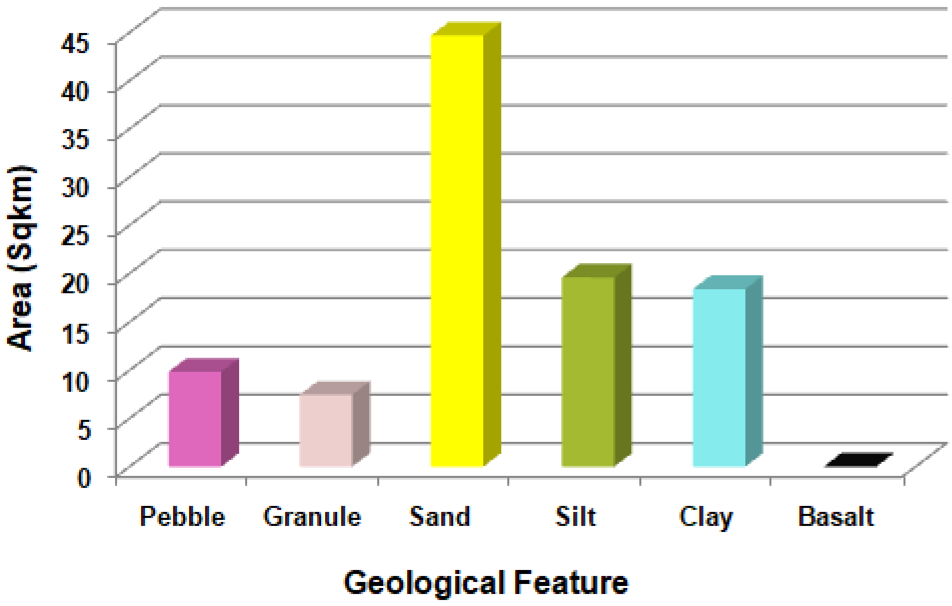

Figure 4: Area Covered for Each Classes in Percentage

The geological features comprised of six (6) classes such as: pebble, granule, sand, silt, clay and basalt. Table 1 presented the area covered in kilometre square for each class. Pebble covered 8131.63km^2 with (9.87%), Granule covered 6153.92km^2 with (7.47%), Sand 36813.80km^2 with (44.67%), Silt covered 16141.48km^2 with (19.59%), Clay covered 15150.57km^2 with (18.38%) and Basalt only covered 18.75km^2 with (0.02%).

Table 1: Area Covered in Kilometre Square

Geological Feature	Area (Sq km)	Area (%)
Pebble	8131.63	9.87
Granule	6153.92	7.47
Sand	36813.80	44.67
Silt	16141.48	19.59
Clay	15150.57	18.38
Basalt	18.75	0.02
Total	82410.15	100.00

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The objective of this study is to map out an up to date geological map of Lake Chad school using geospatial approach. Based on this objective, the geological feature map is produced and also demonstrates the potencies of GIS in assessing the impact of aforementioned parameter (geology). Also, the mapped-out geology of the Lake has provided the details of its features in the study area. Consequently, based on the geological features identified with their percentage in terms of compositions, proved that geology influenced the Lake shrinkage which, leads sand to have the highest percentage in the study area compared with other geological features to low retention capacity.

5.2 Recommendations

1. This study provides the reasonable results on implementation of GIS in map out an up to date geological map of the study area, more and efficient data need to be considered for future studies. For their diversity and complexity of mapping an up to date features.
2. The study utilized geospatial techniques. So, the study suggests other additional techniques to be used for map update.

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