REMOTE SENSING AND GIS TECHNIQUES IN MAPPING THE LIMESTONE DEPOSITS OF GUYUK REGION – ADAMAWA STATE, NIGERIA

Musa, Abubakar A. and Edan, Johnson D.
Department of Surveying and Geoinformatics
Modibbo Adama University of Technology, Yola,
Adamawa State- Nigeria.
Email: drabumusa@yahoo.com, johnsonedan@yahoo.com

Abstract

The Guyuk local government area is blessed with abundant deposits of limestone which are visible at the surface. Mapping the entire local government in order to comprehend the spatial pattern of the limestone deposits is the main objective of this paper. The nature of the terrain coupled with the share size of the project site makes ground survey a very unattractive option. Using the three bands of SPOT XS images, lineament analysis was first conducted to understand the nature of the bedrock. Then using Landsat images of the area, an unsupervised classification routine was attempted. Result of the analysis revealed that there are higher concentrations of limestone deposits in the central portion of the local government, and these deposits spread to the neighbouring Gombe state. This paper has not only confirmed the availability of limestone deposits in Guyuk, it has also demonstrated the effectiveness of Remote Sensing and GIS techniques in mapping mineral deposits.

Keywords: Limestone, Spectral distance, Cement, Karst, Guyuk

1.0 Introduction:

Identifying and mapping areas with limestone deposits is a first step to understanding the viability or feasibility of establishing a cement factory. Limestones, according to the Encarta dictionary, are sedimentary rocks formed from the skeletons and shells of ocean organisms that consist chiefly of calcium carbonate. Limestones are used for a variety of purposes, among which are roofing granules (a coating that helps shingles resist heat and weathering), floor tiles, and some animal feeds because of its calcium carbonate content. But by far the most common use of limestone is in the manufacture of cement. It is usually combined with crushed shale in a kiln to make cement. Limestone's usefulness stems from its strength and density. Cement is a fine grey powder mixed with water and sand to make mortar; or with water, sand and aggregate to make concrete. Cement is an indispensable material in the construction industry.

The optimum location of an industry depends upon demand in relation to supply (i.e. market for its product), availability of raw materials, production costs, distribution costs (particularly transport cost), management's regional interest and government's policy. In the cement industry, availability of raw materials and fuel and transport costs are more significant than the other factors because cement is a weight loosing and bulky product. While its weight loosing nature argues for location near raw materials, bulkiness on the other hand favours location near the supply (i.e. market). However, the material index (i.e. the ratio of localized materials to output) is more than 1.5 for cement (Gupta & Patel, 1976). The net effect of these two factors favours nearness to raw materials. As a result cement factories are, in fact, located in close proximity to the sources of raw materials. Thus, most cement manufacturing units are established within a radius of 15 to 20km of limestone deposits. The presence of a cement factory in an area is an economic boost for the area. It invariably increases the income and standard of living of inhabitants and ultimately brings development to the area. It is for this reason that the presence of limestone deposits is a source of anxiety and hope.

Guyuk is a poor, agrarian community in Adamawa State. It is headquarters of Guyuk local government. For several years, knowledge of the availability of limestone deposits in commercial quantity in this community was within the realm of speculation, since no proper mapping of the deposits was ever made. However, all that changed when the Dangote group wanted to expand their sugarcane plantation to areas that are sitting on limestone deposits. The discovery of these deposits prompted the Dangote group to deplore experts to conduct feasibility studies in the area. Results of the feasibility studies indicate that limestone deposits in the area could last 100 years (Kabiru, 2016). It cannot be confirmed if proper surveying and mapping formed part of the feasibility studies. However, it is known that the Office of the Surveyor General of Adamawa State (OSGAS) deployed its personnel to the area to conduct a proper survey of the area. While OSGAS staff identified the limestone deposits on the field, they were limited by two factors: - (i) they could only map areas identified from the ground; without the advantage of the synoptic view from the air. (ii) since they were staff of Adamawa State government, they were only restricted to the boundaries of Adamawa State. Hence, while the quality of the limestone in Guyuk has been investigated and found to be suitable for cement production (Magili et al, 2010), the spatial spread, exact boundaries and distribution of the limestone deposits remains unknown.

This paper aims at mapping the limestone deposits of Guyuk LGA using a remote sensing and GIS approach. Encouragement to use this method stems from the fact that the limestone deposits are exposed to the surface. Numerous authors have used similar techniques to solve similar problems. Barbara et al (2014) used GIS and remote sensing to identify karst (limestone) landscape and detect geological features related to karst development in North West Morocco. The inventory of the karst landscape was carried out using satellite and aerial imageries together with ASTER DEM. Results of analysis provided a better understanding and visualization of factors influencing the development of karst landscape.

Muhammed et al (2013) attempted land use change detection in the limestone exploitation areas of Margella Hills National Park (MHNP) at Islamabad, Pakistan. The methodology used in identifying and mapping limestone areas on the multi-temporal images included principal component analysis (PCA) and maximum likelihood (MLH) classification. PCA was used on the images before extracting specific training sites. Then MLH supervised classification algorithm was used to derive satellite derived maps. A classification accuracy of 98% was achieved. Likewise, Samih et al (2006), also used remote sensing technology for geological investigation and mineral detection. Using Landsat Enhanced Thematic Mapper plus (ETM+) and radar SAR images, with image processing techniques like principal component analysis (PCA), rationing and intensity hue saturation (IHS) transformation; the El-Azraq region of Jordan was successfully classified into various geological units

2.0 Study Area:

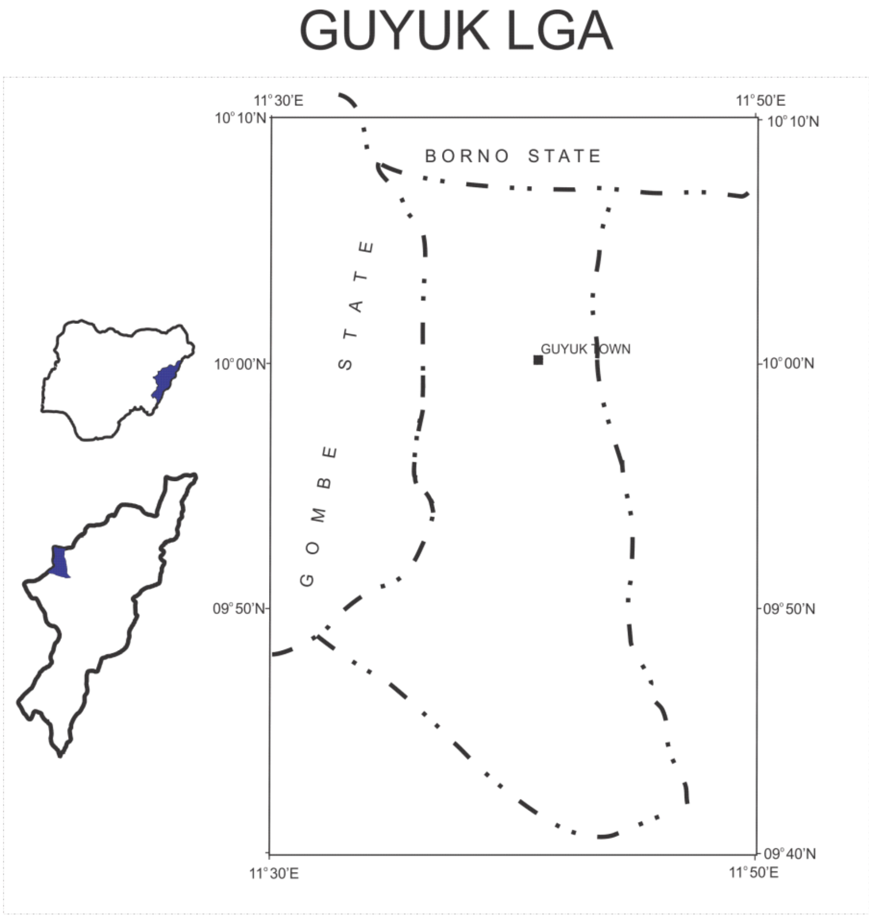

Figure 2.1: Guyuk LGA of Adamawa State

Guyuk is one of the twenty-one local government areas of Adamawa State, with headquarters in Guyuk town. Guyuk local government area (LGA) is located at the western edge of the state. River Gongola, a prominent landmark in the area, flows from the northern part of Gombe State and maintains a relative latitude of 10º 02'N till it meets River Hawul to form a confluence. The confluence between River Gongola and River Hawul (Lat. 10º 02' 52"N, Long. 11º 59' 10"E) defines the northeastern edge of the local government. River Gongola also acts like a natural boundary between Guyuk LGA and Shani LGA of Borno State at the northern edge of the local government area. The same River also serves as the boundary between Guyuk LGA and Shelleng LGA to the east. The river was dammed at Kiri, and later empties its content into River Benue. The north western boundary of the LGA is shared with Balanga LGA of Gombe State; the west and south east boundaries are shared with Lamurde and Numan LGAs of Adamawa State.

The local government is occupied by the Lunguda people. They are predominantly hunters and farmers. Their population has been projected to be about 204, 050 (Wikipedia, accessed 9/11/2016). For the purpose of administrative convenience, the LGA is divided into 7 districts, namely; Dukkul, Banjiram, Kola, Boboni, Chikita, Dumna and Guyuk.

3.0 Materials and Methods:

3.1 Data

Table 3.1: Data Information

S/N	Spatial Data	Resolution	Bands	Date	Format
1	Spot scene 82/330	20m	R,G & IR	24/11/1994	BIL
2	Spot scene 82/331	20m	R,G & IR	24/11/1994	BIL
3	Spot scene 83/330	20m	R,G & IR	30/11/1994	BIL
4	Spot scene 83/331	20m	R,G & IR	30/11/1994	BIL
5	Guyuk NE (Sheet 174NE)	1:50,000	NA	1971/1972	Paper
6	Landsat8 scene 186/53	30m	R,G & IR	21/10/2016	GeoTIFF

3.2 Hardware/Software:

1. HP Laptop computer
2. Etrex 20 GARMIN Handheld GPS
3. ITC's ILWIS 3.3 Academic
4. Intergraph's ERDAS IMAGINE 2014

3.3 Data Preparation

Four SPOTXS scenes were imported into the GIS package using the geo-gateway import/export tool. Geo-referencing parameters were extracted from the leader file (LEAD.DAT) supplied together with the spot data and manually inserted into the images using the GeoRef tie-points tool. The four scenes were later mosaicked together to form a single scene of the study area. This was done through the 'Glue' tool in ILWIS. To make the map north-oriented and extract the area of interest desired, a GeoRef corners (reference frame) was created. The mosaicked image was resampled to the reference frame.

In the case of the Landsat image, the acquired Landsat scene covered the entire local government. The scene, which came already geo-referenced and rectified, was imported into the ERDAS software for further processing.

3.4 Lineament Analysis

The SPOTXS images were used for lineament analysis. In order to remove the effects of shadow, the image was first rationed. An edge enhancement filter was then applied on the image. This was done using the 'Operations/Image

Processing/Filter' module. The edge enhancement filter chosen is named 'EDGESENGH'. Edge enhancement filters enhances the total image and detect linear features like roads, geological faults, drainage systems etc. The drainage pattern on the filtered image was digitized on a vector file and studied more closely in order to understand the kind of bedrock of the region.

3.5 Image Classification

Image classification was done in ERDAS imagine software. An area of interest (AOI) was carved out of the Landsat image. Since the boundary of the AOI is the extent to which image classification will be done, the AOI tool was used to zoom the Guyuk LGA. The unsupervised classification ('raster/unsupervised/unsupervised classification') routine was activated. Forty (40) clusters were created from the image. The large number of clusters is to ensure that each class has a small spectral distance, hence ensuring the isolation of the spectral signature of limestone.

GPS coordinates earlier picked from the limestone sites (I.e. the Gindore and Gunda limestone sites) by OSGAS personnel were plotted on a vector file overlaid on the satellite image. By doing this, the analyst was able to identify the limestone sites on the image.

3.6 Identifying Spectral Signatures for Limestone:

The attribute table of the classified image was opened. This shows various columns, one of which is dedicated to the colour code used for the spectral signatures in the classified image. (Figure 3.1). Each row of the attribute table signifies a spectral class. By manipulating the colours therefore, the particular land cover depicted by the colour changes in the classified image.

While focusing attention on the Gindore and Gunda limestone sites, colour codes for each spectral class were changed sequentially. When the colour code changes in the limestone sites, the spectral class which causes the change were taken as the class that depict limestone deposits. Four out of the forty classes were found to represent the limestone sites. Similar procedure was used to detect the water bodies and the marsh lands. The Kiri dam and the river Gongola are very prominent landmarks in the landscape of Guyuk. Identifying these landscapes makes it easy to locate other less prominent areas. It is for this reason that spectral classes for water body were used in the classified map.

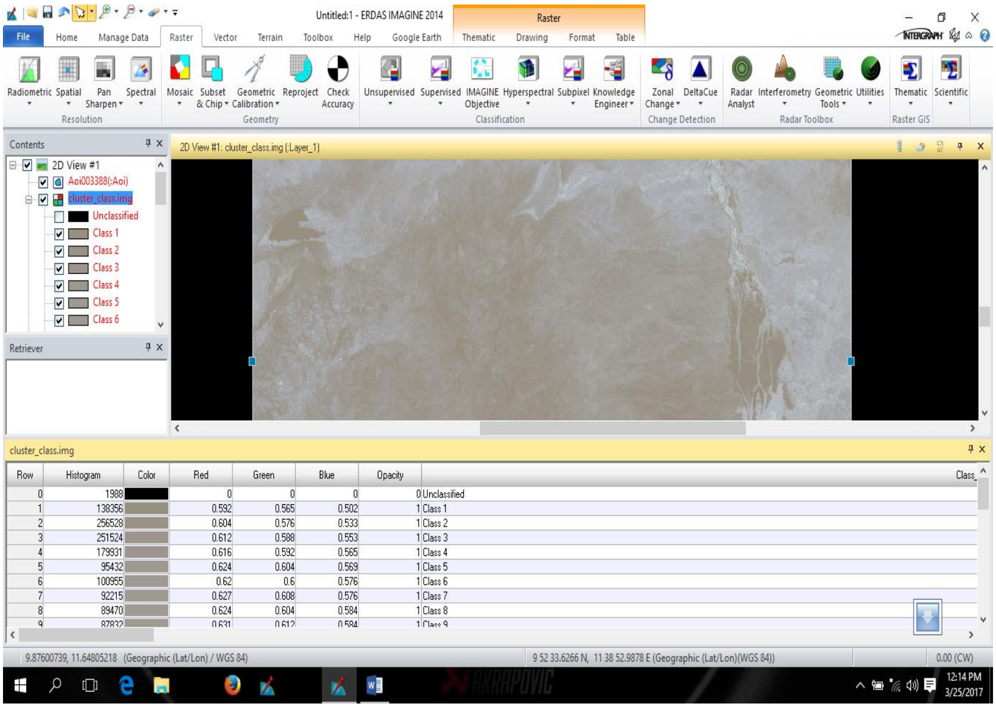

Figure 3.1: Attribute Table of an Unsupervised Classification

3.6 Grouping of Spectral Classes and Map Composition

The spectral classes need to be grouped into informational groups. This enables the legend use one colour code to reference a group of classes rather than an individual class. The grouping tool (Figure 3.2) was used for this. Only one spectral class represented water bodies while two spectral classes represented marsh land and four spectral classes represents limestone deposits. All the remaining spectral classes (33 of them) were grouped as unclassified.

After grouping, the data need to be recoded. Recoding is done with the 'fuzzy recode' process. The fuzzy recode process resolves issues of overlap where certain classes belong to more than one group. The output from the fuzzy recode process is the final classified map. The final stage involves the creation of the map composition. Here, the classified map from the fuzzy recode process constitutes the map frame. The map frame is positioned in a map view, and other map elements like map grid, scale, north arrow, legend etc are added.

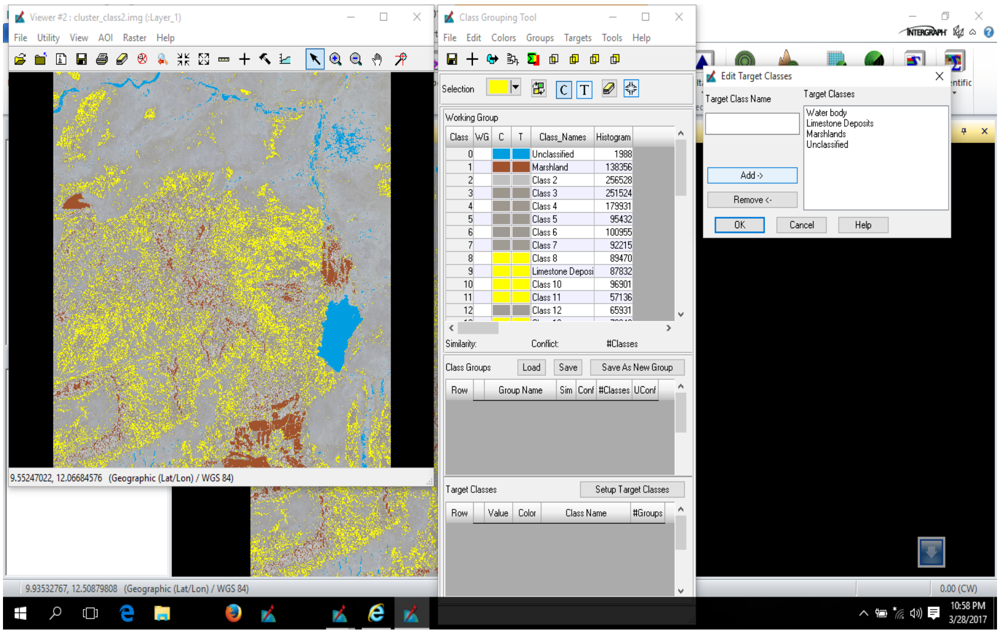

Figure 3.2: Grouping Spectral Classes to Information Groups

4.0 Results/Discussion

4.1 Drainage Pattern

The drainage pattern of the study area is clearly a modified form of dendritic pattern. The dendritic drainage pattern is tree-like in form. The main stream corresponds to the trunk of the tree and its tributaries resemble the irregularly sub divided branches of the tree. The dendritic pattern is probably the most common type of drainage pattern. It is developed where the rock structure does not interfere with the free development of the streams (Merle Parvic, 1947).

The drainage pattern of the study area is shown in Figure 4.1. The streams were examined for two characteristics – angular bends and streams disappearing into sink holes. Streams with angular bends were discovered close to the Kiri dam. Here, the main streams have many angular bends where resistant rocks have deflected it. The fact that not all the streams in the study area have these type of angular bends is the first indication that limestone deposits might not be available all over the study area. However, the areas with such bends have a higher probability of having limestone deposits.

The hydraulic action of water draining into sink holes and producing many surface depressions is a common characteristics of limestone areas. This was not noticed in this study area. Limestone are composed predominantly of calcite (calcium carbonate or dolomite). While some limestone are almost pure carbonate, others contain substantial proportions of other materials – most commonly sand, clay – i.e. mud or shale (Amethyst, 1995). The non-availability of sink holes strongly indicates that the limestone deposits in the Guyuk area are of the latter type.

4.2 Spatial Pattern of Limestone Deposits

Figure 4.2 shows the final map of the classification done for the study area. The map clearly depicts the limestone deposits (in yellow). From the spectral signature for water, the River Gongola and the Kiri dam were identified. The portion of the River Gongola running North-South appears to mark the eastern limit of the limestone deposit. Incidentally, this line also marks the boundary between Guyuk and Shelleng local government areas.

To the west of River Gongola is a large deposit of limestones scattered about the landscape, the highest concentration being between 11^{o} 50'E and 12^{o} 00'E. These deposits however did not extend to the northern boundary of the local government, disappearing around latitude 9^{o} 56'N. The southern part of the local government extending into Numan local government is characterized by marshland. This could probably be the reason the area is used for sugarcane plantation. Though limestone deposits exist here, it cannot be compared with the ones in central Guyuk in terms of quantity and concentration.

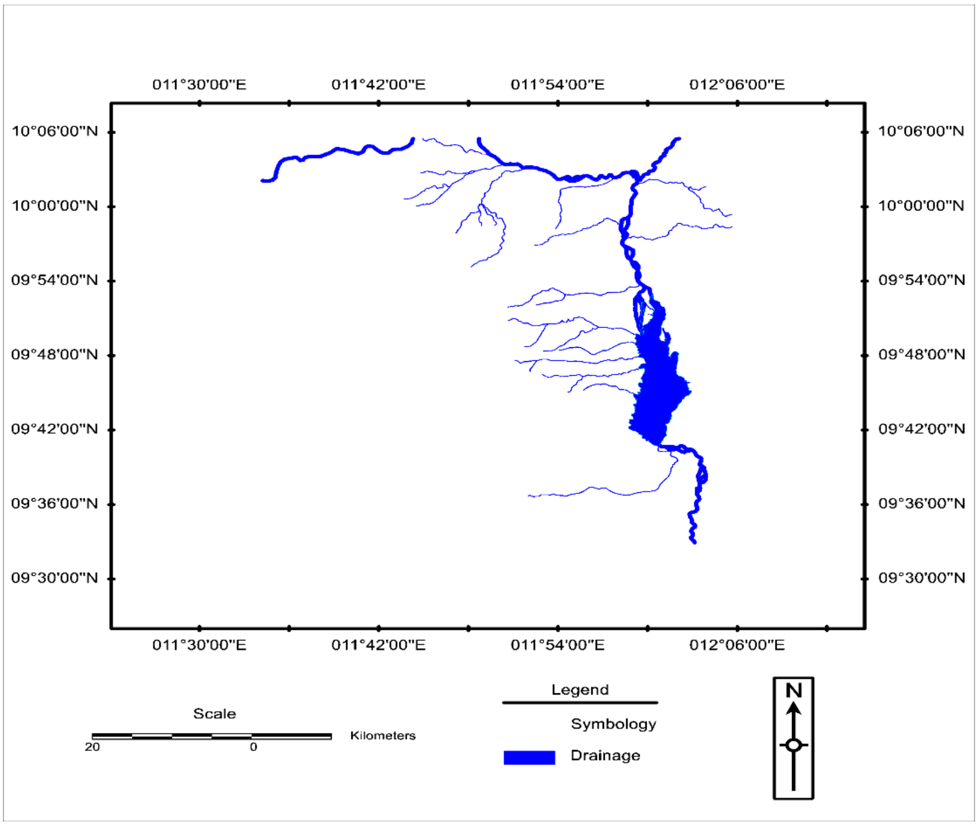

Figure 4.1: Drainage pattern of the Guyuk Area

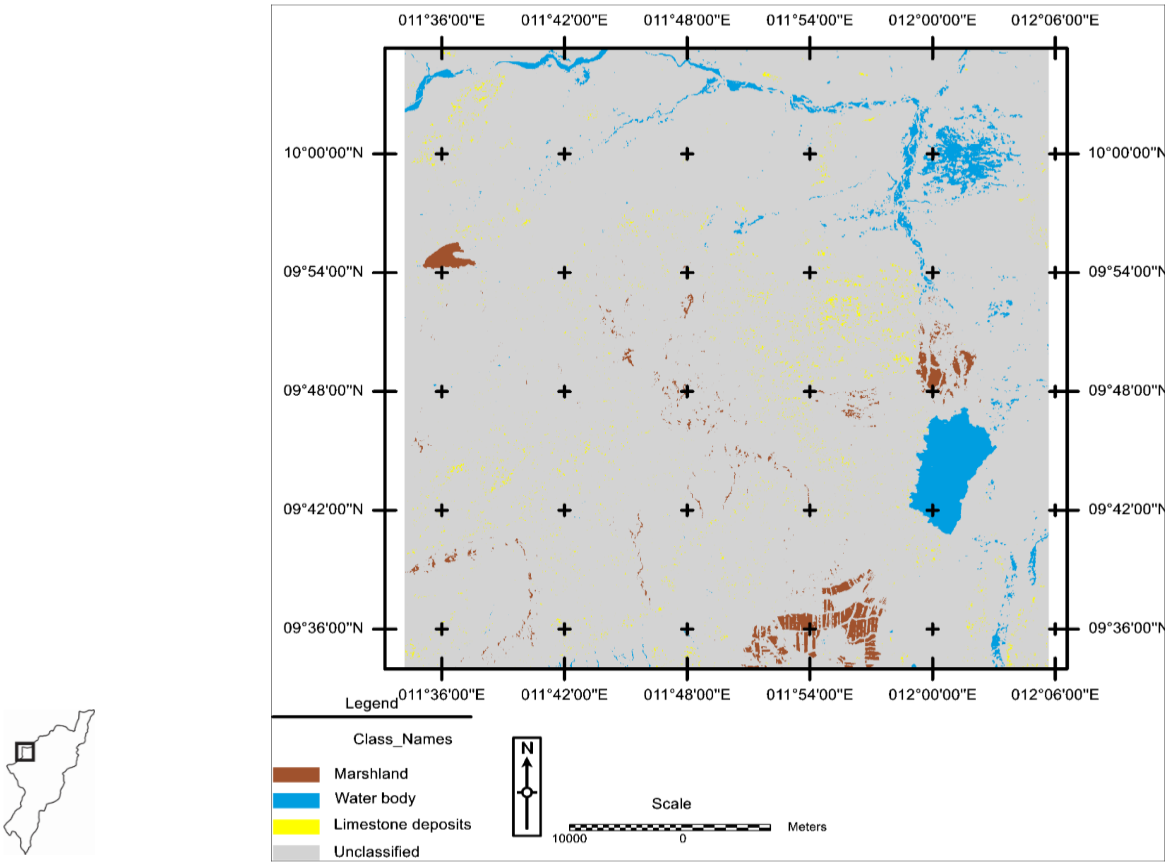

Figure 4.2: Distribution Pattern of Limestone Deposits

5.0 Conclusion/Recommendations

This paper has confirmed the availability of limestone deposits in Guyuk local government area of Adamawa State. With two thirds of the LGA covered with limestone deposits, there is no doubt that the quantity laying untapped on the landscape is enough to support a large cement factory. The paper has successfully mapped out the limestone deposits, thereby demonstrating the effectiveness of Remote Sensing and GIS techniques in mapping mineral deposits. Its advantage over ground survey techniques stems from the wide expanse of landscape it is capable of covering and the relative ease with which the mapping can be done.

Just as survey ministries have cartographic units, computation units, photogrammetric unit etc., it is recommended that Survey Ministries should ensure they establish a GIS unit. This unit, where they presently exist, only concentrate on cadastral databases. This paper has demonstrated cadastral databases are just a small aspect of a whole range of tasks the GIS can handle.

The surveying profession in Nigeria seem to tilt heavily towards cadastral surveys. The way Survey Ministries are structured and the laws guiding survey practice cannot be totally exonerated from this. However, the sad truth is that it is high time we start thinking out of the box. Not only should we embrace modern technology, we should look for ways of generating revenue out of it. The future of the surveying profession relies in our zeal in integrating modern technology into main stream survey practice. If we do not act fast, other professions will take over what is rightfully ours.

References

Amethyst (1995). LIMESTONE. The Amethyst Mineral Gallery. www.galleries.com

Barbara Theilen-Willage, Halima Ait Malek, Abdessamad Charif, Fatima El-Bchari and Mohammed Chaibi (2014). Remote Sensing and GIS Contribution to the Investigation of Karst Landscapes in North West Morocco*;* *GEOSCIENCES*; Vol 4, pp50-72; doi: 10.3390/geosciences4020050. Downloaded from www.mdpi.com/journal/geosciences.

Gupta. G. S. and Patel. K (1976). Location of Indian Cement Industry. *Vikalpa* Vol 1, No 4.

Kabiru Anwar (2016) Dangote to Establish Cement Factory In Guyuk. *Daily Trust March 23, 2016*

Magili. T. S, Maina. H. M and Matera. O. N, (2010). Comparative Assessment of Limestone Resources of Guyuk and Ashaka Areas for Industrial Utilization*. Journal of Physical Sciences and Innovation.* Vol 2. Cenresin Publications. www.cenresin.org

Merle Parvic, (1947). Regional Drainage Patterns In Indiana. Purdue Univeristy. www.docs.lib.purdue.edu

Muhammed F. Iqbal, Mobushir R. Khan and Amir H. Malik (2013). Land Use Change Detection in the limestone exploitation area of Margalla Hills National Park (MHNP), Islamabad, Pakistan using geo-spatial techniques. *Journal of Himalayan Earth Sciences* Vol. 46 No 1 pp89-98.

Samih Al-Rawashdeh, Bassam Saleh and Mufeed Hamzah (2006): The Use of Remote Sensing Technology in Geological Investigation and Mineral Detection in El Azraq, Jordan. Cybergeo – European Journal of Geography. DOI: 10.4000/cybergeo2856. https://cybergeo.revues.org/2856.