ABSTRACT.

Landslide phenomenon includes a wide range of ground movement, such as rock falls, deep failure of slopes and shallow debris flows, which occurs over a given terrain. It play a major role in the development of hill slopes. It has threaten people, properties and livelihood sources. Geographic Information Systems (GIS) have become the promising tool for an effective analysis associated with the study of geologic hazards. GIS is an ideal tool for landslide modeling owing to its versatility in handling a large set of data, providing an efficient environment for analysis and display of results with its powerful set of tools for collecting, storing, retrieving, transforming and displaying spatial data from the real world. A review of how GIS(geographic information system) was employed in landslide investigation and used to analyze area vulnerable to landslides was conducted. It was discovered that natural and human activities are responsible for landslide.

INTRODUCTION.

The occurrence of landslides is sometimes surprising for humans as they seem to occur without previous warning signs. However, (Terzaghi 1950) noted that if a landslide comes as a surprise to eyewitnesses, it would be more accurate to say that the observers failed to detect the phenomena which preceded the slide. Therefore, dedicated landslide analyses and monitoring methods have to be applied to be able to recognise potential slope failures.

Landslide is a geological phenomenon which includes a wide range of ground movement such as rock falls, deep failures of slopes and shallow debris . It may also be referred to as any down slope movement of soil, vegetation and rock under the direct influence of gravity. It encompasses events such as rock falls, topples, slides, spreads, and flows. It can be initiated by rainfall and erosion, volcanic activity, earthquakes, slope saturation of water, change in groundwater, land use, land cover and the terrain slope of the area, disturbance and change of a slope by man-made construction activities, or any combination of these factors (Saher, 2009). A land slide occurs when the down slope weight of the slide mass exceeds the strength of the soil along the slip surface. That is, when the down slope weight (driving force) exceeds the soil strength (resisting force). Factors influencing the stability of a slope include: steepness of slope, composition of soil and rock, groundwater conditions, recent precipitation patterns, slope aspect, vegetation on slope and anthropomorphic activities (land clearing, overgrazing, bush burning, grading, etc.,).

Landslide susceptibility shows the risk of an area experiencing the occurrence of a landslide. They are more likely to occur in a landslide susceptible area, but vary according to the degrees of surface and sub-surface dynamics in the area concern. Therefore, the magnitude of landslides could be assessed at micro-scale, small, medium and large scale levels respectively.

Advances in Geographical Information Systems (GIS) technology and the mathematical/ statistical tools for modeling and simulation, have led to the growing application of quantitative techniques in many areas of the earth sciences (Carrara & Pike, 2008). The study of landslide hazard also applied these basic tools frequently with intensively use of digital elevation models (DEMs) and SOPT images. The use of GIS method play an important role in all phases of the risk-management chain in hazards such as flood and landslide to analyze various generated elevation models and surface analysis which will provide useful data for monitoring and proper decision making on landslide susceptibility.

GIS and Remote sensing has been used to study, evaluate and model landslide susceptibility in different parts of the world. For example Gao and Lo (1995) were able to predict landslide probabilities of the mountain terrain of Nelson County, Central Virginia, USA. Similarly, Melzner et al (2006) performed landslide susceptibility analysis using remote sensing derived data and GIS techniques in South Viti Levu, Figi Islands. The study used aerial photography to create a digital landslide inventory map of the area.

STATEMENT OF PROBLEM.

Landslide occurrence has been seen as a threat to human existence, It has claim many life in recent years. With the rapid urbanization in the most cities of the world, landslide investigation will serve as a pre-requisite for effective planning and management of the environment. Recent research shows that most cities of the world are becoming vulnerable to slope failures and landslides due to some human activities such as mining, wood logging, abandoned construction works et.c. If land use is not properly monitored it may result to severe environmental hazard such as landslide. GIS is a tools that can be used for effective monitoring and aid decision making.

AIM AND OBJECTIVES.

The study aims at GIS as a tool for landslide investigation, prediction and monitoring. The objectives are:-

- To reveal how GIS is being used as a decision making tools in landslide investigation.
- To review past and recent research in landslide investigation.
- To review recent research on GIS as a means of landslide investigation.
- To recommend control measures on landslide.

GIS (GEOGRAPHIC INFORMATION SYSTEM).

GIS is a set of computerized tools (including both hardware and software) for collecting, storing, retrieving, transforming, and displaying spatial data. GIS is essentially a marriage between computerized mapping and data base management systems. Anything that can appear on a map can be encoded into a computer and then compared to anything on any other map, using longitude-latitude coordinates. GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information to their locations. GIS technology can be used for scientific investigations, resource management, and community education.

GIS AND LANDSLIDE ANALYSIS.

The unique capability of GIS to work (to capture, store and manage the data) with data referenced by vast spatial or geographic coordinates and its ability to incorporate appropriate engineering models, have caused its proliferating application across the wide sections of engineering, especially in civil engineering where, management of spatial-data is pivotal for the analysis. As the typical landslide analysis demands, collection of numerous data, storage of them and using them in the analysis could be handled well in the GIS environment. Any spatially-distributed data with a geo-reference to real world could be stored as points, lines and polygons (vector model) or as continuous fields (raster data model). Beyond GIS being used as a spatial database, it assists in modelling applications through handling a special form of data that would otherwise be compromised in conventional analysis (Miles et al. 1999). Also, GIS does not only serve as a database for parameter data, rather qualitative and quantitative data can be integrated through spatial relationships rather than through relationships between attributes that may not exist (Frost et al. 1997). The other facilities such as: Query languages and user interfaces permitting rapid modification of parameter values; Convenient and quick updating of model parameters; Overlay function, where multiple maps are either visually or topologically combined and the its potential in visualization of data using the graphic features, that assists the engineer in verifying data and information pertaining to the model and its application; and developing elevation maps and subsequent slope, aspect and hillshade themes (which are useful in the landslide analysis) are worth mentioning, as they are common to many applications of engineering models (Miles et al. 1999). In particular, the ability of GIS to present the data and analysis results in map forms plays a key role in identifying the critical areas (where more rigorous analysis and improved solution is required) by its interactive visualization in a spatially optimized mode.

Landslides constitute one of the major hazards that cause losses in lives and property. Landslides are one of the complex analyses, involving multitude of factors and need to be studied systematically in order to evaluate the hazard. The increasing computer-based tools are found to be useful in the hazard mapping of landslides. One of such significant tools for hazard mapping of landslides is Geographic Information Systems (GIS). A GIS is defined as a powerful set of tools for collecting, storing, retrieving at will, displaying, and transforming spatial data (Burrough and McDonnel, 1998). One of the main advantages of the use of this technology is the possibility of improving hazard occurrence models, by evaluating their results and adjusting the input variables. An important aspect of landslide investigations is the possibilities to store, treat, and analyze spatiotemporal data that are available.

HAZARD MAPPING OF LANDSLIDES.

Landslide hazard maps have been constructed by different methods, such as, from inventories; by consideration of site conditions including geology, hydrology, topography, and/or geomorphology; by statistical correlation of landslide frequency with geologic and geomorphic factors; using safety factors from stability analysis. Mechanics based models have also been used to estimate failure probability based on uncertainties about infiltration of rainfall, or pore pressure, and soil strength (Wu et al. 2000). An a priori study of causal factors of landslides indicate, the ground conditions, geomorphological processes, physical processes and man-made processes as the significant contributors. The pertaining data needed for landslide analysis for a particular slope are:

- ✓ Geologic and Geomorphologic features/setting
- ✓ Types and quantification of soil and/or rock properties
- ✓ Details of vegetation cover, folds, faults, etc.
- ✓ Past records of rainfall and earthquake incidences
- ✓ Appropriate hydrologic and stability models

LANDSLIDE INVESTIGATION CASE STUDIES.

Kuje is located in the North Central part of the FCT, Abuja Nigeria. It is bounded on the North-eastern part by Abuja Municipal Area Council (AMAC), to the west by Gwagwalada and Kwali Area Councils and to the South by Abaji Area council. The Kuje Area Council covers a total land of about 1,800sq km about 22.5% of the FCT. It has an estimated population of about 270,000 people comprising Gbagy, Gude, Bassa, Hausa and Fulani with other ethnic group that have migrated from other parts of Nigeria and the World at large. The average rainfall is 1200mm and spread from late April to late October, while the dry season starts in late October to March. The soil and geology of Kuje consists of schist, including biotite/muscovite schist muscovite and tale schist with quartz intrusive which accounts for most of the rugged landscape in the area with rocks such as migmatite, granite, gneiss and boitite underlying the region. These geological characteristics pre-dispose the surface soil and land form to slope kinematics such as surface erosion, river bank and mining site landslides and slope failures.

Figure 1: Satellite imagery of the study area.

FIELD SURVEY.

The field survey was conducted using the printed copies of satellite imageries, maps, digital camera and GPS Receiver to identify land marks that potent risk areas and locations for landslides, slope failures and associated land use activities**.** During the field survey, the physical measurements on landslide site and slope failure site covering the depth and width of the built environment were carried out with linear tapes. The xyz (3D) data set of built-up area of Kuje urban and surrounding areas of ongoing physical development were extracted from the SRTM and ASTER data. The SRTM and ASTER 3-D data (xyz) where combined to have densed 3-D dataset for detailed description of the topographic features and surface break lines in the area.

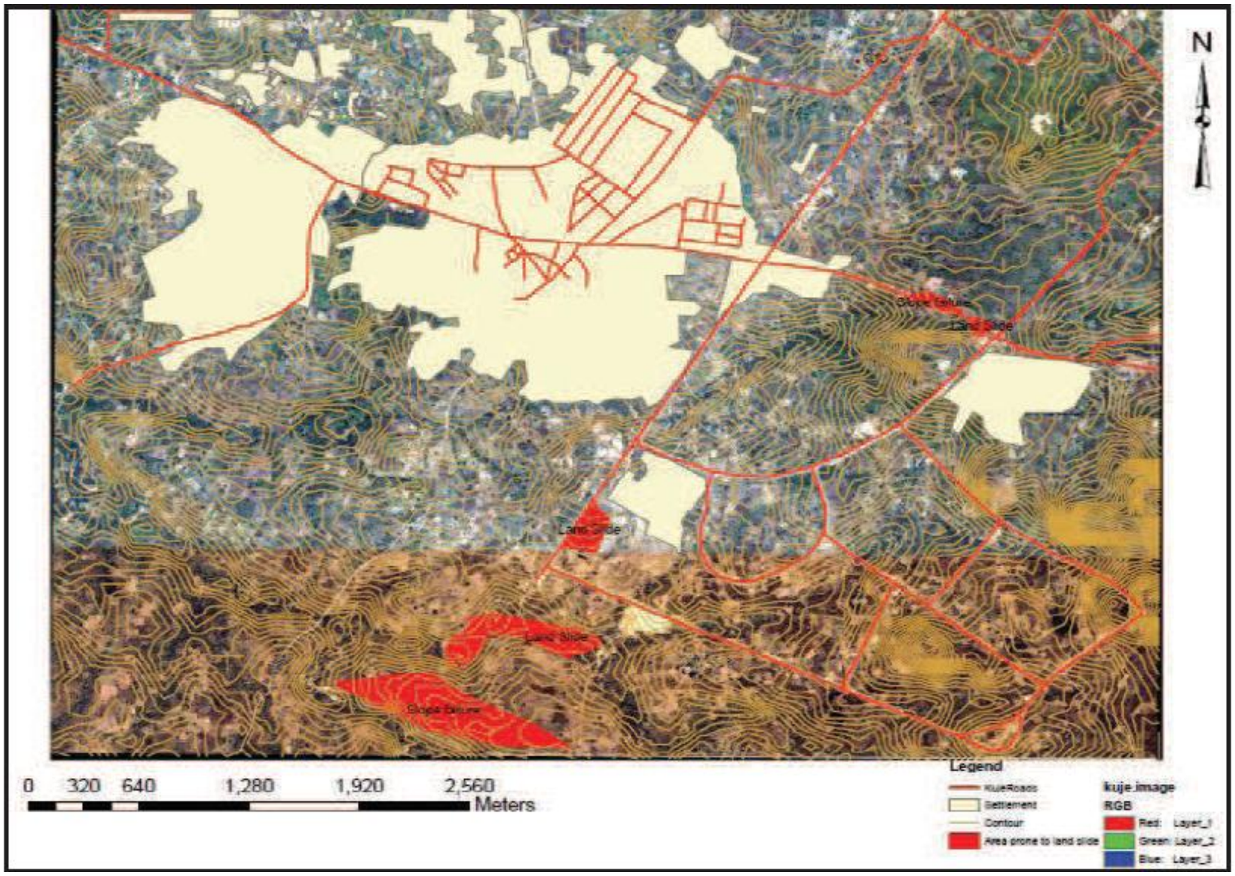

Figure 2: Land use and landslide map of part of Kuje, Abuja, Nigeria.

The study area is undergoing severe deep surface sand mining along critical features such as streams, roads and drainages, which has resulted in huge slope failures across slope height of between 3.5m and 4.4m. The long term danger inherent in the activities of human in the areas is ground subsidence and structural deformation. The continuous sliding of the earth to fill up vacuums created by sand miners and river bank erosions will pose dangers to buildings and road infrastructure in the vicinity.

The result obtained identify areas vulnerable to landslide as those subjected to intensive deep surface sand mining and gullies due to erosion.

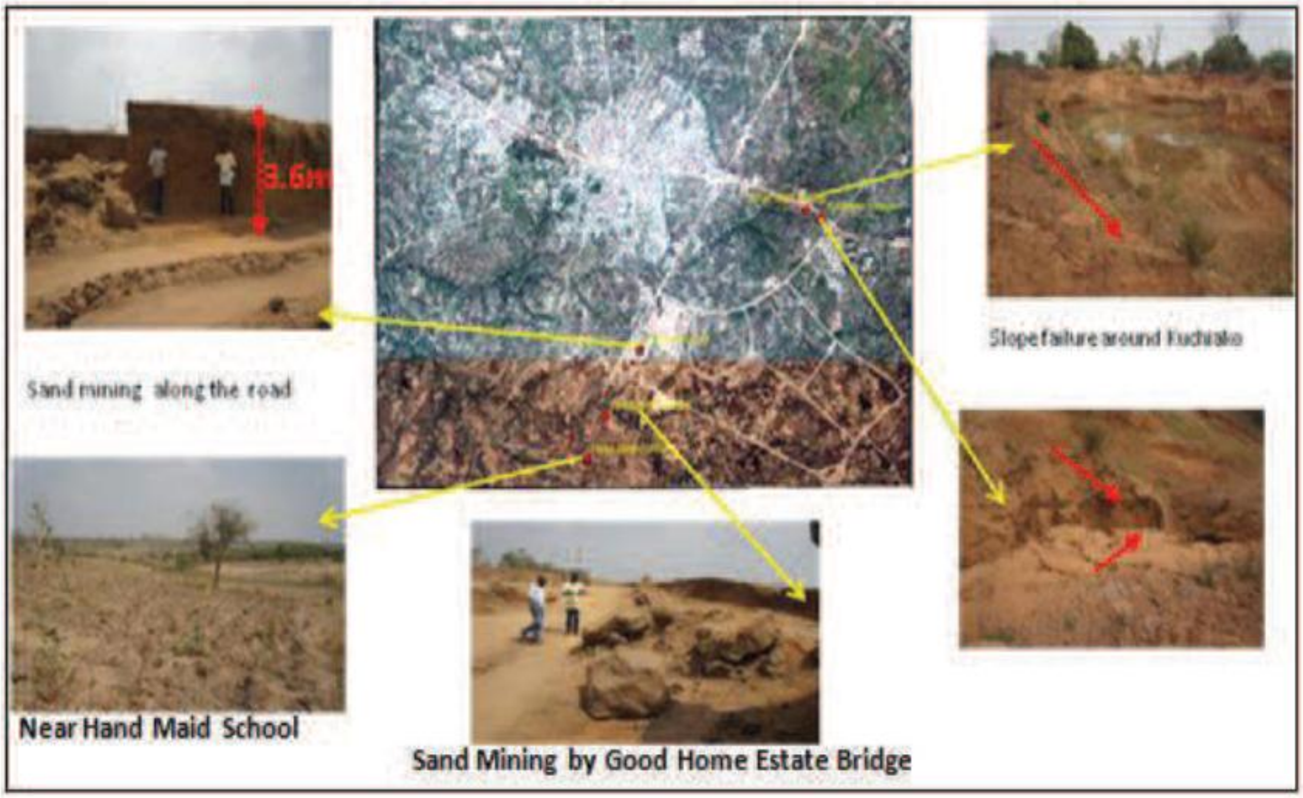

Figure 3: shows sand mining-induced landslide and slope failure scenarios in parts of the study area

CONCLUSION.

GIS has proved to be an excellent tool in the spatial analysis of the terrain parameters for landslide hazard zonation. Geographic Information Systems (GIS) is being exploited widely in many engineering problems, which involves spatial data management. Landslide hazard mapping, one of the important task in disaster/hazard mitigation projects is a typical problem involving huge database. The posterior analysis of GIS results gives the engineer a better understanding and visualization of the problem and results.

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