THE DETECTION OF CHANGE VOLUME OF TAGWAI DAM, MINNA, NIGER STATE, NIGERIA, USING GEOLOGY, REMOTE SENSING (RS) AND GIS TECHNIQUES

Alabi, A. A.
Department of Geology,
Federal University of Technology Minna, Nigeria
E-mail:- kola_rock@yahoo.com

Abstract

Scarcity of potable water in Minna metropolis with population density of about 1.93 million, during the dry season creates a demand for sustainable water conservation and management. This requires using appropriate and reliable information and data; hence the use of geological mapping and remote sensing techniques for relevant findings and decision making for current and future management of Tagwai dam. Assessment of the dynamics of Tagwai dam in Minna, Niger state, Nigeria was investigated using Geological mapping, Landsat-ETM 2000 and Quickbird image 2008. The images were processed, interpreted and classified using ILWIS 3.3 software. The results of the study showed a sharp decline in the surface area of the dam as indicated by 59 percent reduction between 2000 and 2008. In the light of the above and to prolong the lifespan of the dam that serve the population of about 1.9 million people, there is need to carryout dredging and evacuate weeds which have colonized the dam.

Keywords: Assessment, Geology, LANDSAT-ETM and Quickbird, dam

Introduction

The World Health Organization (WHO) and the United Nation Children's Fund (UNICEF) estimated that at the beginning of the year 2000, one-sixth (1.1 billion) of the world's population lacked access to a safe water supply (WHO/UNICEF 2000). Despite global effort made in the decade between 1980 –1990, majority of the world's population with access to safe water remains in the developed countries. The principal target of the Millennium Development Goals (MDGs) is to ensure halving the proportion of people without access to safe water by 2015 (WHO/UNICEF 2000).

For these reasons conserving and managing water is very important for supplying water for human needs. This gave rise to the construction of Tagwai dam in Minna, Niger State in November 1978. Construction of a dam depend on many factors among which include size of the population, the prevailing level and pattern of socio-economic activities. This involves the diversion of rivers to store water during raining season for use in the dry season.

Scarcity of potable water in Minna metropolis, with population density of about 1.93 million (National Population Commission 2006) during the dry season creates a demand for sustainable water conservation and management. This requires using appropriate and reliable

information and data; hence the use of remote sensing and geological mapping techniques for relevant finding and decision making for current and future management of Tagwai dam. This study aimed at assessing the state condition of Tagwai dam between year 2000 and 2008.

The Study Area

Tagwai dam is located in the south-eastern part of Minna, Niger State, and lies between Latitude $09^0 33^1$N and $09^0 37^1$N; Longitude $06^0 39^1$E and $06^0 42^1$E (Fig. 1a). The dam covers a total area of 5.5Km^2. Vegetation of the area is Guinea Savannah. Rainfall is moderate as expected within the Savannah region. The bulk of the rainfall is between May and September, the heaviest rainfall is experienced in the month of August. Mean annual precipitation ranges between 1300 and 1350mm and mean annual temperature of 32^0C (Iloeje 1978). The Tagwai dam is drained by two major rivers namely River Jidna, and River Lumo (Fig.1b), which are of low capacity at the pick of dry season.

The study area is marked by undulating topography formed by dissected hill characteristic of the basement complex. The north-eastern end of the dam is formed by an upland with elevation of 462metres above sea level. The crystalline rocks have been weathered to form a regolith which varies considerably in thickness toward low lying ground of the dam.

The gross capacity of Tagwai dam is 28.3 x 10^6m^3 (NSWB 1978), and the associated head works were design to provide potable water supply to Minna town. The dam is located within a comparatively rural area. However the widespread cultivation of cash crops such as yam, cassava, millet and rearing of animals has led to the destruction of the original vegetation especially around the study dam and can further contribute to sedimentation of the dam and consequent vegetation growth.

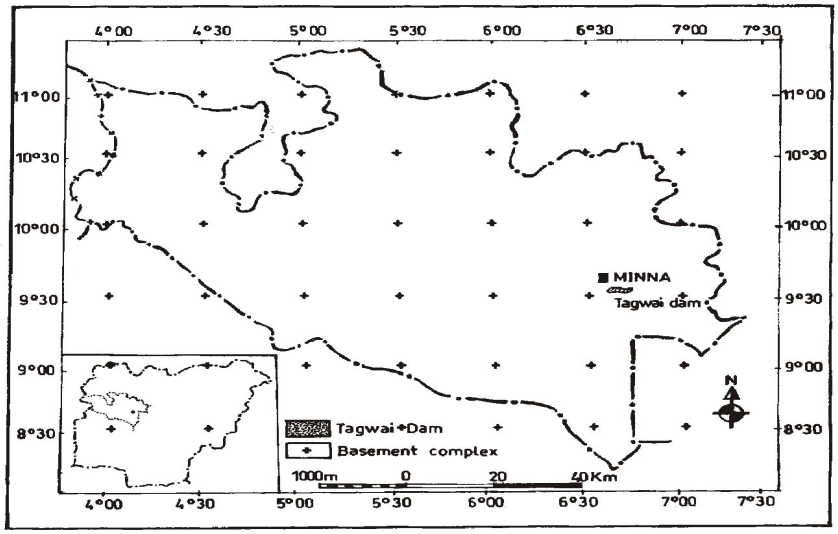


FIG. 1a **NIGER STATE MAP SHOWING TAGWAI DAM**

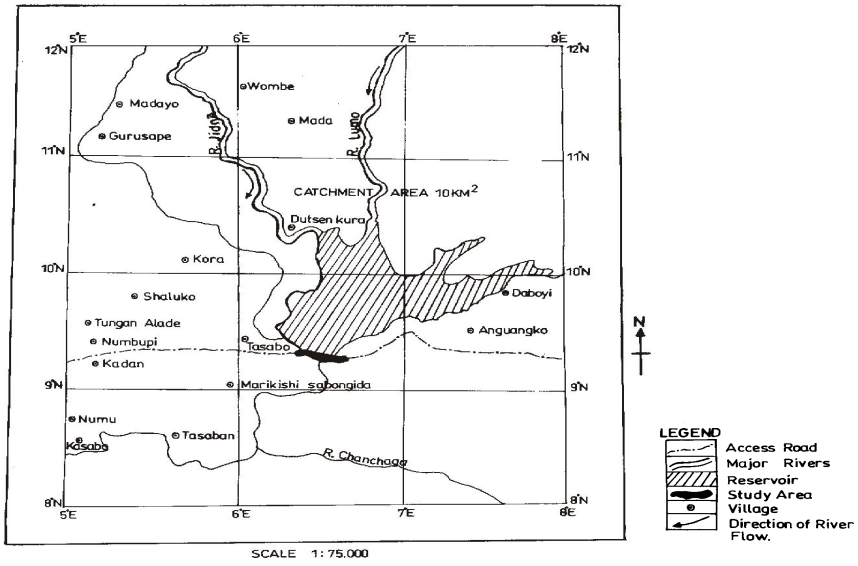


FIG. 1b **MAP OF TAGWAI SHOWING THE DAM SITE**

Methodology

Reconnaissance survey and geological mapping of the study area was carried out conventionally using topography map of Minna NE Sheet 164 on scale 1:50,000, GPS, hammer, compass clinometer and hand lens. The mapping exercise was carried out using footpath and canoe, between the months of November and April, at the period the study area is accessible. Area of 80km^2 covering the dam and it's environ was mapped. Each outcrop visited was investigated for their texture, colour, mineral composition in hand specimen and their structural relationship. Also, the slope nature of the outcrops was calculated.

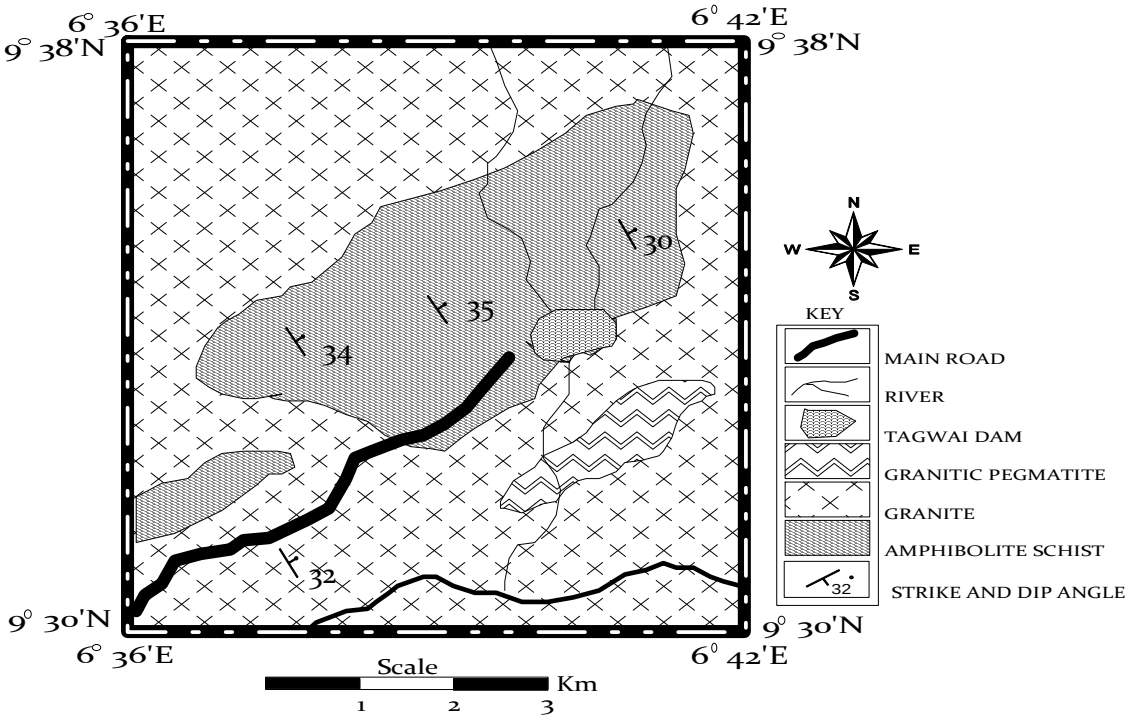


Fig 2. Geological Map of the Study Area

Remote sensing imageries covering the dam area were down loaded from Global Land Cover Facility (GCLF) website which is band sequential (BSQ) represented in seven bands in raster format, Enhanced Thematic Mapper (ETM) and Quickbird for 2000 and 2008 respectively. The images used for this study were already georeferenced and geocoded. Also, the images used for this study were taken during the dry season precisely December 2000 and 2008. The ILWIS 3.3 International Institute for Aerospace survey and Earth Sciences (Netherlands 1997), software was used for the processing of the image, while Arc 3.2 software was used for visualization and production of thematic maps for the study dam.

The processing of the images was done by importing the images from the file folder in the computer hard disk to ILWIS environment. In the ILWIS environment, each of the seven bands in the images were filtered using Linear AVG 3 by 3 filter before colour composite of the selected bands 4, 5 and 7 was carried out, Band 4, 5 and 7 were selected for the classification of land uses around the study dam due to reason that water body and vegetation features are best displayed in infrared, near infrared and middle infrared band ranges. Thereafter, the colour composite of the selected bands was created using the filtered bands. This was subsequently followed by the creation of the submap of the study dam area. The submap created was

displayed in false colour composite (FCC) and images classification and analysis was done using unsupervised classification method.

In this study, after the spectral classes (that is dam, farmland/vegetation) were defined, the pixels are assigned to the classes based on criteria such as colour, farm, pattern and association. The farmland/vegetation are added because these are related to the dam. After the classification was completed, the surface area of the study dam, rock types and land uses were determined using ILWIS 3.3 software.

The systematic method of investigation is summarized in the flow chart (Fig 3).

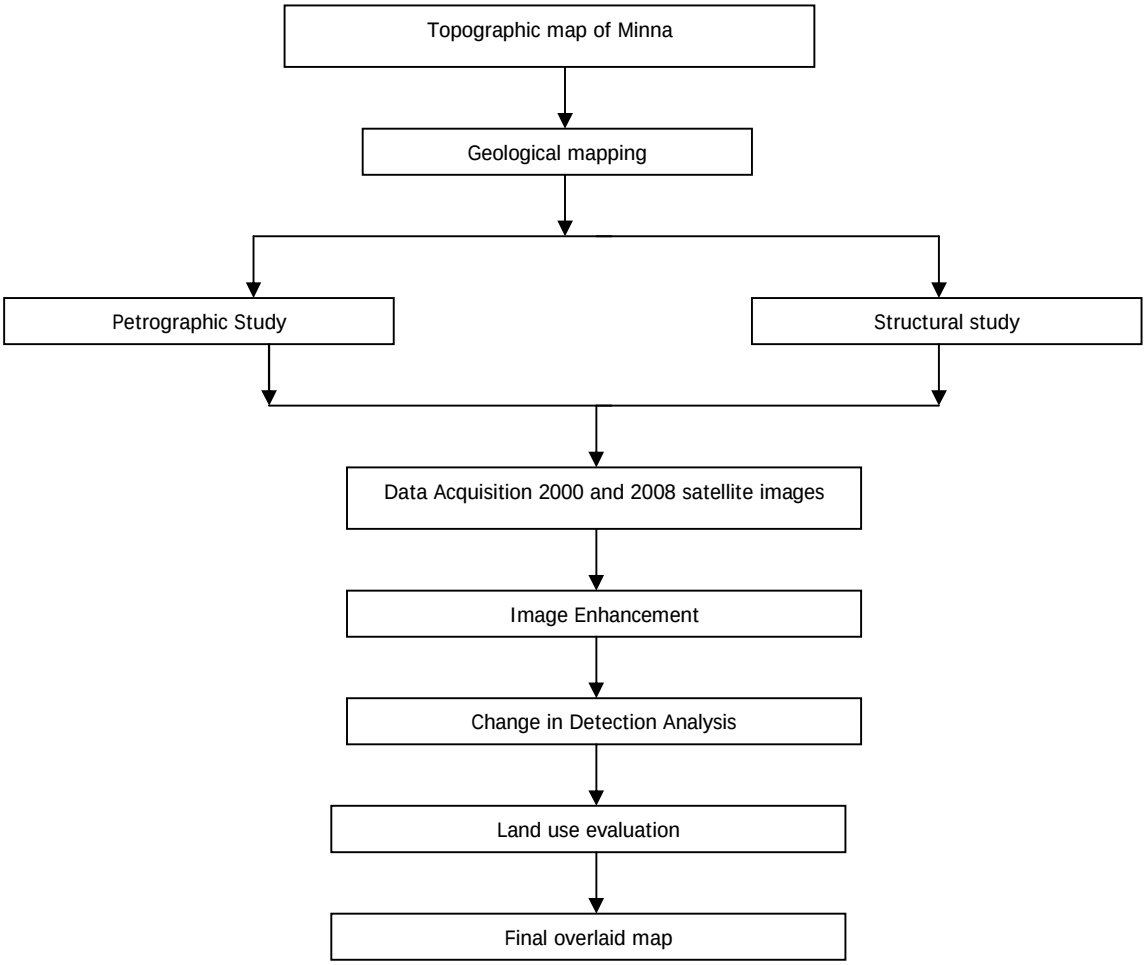


Fig. 3: Flow chart showing major steps in the study method

Result and Discussion

The result of the geological mapping shows that three rock types occur in the study area, these include amphibolite schists, granite and granitic pegmatite. The amphibolite schist occurred as flat laying outcrop at the central and western part of the study area and constituted

45% of the rock type in the area, granite occurred as batholiths, and granitic pegmatite as dyke cross cutting the granite at the eastern part of the area and constituted 55% of the rock types in the area. Petrographic study indicates that the granite is porphyritic, light in colour and predominantly dominated by quartz. The amphibolite schist is fine grained and poorly foliated. The rocks lack megascopic and mesoscopic structures and most of the joints were healed joints with no fracture. These structures were restricted mainly to the granite. As observed during the field work the granite is more susceptible to mechanical weathering due to the phophyritic nature and can easily move down slope.

The result of the overlaid map of the study dam (Fig.6) shows the change in the surface area of the study dam between 2000 and 2008. The change in the size of the study dam is mostly visible by examining the corresponding changes in the surface area of the dam between 2000 and 2008 (Fig.4 and 5).

As observed during the field work the edges of the dam surface have been colonized by weeds and desiccation cracks. In addition, animal tracks, footpaths used by the herdsmen and farmland were noticed around the dam. These will further encourage high rate of run off loaded with sediment into the dam.

Furthermore, as evident from the field and overlaid images (Fig 6), there is sharp reduction in the surface area of the study dam from $320m^2$ in 2000 to $132m^2$ in 2008. In addition, as evident from the images, the decline in the surface area of the dam may possibly be due to increased exposure of the land surface around the dam resulting from the sharp increase in farming activities with decline in the area extent covered by vegetation in the area. This situation further exposes the area around the dam to direct rain drop impact and thus enhanced accelerated erosion into the dam. This confirms the findings of Mironga (2004) that rapid and continuous farming activities around reservoirs may result in silting of such reservoir.

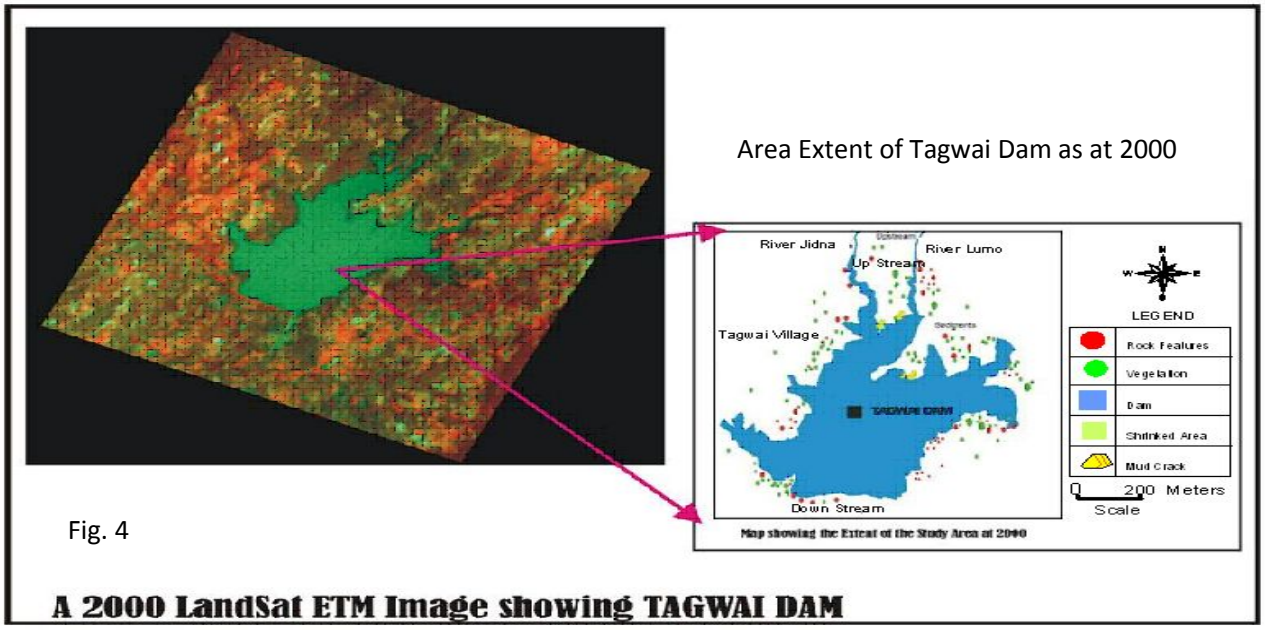
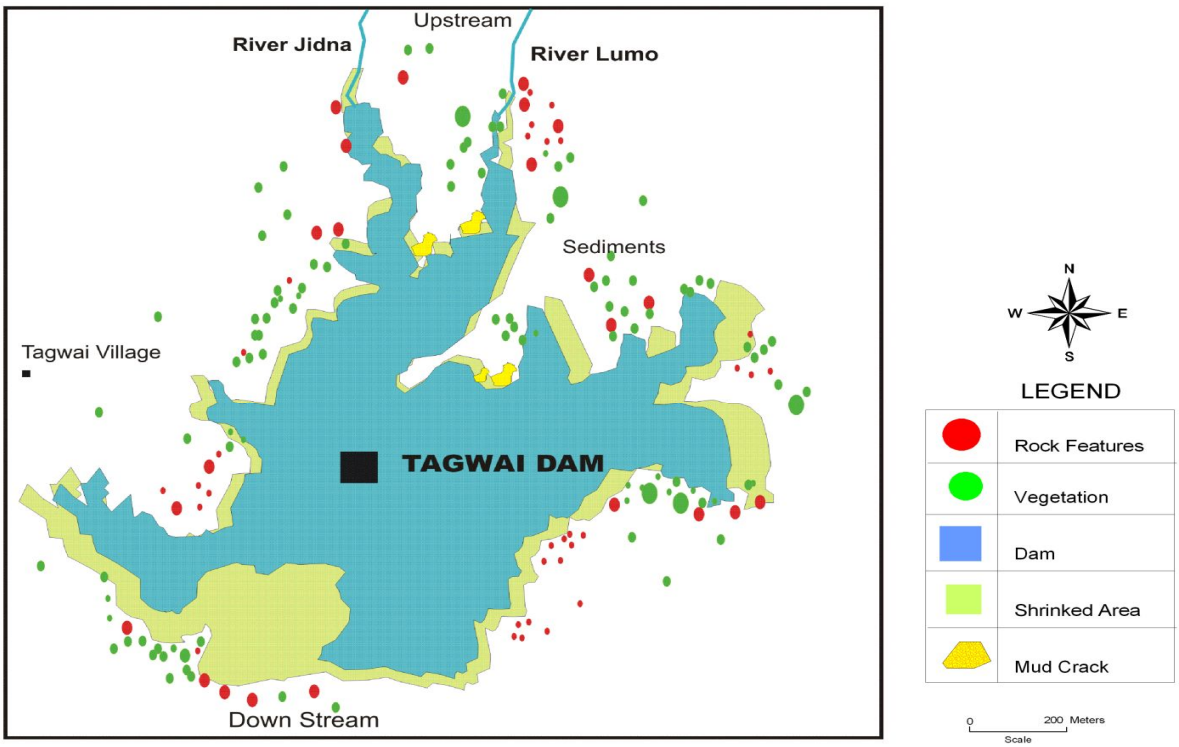


Fig. 4

Fig. 5 **A 2008 QuickBird satellite Image showing Tagwai Dam.**

Area Extent of Tagwai Dam at 2008



2000 and 2008 Overlaid Map of the Study Area Showing the Shrunk Areas and the present Dam Extent .

Fig. 6

Conclusion

The assessment of the dynamic of Tagwai dam in Minna, Niger State, Nigeria, was investigated using geology mapping, Landsat-ETM 2000 and Quikbird 2008 satellite images. It shows that the surface area of Tagwai dam reduced from 320m^2 in 2000 to 132m^2 in 2008, as a result of silts coming from the weathered granite ridge at the north eastern part of the dam, and also grazing around the dam.

To prolong the lifespan of the dam, there is need to carry out the dredging of the dam every ten years and remove weeds which have colonized the edge and thus reduced the surface area. Farming activities and herdsmen tract should be discouraged around the dam site, also the northeastern section of the dam should be embanked. This will maintain the volume of the dam.

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