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Application of Geoinformation Techniques in Identifying and Mapping Land Degradation Problems within Amasaman-Pokuase (Northeast of Accra) and its Surrounding areas.

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Abstract

The activities of sand winning and stone quarrying have existed in the Amasaman-Pokuase and surrounding areas for quite some years now. These activities have intensified within the last two decades due to the increasingly high demand for sand and gravels by the construction industry in the Greater Accra Region, Ghana. These activities have resulted in serious environmental hazards such as soil erosion, air pollution, deforestation, contamination of both surface and ground water systems, etc. in the study area. Thus, the project work involved the use of aerial photographs, topographic map, field observation and geoinformation techniques (spatial data acquisition, digital cartography and spatial information systems) in identifying and mapping degraded areas associated with these activities. The end result of this study are environmental hazard maps which led to classifying these environmental degradations into first, second and third classes depending on the extent of damage, either recoverable or non-recoverable. Also appropriate recommendations which include mitigation measures were considered to ameliorate the cumulative negative impact of these activities on the environment. This approach to the project is expected to serve as a model for other sand winning and quarrying areas of similar geo-environmental settings in Ghana and elsewhere in Sub-Sahara Africa.

Introduction

Landscapes naturally undergo some form of transformation processes that include some form of natural degradation, but these processes are insignificant and usually compensated for and counter balanced by nature's inherent recovery ability. Net degradation occurs whenever the degradation processes significantly exceed nature's restorative capacity.

Environmental experts defined land degradation as a reduction in the soil capacity to produce in terms of quantity, quality, goods, and services. Nsiah-Gyabah (1994) defined it as a process where a formerly productive land is rendered economically unproductive because of erosion by winds or water, loss of soil nutrients, and salinization or acidification. The identification and analysis of social factors that contribute to land degradation deserve particular attention, because they often set the stage for corrective actions and policies. In recent decades, a number of human factors associated with land degradation have been identified. These include poor land management, inadequate technology, overpopulation, poverty, and decisions of social and political structures (Nsiah-Gyabah, 1994).

The rate at which the environmental problems are being compounded can be compared to the population increase at the Capital, Accra and its environment. The comparison will enable proper planning and predictions such as accessibility of durable land for housing, commercial farming, access to portable water, evaluation of the rate at which groundwater as resource is being polluted, and other developmental projects within the study area. In addition, the necessary mitigation measures are then considered to forestall these environmental problems from occurring in the near future. Undoubtedly, the continued development of GIS and other remote sensing techniques has become an important tool in hazard mapping, planning and other research activities in this era. Due to technological advancement, it is convincing that GIS and other related remote-sensing techniques can be used to identify and map land degradation problems within the study area.

Materials and Methods

The necessary information for this study come from visual field observation and digital elevation geoinformation data compiled from hard coy topographic map (scale 1:25000) obtained from the survey Department, Ghana. The relevant geoinformation were input, stored, processed and analysed in GIS system using ILWIS, Surfer, etc from which outputs were derived as hardcopies for the deductions analysis and conclusions.

Field Observation and Mapping

Sand Winning Areas- the field observation and mapping was carried out by site visit with the aid of topographic base map. Old and active sand pits and stone quarrying sites were visited with information on location, size and extend of damage recorded. Hostile atmosphere due to land litigation around Amasaman and Pokuase, prevented detail mapping and thus visual estimation were made.

It was observed that catchment areas of the Nsakyi River and its tributaries have suffered the most intense degradation due to sand winning. The activities involved the removal of the surface vegetation and in some areas the diversion of streams. The natural width the streams in the area range area from 2m to 30m but these have been severely altered in places to widths up to 100m depths of pits measured ranges from 0.5m to 2m to the gravel and laterite layer. The Nsakyi was observed to be no longer perennial as recorded in local reports during August when the mapping exercise was

carried out but rather occur as ponds and over grown with weed and dry in places stream after Pokuase.

Some sites upslope of the stream channels and hilltops near most of the villages were observed to have in the past suffered sand winning in the past. Areas range from 200m^2 to near 2km^2 with depth up to 1.5m. Some of there areas have been reclaim with modern buildings. Some of the areas have been reactivated for sand winning. Very few places close to infrastructure were observed to have fresh and active sand winning activities. These are close to rail lines and second class roads and electrical power lines. The level of the degradation were observed to be less intense as compared to the two previously discussed.

Stone Quarrying Areas-the Togo Akwapim ridges represent the main sites for the quarrying activities. Stone quarrying were on small scale by the locals, capitalising on site exposures. Thus the site of the quarries are very small (less than 1000m^2) but scattered over wide areas. Most were mapped abandoned and filled with subsurface materials from newly excavated ones. The quarries were observed to be very close to major roads, schools and townships.

Aerial photo Interpretation

Manual interpretation of aerial photos of the area gave much information on the drainage pattern, size of towns and villages and the nature of vegetation cover. The vegetation although not virgin at the time the photos were taken, however covers most of the areas with very few areas exposed. Quarries were not visible from the photos presupposing the degradation dates after 1965. the size of the present Towns (i.e., Ofankor, Pokuase, Amasaman) which were by then villages have expanded by about 10 times since 1965.

Application of geoinformation Techniques

Georeferencing and Validation-The scan image (i.e., either the topographical map or aerial photographs) is processed by Integrated Land Water Information System (ILWIS) software programme by importing it as Windows Bitmap. The Image (i.e. raster map in GIS term) is then geo-referenced by tie points. This involves picking four points randomly from the demarcated area on the topographic map. This is then input and processed digitally on the screen. By clicking on the screen the location (selected point) and imputing the co-ordinates repeatedly three or four times the image becomes spatially registered with the new co-ordinates. During the geo-referencing, affine transformation was applied and the root mean square error or the sigma error was 0.00 (to two decimal places) which is very good as most times it is very difficult to achieve such a value. After these processes, validation and verification of the digital data was carried out to check whether if the ground distances on the map are the same as the one on the georeference raster map before it is further processed. However, if some difference still exist the whole geo-referencing process is repeated all over again.

Digitising and Database Editing-On-screen digitising of the scanned georeferenced map was done instead of table digitising, as the latter was not available. This process

converts the digital data, which is having a two-dimensional co-ordinate system (i.e. the eastings and northings), for each contour selected into numerical digital database. The three-dimensional database comprising of the eastings, northings and elevations is achieved by geocoding the numerical database with their respective elevation values from the topographic sheet. These three-dimensional co-ordinates were exported to Microsoft Excel, edited and saved as Comma Separable variable (CSV).

Results and Discussion and Problems

Figures 1 and 2 represent the 3-Dimensional (3-D) views of the study area showing the two major landforms. These are the lowlands (the G1 granites in the west) and the highlands (the Togo series to the east), which are separated by a major structural geological contact trending approximately northeast southwest. The lowlands are the potential sand winning areas while the highlands are the potential stone quarrying areas. Also, there are a lot of fault systems which shows the susceptibility of the study area to tectonic activities in times past. These are delineated on the maps and have experienced degradation activities to various degrees and intensities. Thus, the degraded areas was classified into three categories or classes. These range from 1st, 2nd and 3rd class degradations as shown in Figure 3.

First class/Category 1 Degradation -These represent areas where sand winning activities have damaged and changed the course of most rivers, especially the Nsaki and Nsakyir rivers and their tributaries flowing along the structural contact separating the G1 granites and the Togo series. These damages are the most difficult to recover and are referred to as non-recoverable damages. Communities which fall within this category are Akyiatu, Oduma, Nsakyina, etc.

Second class/Category 2 Degradation – These are intermediate damages which are between those of categories one and three. They are sites which fall outside partially degraded stream channels and also sites that were left fallow for some time and have now been reactivated for sand winning. These areas have a few buildings and infrastructure facilities. Examples of communities within this category are Abehenease, Atsiaman, Odumase, etc.

Third class/Category 3 Degradation – These are areas which have just started experiencing fresh sand winning activities. The level of environmental destruction is not all that intense compared to the other two categories. These damages are considered recoverable if the necessary steps are taken to reduce or prevent the degradation activities from accumulating in such areas. Communities which fall within this category are Obeyie, Olobu, etc.

The problems associated with the sand winning and quarrying activities in the study area are

1) Destruction of flora and fauna resulting in depriving the local people of a source of livelihood such as fishing and farming.
2) Deforestation and soil erosion leading to unproductive farmlands. Hence, this makes agricultural activities an unattractive occupation in such areas.
3) Hydrological imbalance can occur creating problems to aquatic land as well as underground water being in danger of being polluted.
4) Possible reduction of rainfall levels which may result in the drying up of most of the water bodies in the study area.

5) Electric pylons and telecommunication poles are in danger of falling due to undercutting and erosion of their foundations in areas such as John Teye Memorial school along the Accra-Kumasi road near the Pokuase area.
6) Breeding ground for mosquitoes in ponds and stagnant waters created by sand winning and quarrying activities.

Conclusion

1) The application of geoinformation techniques was very helpful in the identification, mapping and classification of the degraded areas within the study area. This method is relatively simple and cost effective for assessing land degradation problems where costly geotechnical, groundwater and other relevant data are not readily available.

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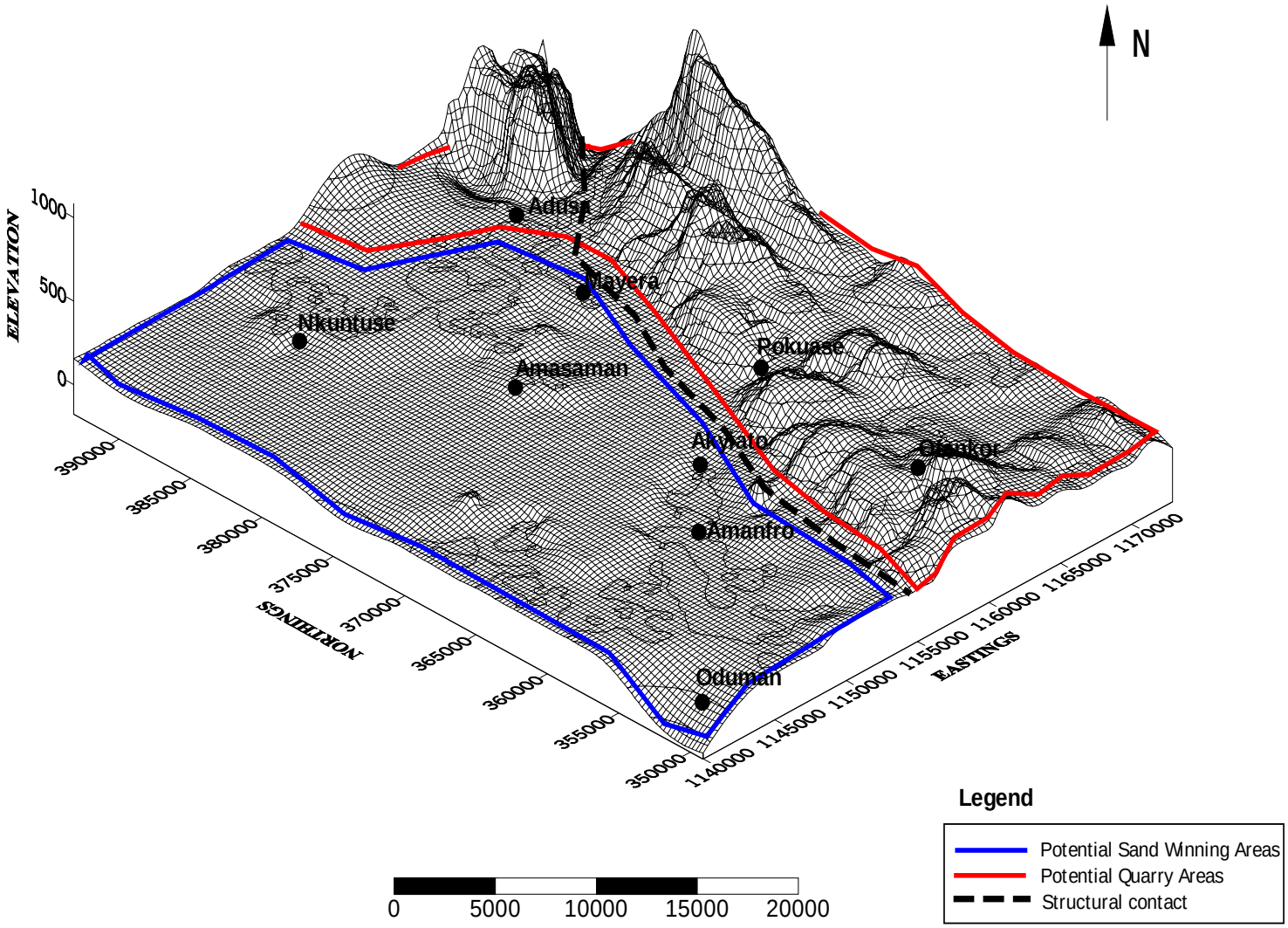

Figure 1. The digital elevation model showing potential sand winning and stone quarrying areas

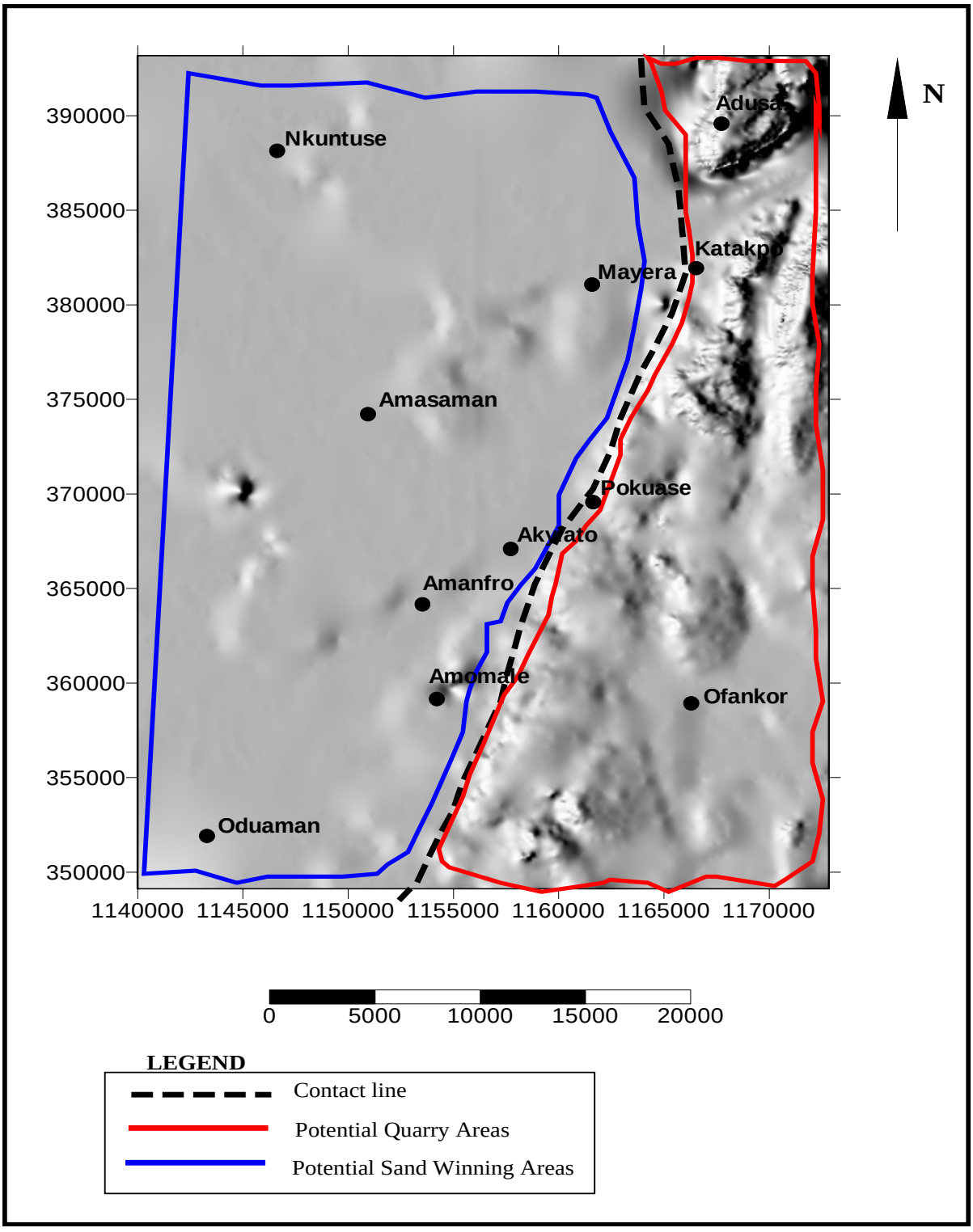

Figure. 2. Shaded relief map showing the potential sand winning and stone quarry areas

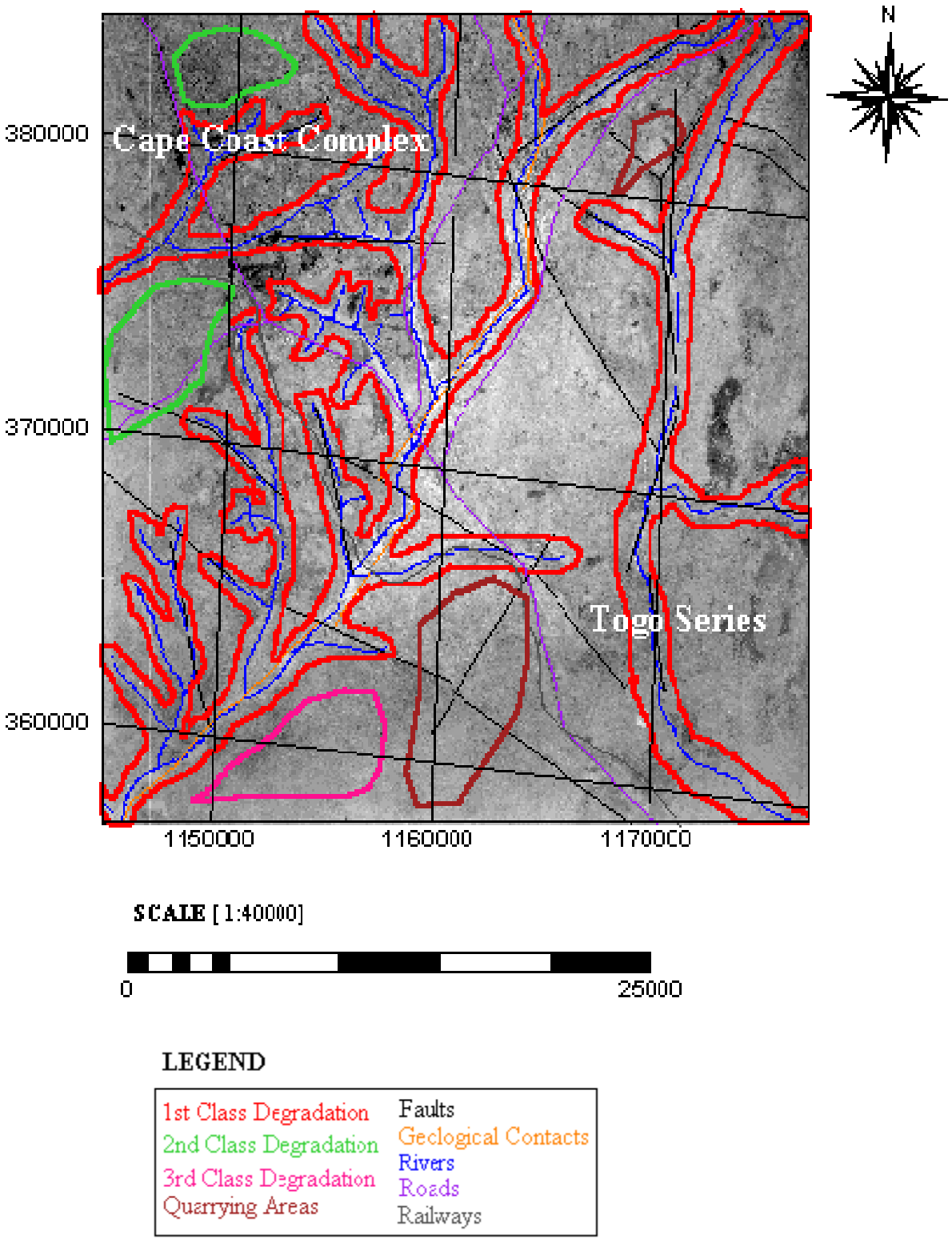

Figure 3. Composite map of sand winning and Stone Quarrying areas with respect to structural geology