Remote Sensing & GIS for Land Degradation Assessment and Land Management in Ghana

Francis Balfour AGURGO

Forest Inventory & Management Project, Planning Branch,
P.O.Box 1457, Kumasi, Ghana.

Abstract

Combined with ground observations, remote sensing and GIS could greatly enhance the inventory of soils and land cover over large areas by providing data of sufficient quality for large scale projects.

This paper seeks to demonstrate how these technologies have been successfully used in Ghana to assess degraded lands within the Nation's Forest Reserves. Landsat TM bands 4,5,3 (R,G,B) are combined with digital maps to separate forest from non-forest. Degraded portions of the forest are then delineated and their areas digitally computed. These areas are then validated through ground checks to provide data for reforestation programs.

Introduction

Land degradation is an expression with several connotations and ought to be viewed against the background of the definitions of the keywords: **Land** and **degradation**. A quick look at the thesaurus reveals that Land is not confined to clay, soil and terra firma, but also has the definition of being a plot, property, or an Estate. Its definition even included such broad terms as Country, Fatherland, Homeland and in fairness to our female counterparts: Motherland.

Out of the sixty synonyms provided under **degradation**, the following are selected: "depreciate", "devalue", "lower", "diminish", "run down", "take away", "downgrade" and "reduce".

This means that any property or Estate that is devalued, depreciated or diminished may be regarded as a form of Land degradation, and certainly this definition suits me as a Forester managing Forest Estates.

Remote Sensing and GIS applications are often considered as cost effective procedures for the collection of data over large areas that would otherwise require a very large input of human and material resources. The ease with which satellite Remote Sensing data can be rapidly processed with computers provides further opportunities for the analysis and interpretation of data, resulting in the acquisition of valuable information over large areas for Policy formulation, Planning and Management decisions.

Soils, which constitute one of the most important of the world's natural resources, are strongly varied in structure and composition. Life on earth is totally dependent on well managed soils. Poor soil management reduces agricultural output, disfigures beautiful landscapes, encourages floods and has other catastrophic effects on animal populations. On the other hand, good soil management has helped to reverse the trend of desertification in several parts of the world. Land cover types which reflect the quality of the underlying soil may be used indirectly as indicators of various levels of land degradation.

Remote sensing and GIS technologies have been used by the Ghana Forestry Department for the past six years for monitoring changes and as a means of rapid assessment of areas of intact forest for purposes of policy formulation and management decision making.

The Pru / Awura Shelterbelt Forest reserve is only one of the numerous forest reserves in the country but highlighted in this paper because of its peculiar location and function.

Location of forest reserve

The forest reserve is located at the intersection of latitude 7°20' N and longitude 1°25' W of the Greenwich Meridian (Fig. 1). Located at the very periphery of the High Forest Zone of the country, it runs in a SE/NW direction. It is bordering the Savannah Grassland regions of the northern half of the country, within a very inhospitable environment and in a fragile ecosystem.

Function

As the name implies, this forest reserve was intended at the time of its constitution to provide a protective function for the agricultural cash crops (such as cocoa, coffee and palm) of the High Forest region from desiccating effects of the harmattan winds from the Sahara desert.

Degradation

The Pru/Awura Shelterbelts have suffered from a number of factors of degradation since their constitution. These effects were mainly due to irresponsible farming practices, fire, and illegal logging activities. Because of the sparse woody nature of the reserve, it was thought that it might be possible to improve their stand density through the introduction of taungya farming; a system whereby land was granted to the local people in exchange for cheap labour in the forest rehabilitation project. The Forestry Department was to do the planting and the farmers, the tending. Land was to be released for a period of three years after which the farmers would have to move to new areas on the assumption that the plants would have survived and grown to form a closed canopy. The species selected for planting were mainly teak and eucalyptus. That surely was a brave test of theory, but the results were completely different.

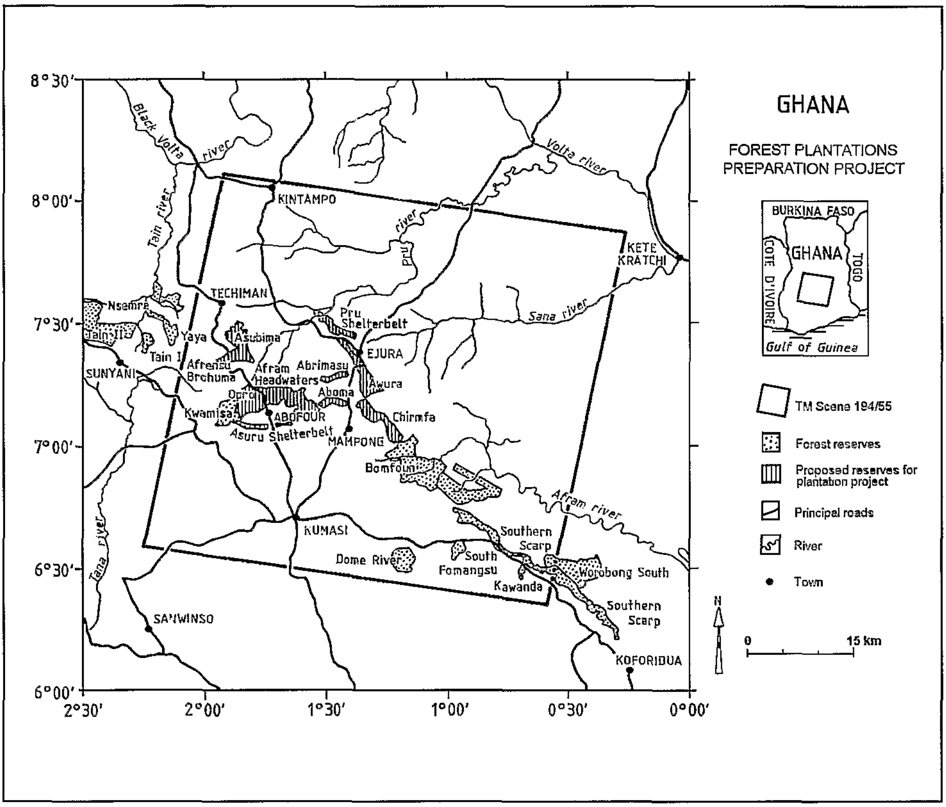

Figure 1. Ghana: forest plantations preparation project.

Once the farmers got in to an area, their tendency was to make it a permanent farm. They applied all sorts of negative practices to standing trees, including watering of the stumps with hot water to kill off their roots or pulling them slightly from their firm positions to introduce pockets of air around the roots. This made the regeneration exercise unsuccessful year after year, and for them a guarantee of permanence of farm practices. These disturbances caused irreparable damage to the Forest reserve leaving behind, large tracts of very open forest, Savannah grassland and in some places, heavily degraded land with exposed bare rock.

Meanwhile seasonal fires from the surrounding grassland areas take their annual toll on the forest with the tacit complicity of negligent forest guards. The heavy litter of teak also served as highly combustible material thus increasing the level of degradation through burning.

While an urgent need to rehabilitate these reserves under a large scale plantation programme became imminent, the scale of the problem could not readily be assessed through ground methods. It was at this point that the need for Remote Sensing approaches became inevitable. The area was flown to obtain aerial photographs and detailed maps of Land-cover types were produced at scale 1:50,000.

Meanwhile all these factors of forest degradation are observable from space and are picked up by satellites in a digital format in different wave band regions of the electromagnetic spectrum. This enables the satellite image interpreter to manipulate these data through multiple band combinations and various enhancement techniques to see and accurately map these problematic areas. Satellite images (Landsat TM and SPOT XS) were consequently acquired for digital processing at the Image Processing Laboratory of the Forestry Department in Kumasi, using ICONOCLAST Image processing software.

Method

The three bands were respectively loaded into the red green and blue (RGB) display stores of the visual display unit (VDU) and enhanced for interpretation.

A Topographic map of the Forest reserve was then video frame-grabbed, and oriented to true North on the screen.

A viewport, which is a window defining the true map coordinates for the lower left hand corner and the upper right hand corner of preselected points on the map was generated. Essential features such as nearby roads, towns and villages were then digitized from the topo sheet using a mouse-driven screen cursor, and the resulting raster data stored in a file. Care was taken to include as many features as possible observable from the Satellite image to use as ground control points for geometric correction of the satellite image.

The extracted features were then recalled from file to the overlay plane of the VDU while an extract of the forest reserve was loaded into the RGB display stores.

Geometric correction

Points from the topographic map data such as road intersections, angular turns and small villages were tied to corresponding points observable from the satellite image and the image resampled to the geometry of the map. This procedure was repeated until a satisfactory fit was obtained between the image and the topographic map, with all the map features directed exactly on the corresponding image features. A geometric correction was then said to have been achieved through warping of the image.

A progress map of the forest reserve which shows the compartments and the boundary pillars of the reserve and a sample plot location map were also video-grabbed and the features digitized into separate raster files. These features were also recalled and warped to the geometry of the topo map data for ease of data juxtaposition.

Image interpretation

The satellite image was visually interpreted using the cursor to delineate areas of similar spectral response patterns on the screen, zooming in and out where necessary. The result was two classes; one of forest and the other of grassland. Appropriate colours were then assigned to each of the two classes and a thematic map generated and also saved as a separate file. The creation of plot files from each of the different files generated made it possible to plot either single files or any combination of the sets of data.

Management decision making

Digital mapping eases the problem of data integration from different sources involving maps of different scales. A combination of the satellite image interpretation and the progress map makes the Forest manager see through each of the compartments and assess their stocking levels. This information is vital in deciding whether a stock survey team has to be sent to an area for timber stocking assessment.

Since areas of the different classes can readily be computed, the resource manager is in a position to intently tell what area needs to be reforested and even calculate the amount of money that will be involved.

Rational decisions could also be arrived at, regarding whether an area could or could not be logged.

What is even more important is the fact that the resource manager knows precisely where to direct his energy and will not have to wander around the forest reserve.

Needless to say that an up-to-date and reliable map of any resource area is a great asset to the resource manager.

Conclusion

In conclusion, I would like to state that remote sensing and GIS applications have greatly eased the process of data acquisition over the forest reserves of Ghana, which cover large areas. The technologies have considerably reduced the cost of such operations; and with a good knowledge of where the problems are and a fair assessment of their magnitude Ghana is on the right path towards effective land management.

Acknowledgements

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