MINISTRY OF NATURAL RESOURCES AND TOURISM
FORESTRY AND BEEKEEPING DIVISION

REGIONAL WORKSHOP ON THE USE OF GEO – SPATAL TECHNOLOGY FOR NATURAL RESOURCES MANAGEMENT, ENVIRONMENTAL MONITORING AND DISASTER MANAGEMENT HELD IN KHARTOUM, SUDAN

A PAPER PRESENTED AT A WORKSHOP ON THE USE OF GEO-SPATAL FOR FOREST RESOURCE MANAGEMENT

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LIST OF ABBREVIATIONS AND ACRONYMS

CBO	**-**	Community Based Organization
DFOs	**-**	Districts Forest Officers
FAO	-	Food and Agriculture Organization of the United Nations
FBD	-	Forest and Beekeeping Division
GEF	**-**	Global Environment Facility
GIS	**-**	Geographical Information System
KVTC	**-**	Kilombero Valley Teak Company
LDCs	**-**	Least Developed Countries
MNRT	**-**	Ministry of Natural Resources and Tourism
PO-RALG	**-**	President's Office – Regional Administration and Local Government

SUMMARY

Tanzania is covered with forests and woodland which are estimated to be between 30 and 40 million ha. the Ministry of Natural resources and Tourism through the forestry and Beekeeping Division is entrusted with the responsibility to manage the country's forest and bee resources on a sustainable basis to meet the needs of the local and global communities. The forests and woodlands are subject to immense pressure leading to high rate of deforestation. There are no reliable data on deforestation rate although estimates range from 130,000 to 500,000 ha per year (National Forest Policy, 1998). Recent estimates (FAO, 2002) indicate that Tanzania's deforestation rate is about 92,000 ha per annum. Reasons for such variation are difficult to establish but are mainly no mechanisms for collection and analysis of data. The main causes of loss of Tanzania's forest, woodlands and biodiversity include shifting cultivation, planned agriculture, development of settlements, overgrazing uncontrolled fires and cutting trees for charcoal production as well as over-exploitation forest resources for income generation and domestic uses. Most of human activities take place in the unreserved forest and woodland area (the general lands). Furthermore, due to inadequate human and financial resources the Forestry and Beekeeping Division has not attained sustainable forest and woodland resources management in the gazette forest reserves. Thus deforestation through encroachment and over utilization of resources are still taking place in forests and woodlands with legal status.

Geo – spatial technology is an important tool for forest management since it assists in estimating volume of wood, area determination, detection of illegal activities and mapping of catastrophes in the forest estate.

In Tanzania this technology has been used in various projects.

The forest division does not have the facility and capacity is low. Most of the project done have been facilitated through consultants.

Application of geo-spatial technologies is crucial in obtaining sustainable management of Tanzania's forest and woodlands.

1. INTRODUCTION

Tanzania is geographically located in the eastern part of Africa and lies between Latitudes 1^0 and 11^0 10' 5" South and Longitudes 29^0 and 41^0 East. Tanzania occupies about 94 million ha and is endowed with abundant natural resources such as forests and woodlands, lakes and rivers, wildlife spread in 12 National Parks and in 50 Game Reserve with Selous Game Reserve being the largest in Africa South of the Sahara. Tanzania is also endowed with a number of minerals such as diamond, gold, tanzanite, rubies, coal and iron just to mention some.

Forests and woodlands account for a large proportion of Tanzanian's land-use pattern and also recognized as important resources for social-economic advancement but faced with enormous pressure due to uncontrolled human activities leading to high deforestation rate. The object of the paper is to highlight on the forests and woodland resources and the need to have accurate/reliable data/information for resource management planning, basis for decision making and control through the application of remote sensing and GIS technologies.

2. THE STATUS OF FORESTS AND WOODLANDS

The forests and woodlands in Tanzania constitute of Miombo woodlands (wet and dry, which occupy about 96% of Tanzania's forest estate), moist forests in mountainous areas, coastal forests and Mangrove. Itigi thickets found in central Tanzania are quite unique. The moist forests account for a relatively small percentage of the total estate. The Miombo woodlands are the main source of wood and other woodland-based products (honey, fruits, traditional medicines/herbs, withies, resins, mushrooms etc.).

2.1 Natural Forests

Tanzania is covered with extensive forest and woodland resources but there has been inadequate reliable data about Tanzania's forest and woodland estate. Whereas the Ministry of Natural Resources and Tourism (MNRT) in (1998) calculated the forest and woodland estate to be about 33.5 million hectares (ha) also see Table 1. FAO (2000) estimated 38.8 million ha while the World Bank (2003) refers to about 40 million hectares. This means the exact forest and woodland estate is between 30 and 40 million ha or between 32% and 43% of Tanzania's total land area. About 13 million ha of forest and woodlands estate have legal status as gazetted Forest Reserves, of which about 2 million ha are gazetted as Local Government Forest Reserves. Forest Reserves account for about 37% and non-reserved forests and woodlands 57% while the remaining 6% falls under the National Parks (Iddi, 2002). Furthermore, reserved forests and woodlands are categorized into productive forests which occupy about 76% and protective forests covering about 22% of the forest reserve area which 2% meets both productive and protective functions.

There are several past studies to map the extent of forest cover using remote sensing resources. One of those studies focused on closed natural forests, assessing extent of closed forest, thickets and mangrove within different administrative regions, and different rainfall zones. This study (Rodgers, Maide, Malima 1984) estimated 1.96% of Tanzania land area to be closed natural forest. Late MNRT, using the Regional Remote sensing Facility in Nairobi mapped all natural vegetation classes; this map has been used widely in Tanzania. More recently; with a world Bank Credit a detailed land use cover mapping exercise was completed for the whole country; at a scale of 1,250,000. Detailed analysis of spatial cover of forest types was described in accompanying reports.

Table 1: Distribution of Forest Area by Type, Use and Legal Status

Forest type	000 ha	Proportion in %
Forests (other than mangrove forests)	1141	3.4
Mangrove forests	115	0.3
Woodlands	32 299	93.3
Total	**33 555**	**100.0**
Use of Forest Land		
Production forest area	23 810	71.0
Protection forest area (mostly catchment areas)	9 745	29.0
Total	**33 555**	**100.0**
Legal status		
Forest reserves	12 517	37.3
Forest/woodlands in national parks, etc	2 000	6.0
Non-reserved forest land	19 038	56.7
Total	**33 555**	**100.0**

Sources: (MNRT, 1998)

2.2 Industrial Plantations

The MNRT owns and manages 16 industrial plantations with a total of 80,000 ha of both hard and softwood species. The main species include Cupressus lusitanic, (which has been seriously affected by aphids), *Pinus patula, Tectona grandis* and some *Eucalyptus spp.* The plantations are found in different locations in the country. The recent Wold Bank report (2003) shows the private sector owns and manages about 55,000 ha of forest plantations including about 6,000 ha of Wattle (*Acacia mearnsii)* and about 8,000 ha of Teak *(Tectona grandis)* most of which is owned by the Kilombero Valley Teak Company (KVTC) whereas Iddi (2002) indicates that about 80,000 ha of forest plantations are operate by the private sector mostly as woodlots ranging from 50 ha to over, 1,000 ha owned by individual households, villages and Community-Based Organizations (CBOs) such as Youths and Women. Over 24,000 ha of privately owned plantations in Tanzania are found in Mufindi district in the Iringa Region. It is the only district where forestry activities are second to Agriculture in terms of income generation.

The forest and beekeeping sector's potential to poverty reduction is also highly acknowledged. Experiences from Sao Hill forest plantation and other plantations in the country show that adjacent local people can earn some modest income through employment and by establishing own woodlots. Sao Hill plantation surrounded by 44 villages spent about 180,000 USD during the 2002/03 financial year on casual labourers to raise 1.9 million seedlings and planting the seedlings I 1,105 ha. In the same period about 300,000 m^3 of wood was harvested thereby earning the nation about 1.2 million USD. This demonstrates that industrial plantations can contribute to environmental conservation, poverty reduction and national economy as a whole.

2.3 Administration and Management of Forests and Woodlands

The MNRT has overall responsibility for the development of the forestry and beekeeping sector thus it formulates policy and supervises its implementation. However, other government structures overseeing the implementation of activities in the sector also exist. For instance, at local level implementation of the policy becomes the responsibility of the President's Office- Regional Administration and Local Government (PO-RALG) with the mandate to coordinate and oversee the functions performed by Regional secretariats and Local Government Authorities and District Council. The FBD provides overall policy guidance and technical insight. It is also the responsibility of the FBD to undertake law enforcement through monitoring and supervision in order to ensure compliance. District Forest Officer (DFOs) are in charge of all forestry matters in the districts with technical guidance from FBD. Further to that, the latter also facilitates training to technical and professional cadres. This includes organizing in-service training for DFOs and the paraprofessionals who undertake regular extension services to farmers. Such capacity building is done through tailor-made short courses and conducting study tours ranging from one week to three months.

The MNRT through the FBD is directly managing 16 industrial plantations and about two million hectares of critical Catchment forest Reserves in Arusha, Kilimanjaro, Morogoro and Tanga Regions. The rest of Tanzania's forests and woodlands including most of the Territorial Forest Reserves which are owned by the Central Government are protected and managed through the districts administration under PO-RALG. In most cases FBD has inadequate numbers of staff in the regions and very few at the district level. In such a situation FBD operate through the DFOs who administratively are answerable to the District Council Authorities. Under this arrangement FBD provides some financial support to the Districts in order to enhance their performance in terms of improved forest and woodland resource management and service delivery to customers, especially the local communities.

2.4 Constraints

Tanzania's forests and woodlands are under increasing pressures mainly due to population growth and desire for economic advancement. There is an ever-increasing demand for expansion of agricultural areas, more human settlements, and livestock grazing, and cutting more trees for construction poles, timber, firewood and production of charcoal. The forests which are in the general lands suffer from this calamity.

Although the deforestation rate differs from different source e.g. 91,200 hectares of forests and woodlands are lost each year (FAO, 2000). The National Forest Policy (1998) refers to a deforestation rate of between 130,000 ha to 500,000 ha per year. Shifting cultivation may account for more than 50% of deforestation on Tanzania mainland. Charcoal making becomes the second contributing factor. Illegal harvesting and mining activities are also reported (Iddi, 2002) to contribute to deforestation in Tanzania.

Annual and uncontrolled fires which occur during the dry season are a major threat to forests and woodlands including biodiversity resources therein. Industrial plantations are also damaged by fire thereby causing substantial losses. For example, in 1993 Sao Hill plantation lost about 6000 ha due to severe fires. It is very rare to have fires occurring due to natural causes like lightning or extreme heat during the hot session. However, in most cases bush fires are caused by human activities through agricultural activities (slash and burn), or burning rangelands to pave way for new pasture for livestock. Furthermore, fires are caused as a result of honey collectors when smoking bees and then fire erupts and get out of control. Sometimes fire occurs through hunter's burning bushes to scare the animals as well as smokers throwing cigarettes to dry matter which through the effect of wind catches fire. Once fire occurs in forest plantations, it becomes very difficult to contain because of inadequate fire fighting tools like fire beaters or aircrafts which can spray over the fire.

For more than 20 years Tanzania has been a home for refugees due to civil wars and tribal conflicts occurring in several Countries in Africa. The refugees have caused tremendous environmental degradation in Western Tanzania especially in Kagera, Kigoma, and Tabora Regions. Large tracks of forests and woodlands have been cleared by refugees either for human settlements or cultivation of food crops. In addition to that, refugees led to over exploitation of forests and woodlands for fuel and building poles.

3.0 BASIC CONCEPTS OF GEO-SPATIAL TECHNIQUES

Geo-spatial technique is the science and art of obtaining information about an object, are or phenomenon through the analysis of data enquire by a device that is not in contact with the object, area or phenomenon under investigation.

In many respects geo-spatial technique can be thought of as a reading process. Using various sensors data remotely collected and analyzed to obtain information about the object, area, or phenomenon being investigated. There are two basic processes involved i.e. data acquisition and data analysis. The data acquisition process involves the use of sensors to record variations in the way earth surface features reflect and emit electro-magnetic energy. Data analysis involves examining the data, using various viewing and interpretation devices to analyze pictorial data, and/or a computer to analyze numerical sensor data. Reference data about the resources being studied (such as forest maps, soil maps and crop statistics) are used when and where available to assist in the data analysis. With the aid of the reference data, the analysts extracts information about the type, extent, location and condition of the various resources over which the sensor data were collected. This information is these presented, generally in the form of maps, tables and a written discussion or report. Typical information products are such things as land use maps and crop area statistics. Finally the information is presented to users who apply it for decision making.

4.0 APPLICATION OF SPACE SCIENCE TECHNOLOGY FOR THE MANAGEMENT OF FORESTS

4.1 General Application

Remote sensing and GIS are crucial technologies for attaining sustainable Forest management.

The importance of space science technologies cannot be over-emphasized. In terms of forests and woodlands management remote sensing and GIS can help to**:**

- Estimate the volume of wood (biomass) in terms of growing stock;
- Determine areas covered by (extent) forests and woodlands;
- To detect illegal activities e.g. farming or timber harvesting inside forest reserves, and human settlements in gazetted forests and woodlands.
- To detect and map catastrophes in the forest estate.
- To monitor vegetation change.

Application of remote sensing and GIS technologies is not a new thing in Tanzania.

Tanzania has used these technologies to obtain information/data possibly without physically visiting the site. In essence geo-spatial technology has been used in the following projects:

1. Sao Hill softwood plantation with an area of 42,000 ha. was mapped in 1965, 1968 from Aerial photographs. The same plantation was re-mapped in 1978 and 1998 using both Aerial photographs and satellite imageries.

2. Tanzania Vegetation cover map was made from satellite imageries at the scale of 1:2,000,000 in 1982/4. Aerial photographs were also used where detailed information was needed. This exercise covered the whole country.

3. Dar es Salaam vegetation cover map at the scale of 1:250,000 were made from both Aerial photographs and satellite data in 1989.

4. Tanzania Land use maps at the scale of 1:250,000 crossing the whole country were made from satellite data and Aerial photographs in 1994/6.

5. Tanzania vegetation cover maps and land use Database funded by FAO were made from both satellite data and Aerial photographs in 1997/8. Interpretation was done both visually and by computer methods.

6. Mangrove Resources of Tanzania Mainland were Mapped from Aerial photographs digitalized and printed in 1990. The maps are at the scale of 1: 25,000 and 1:50,000.

7. In early 1990's NORAD supported the mapping of Catchment Forest Reserves using remote sensing to attain information with regard to degradation. This further required ground truthing to get sufficient useful data for defining levels of encroachment.

Furthermore remote sensing and GIS technologies can contribute significantly to improved conservation and management of natural resources in Tanzania through:

- Facilitation data collection for preparation of natural resources management plans. For instance, remote sensing and GIS technologies can help to determine exact rate of deforestation in forests and woodlands;

- Assessing the extent of environmental degradation in national parks and game reserves, which are largely composed of woodlands;

- Easily detecting forests and woodlands degradation and appropriate interventions quickly undertaken;

- Monitoring forests and woodlands health conditions;

- Managers can easily detect special changes due to natural calamities like bad weather conditions e.g. drought, floods or die back due to an out-break of unknown diseases. For example, aphids' attack, which resulted into massive mortality of *Cupressus lusitanica* which occurred in nearly all the industrial plantations, threatened growth of *C. lusitanica* in Tanzania. It took time to understand the casual factor and areas affected were not easily known but through remote sensing and GIS technologies it could have been possible to determine extent of damage and where it had occurred basing on coordinates and digitized information.

4.2 Geo –Spatial Activity in Tanzania's Forests and Woodlands

While there have been a number of remote sensing initiatives leading to computerized outputs of Tanzania vegetations including forests there is no overall GIS facility within Tanzania's forest and beekeeping sector. GIS facilities are found in Uganda and Kenya (relatively small) and there are GIS units in other sectors in Tanzania (water, environment, land, PO-RALG under the sustainable cities programme and Universities) but not in the FBD. However, re-structuring of the sector; with an increasing emphasis on resource monitoring has emphasized the need for such developments.

On the other hand, forest project based activities in Tanzania have used both GIS and remote sensing products in a variety of ways:

- The UNDP- GEF Cross Boarders Project has used GIS as a tool to develop maps of forest resources for management plan purposes. Such maps showing topography, water, sacred sites, fires, rare species, and proposed connation are used for awareness and for particularly planning. They become key components of a management plan.

- The DANIDA supported Uluguru Forest Conservation Project, implemented by the Wildlife Conservation Society of Tanzania used conventional aerial photography over three decades to show patterns of forest loss. This illustrated the impact of deforestation at lower attitudes and remaining forest is virtually on the mountains tops.

- The FINNIDA supported East Usambara Forest Catchment Project used GIS mapping to illustrate the problem of forest fragmentation and the need to develop corridors to improve biological connectivity. GIS was also used to plan the location of the Amani Forest Nature Reserve within a mosaic of village lands and public and state forest. Planning illustrate both rights and responsibilities for management purposes.

- Research input to the Eastern Arc Mountains forests by the US to access land use threats and to map forest health problems was easily accomplished using space science technology. Associated research using new high resolution remote sensing products to map and then predict forest of high biodiversity value.

These initiatives have demonstrated to government forestry authorities the great range of outputs and uses that geo-spatial technology can bring. There are GIS skills in Tanzania (although at a low level), courses are taught in Universities what is needed is to investigate result oriented capacity into forestry; for monitoring, planning and reveal purposes. Such inputs are expected to come with support from donor attributes, challenge then will be to take the results out of a centralized GIS unit and apply it with ownership and involvement at field implementation level.

4.3 Gaps

Generally the application of geo-spatial technology for sustainable management of Tanzania's forests and woodlands is still low. Thus, there is a big gap between developed countries and Least Developed Countries (LDCs) in application of space science and technologies. This can partly explain varying reports about the rate of deforestation in Tanzania which is estimated to be between 90,000 and 500,000 ha per year. With the use of geo-spatial technologies it is most likely to establish a reliable rate of deforestation but also assessing forests and woodlands recovery and regenerating potential basing on species composition, site classification and including other ecological factors such as being in low or mountainous areas. The challenge to LDCs lies in acquisition of technical know-how and inability to build-up the capacity to handle space science technologies. Not only that but also, access and affordability of the required equipment and relevant software's becomes a limiting factor. The majority of the LDCs including Tanzania are poor hence cannot easily mobilize adequate financial resources to meet needs. Thus, technical and financial assistance is required to enable development countries to acquire the space science and technological know-how and equipment to be used and guide management and utilization of natural resources on a sustainable basis.

In most cases the projects that have been done in Tanzania using space science technologies were accomplished using consultancy services. Thus, capacity within the forestry and beekeeping sector is still inadequate to handle such technologies. The need to build internal capacity rather than relying heavily on foreign consultancy services cannot be over-emphasized.

5. CONCLUSION

Destruction of Tanzania's forests and woodlands is largely caused by the poverty stricken local communities and many low income families living in peri-urban and urban areas. Thus, forest resources are subject to immense pressure, which result in deforestation and loss of biodiversity. There are no recent data on extent of forest and woodland resources and changes that take place therein. Availability of reliable data would enable forest resources managers and conservations to design strategies that would lead to sustainable conservation and management

Geo-Spatial technologies will play a significant role in establishing forest and woodland resources base and change. Geo-Spatial technologies can possibly assist mapping the extent of fire damages and to generate useful information that can be applied to design strategies for mitigating annual fires in Tanzania and other developing countries facing similar problems.

6. RECOMMENDATION

Application of geo-spatial technologies is crucial in attaining sustainable management of Tanzania's forests and woodlands. It is through such space technologies that forests and woodlands managers can obtain quick and reliable information about environmental degradation through indiscriminate cutting of trees and clearing forests and woodlands. It is therefore, recommended that deliberate and concerted efforts by global communities be made particularly by developed nations to enable LDCs to have access to and be able to afford utilization of space science and technologies such as remote sensing and GIS in management of natural resources for the benefits of local and global communities.

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