

# **Geo-Information System Application for Sustainable Land Management in Tanzania.**

**(GIS)**

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“The environmental degradation caused by over exploitation of existing arable land and grazing areas which consequently lead to further deforestation, land degradation and the reduction of yields, is a matter of great concern to the countries of Sub Saharan Africa and Tanzania in particular. This calls for continuous attention by all Agencies, Government and private, responsible for natural resources management. For sustainable Land and resource management in these countries, the Geo-Information system or (GIS) technology tool, is the solution to faster and reliable future land use development.”

## **1. Abstract**

Lack of proper land information management systems for settlement, agriculture, livestock, wildlife, mining, etc, is among the factors which affect the development of Tanzania. Many land use systems in Tanzania are subjective to peoples need of land for settlements. Fast population growth and the increase of rural-urban migration has forced people to settle on unauthorized or unplanned land. Likewise, inadequate implementation of land utilization types has resulted in land conflicts, double allocation of land plots and squatting. The existing master plans and their preparation systems are too old today to cope with land use dynamics. Process planning is seen as the proper future approach for sustainable land use development in Tanzania and many Africa Sub Saharan countries.

Inadequate land information systems for sustainable land use management, improper technologies together with funds, make the land problems grew bigger while they remained. The implementation of land use programs which are the basis for National Land Management (NLM) and which are under progress in Tanzania today, give hope for sustainable solutions. The Sustainable Dar es Salaam Project (SDP), Dodoma Land Use Management Project (DLUMP), Forest Resource Management Project (FRMP), and many others, are among the strong land and resource forecast programs in Tanzania. Future management of urban squatters in Tanzania, and the national land use program, have their roots in Geo-Information System development.

## **2. Introduction**

### **2.1 Land use Planning and Information in Tanzania**

Over the past years, Tanzania and most of the African countries have not yet introduced Geo Information Systems development for Sustainable Land Use Development. The recent land resources management practices using GIS and LIS technology made it necessary to have the Geo-Information tools in Tanzania. The Geo Information System has proved to have potential especially where optimization in decision making is required. It is a reliable tool for development plans and long run programs. Planners and decision-making professionals sometimes think that, the available resource data are meager where the evaluation, manipulation and documentation of them can be handled manually. Modern technology for data or information handling depends much on the computer, which calls for skilled personnel, more reliable infrastructure and stable capital and has made Tanzania not

able to afford the full implementation of geo information technology. Old land use systems remained in use while slowly deteriorating. Growth in the land demand and rates of rural to urban migration has forced the old system of data/information management to change. Going for a more sophisticated system such as a GIS, which are rather costly but efficient and reliable, is the task ahead of land use planners in Tanzania.

Traditional systems of information handling require more manpower, space and facilities, and are consequently less portable. Tanzania has experienced this system before and even after its Independence in 1961. With better and improved modern tools at the Surveys and Mapping Division, Dar es Salaam, this system is advancing. Varieties of digital products are available today, including cadastral plans, base map information, land vegetation cover information, and other thematic information. It is not yet clear who is responsible for the development of the National land use Geo Information System in Tanzania, although there is already more land information available than the amount being processed. However, the nature of the land information system in Tanzania is not too bad. It is however non-interactive, and centered at regional and district levels. The cadastral information systems are very well centralized and traditionally organized under the Ministry of Lands, Surveys and Mapping Division (SMD) in Dar es Salaam.

## **2.2 Land and Information Management in Tanzania**

Land in Tanzania is a Government property. No body can own land without local land permit. Land information in Tanzania is kept under two systems. The manual file/record keeping system and the GIS/Cadastral section with the application of Micro station software. Land information is also available at the Digital unit of (SMD). Geodetic survey, remote sensing, ground surveying and aerial photographing are the techniques used in Tanzania for the creation of a Geo-Information database. Data are processed and presented at different organizations. What lacks in Tanzania's Geo-Information systems creation and its development is a *National integrated Land Information structure*. Where the agriculture sector nurtures its own structure for Land Use Management which is not very well linked to forestry, Housing Co-operation (NHC), Settlement sector, Lands department, Mining sector, Environmental Council (NEMC), and the like. Towards the 21st century, the establishment of lacking structure is a target ahead the planning bodies. The power of modern technology in data handling and its integration gives hope of reaching the sustainable land management in Tanzania. Geo-Information applications/approaches have all possibilities to progress today and as well in future using technology innovation and transfer program opportunities.

## **3. Literature Review**

### **3.1 Geo-Information for Settlement/ Housing Management in Tanzania**

According to the available Geo- Information data for settlement, land and housing, the following information was reported to the Members of Parliament (MP) 1996/97 budget session by the Minister for Lands, Housing and Urban Development (Honourable G. Cheyo). In 1996 when the Tanzanian population was estimated to have become 30 million, 25% of it had migrated from rural areas to urban centers. The impact of rural-urban migration caused growth of housing demand and increased dependants due to greater unemployment. This trend if left continuing, will have reached 30% in the year 2000 and can cause serious poverty at the national level. Such information calls for gradual monitoring and analysis of land/social relationship. Land, Housing & Settlement information is somehow integrated under the census programs in Tanzania. It will be useful to the Government of the United Republic of Tanzania, when Geo Information applications are fully implemented. For example, the existing information shows that in 1964-69 about 37,000 people required land for houses. Based on this information the housing demand in the period of 1976-81 could be forecasted. It predicted that about 250,000 people would require land for housing in the Urban areas enabling the National Housing Co-operation (NHC) plan to better its housing

programs for the years 1982-87 and so on. The Information analysis work has made it clear that about 40%-75% of urban residences in Tanzania are squatters, whereby new squatters amount to 65% yearly as reported by G. Cheyo (MP). This being only one sector of Land Use Systems analysis-Housing, it shows the potential application of Geo-Information Systems for Land Use Planning in Tanzania.

### **3.2 Natural Resources Management in Tanzania (Forestry)**

The application for Natural Resource Management in Tanzania has enabled researchers and Planners to obtain reliable information for forest analysis. The Forest Resource Management Project (FRMP) in Tanzania has since 1994 contributed a very crucial part of Tanzania's data bank. When the project will have completed its contract in 1998, Tanzania will for the first time avail of National Land Vegetation cover information in both Digital forms and as printed map images. This information which was derived mostly from 1995/96 satellite images 'Thematic Mapper'(TM), creates a very reliable Geo-Information base for the planning of agricultural land, hydrology, forestry, wildlife, catchments and other designated areas.

In 1938, the forest cover in Tanzania was about 44,300,000 ha, while in the year 1987, about 49 years to time, only 38,096,000 ha, of forest cover remained. Deforestation that affected land and caused severe erosion was 0.5% of the total forest cover in Tanzania. In recent years, the National Environmental Management Commission (NEMC), has reported that over 90% of the national energy supply depends on bio-mass. The Geo Information system (GIS), installed by TANRIC in 1994/95 at the Institute of Resource Assessment (IRA), University of Dar es Salaam, reported that more than one third of most forest reserves in Tanzania, had been replaced by settlement/agricultural activities.

TANRIC is a very new data library in Tanzania, and will make data accessible, using its new Information Structure under Arc-info software.

## **4. Land Use Planing Practices as Future Geo Information Base in Tanzania**

### **4.1 Loliondo area a typical Geo Information case (the 1994-2008 Program)**

The review of the 1994 National Land Use Planning Commission (NLUPC) report has proved that application of Geo Information for land use management in Tanzania will be the proper track towards sustainable land development. The NLUPC is responsible for development and reinforcement of land use policy in Tanzania. Loliondo land use planning is one successful case study to show the importance of geo information application in Tanzania.

#### **4.1.1 Loliondo area-Physical Environment overview**

Liliondo division, part of Arusha Region, Ngorongoro district in northern Tanzania, is located at 2°15 s and 35°30 E. Its approximate area is 289,800 ha, while the population was 21,657 people according to the 1988 population census. The dominant activity in this division is agriculture and live stocking, although there are periodic nomads and game conservation. Soils of Loliondo are highly fertile. Not so many pesticides are found in this area even though animal diseases are common. The great problem observed so far by the NLUPC in Tanzania concerning this area is the fast resource and soil depletion since the 1990's. Population growth, being one of the causes, is recorded to be 5.4% p.a. in 1994. This place is among the few places in Tanzania whose land use data are well collected and organized. Loliondo division's land information demonstrates the potential if progressive Geo Information application in Tanzania. Meanwhile efforts are made by the NLUPC to implement the proposed land use plan of Loliondo area. Objectively it is thought that implementation of the proposed land use plan will help to improve the food situation and reduce drought which was

reported even before 1994. The situation is serious this year (1997), when the government declared the place as critical and requiring extra care on food and water. The situation was never like this before, and resulted from lack of long term land use plans and information analysis that could forecast what is happening. Also, ignoring the recommendations given by researchers contributed to this. Loliondo's information had already predicted the present situation. Arusha Region is one of the places in Tanzania where drought crises are not easily expected, because of its favourable climate and good soils. Due to the pressure on land resources and on the environment as a whole, life is now very difficult at Loliondo as reported by the African Journal in March 1997. Arusha region and especially Ngorongoro district, are among the potential tourist places with a variety of wildlife. Apart from the tourism it receives many foreign executives at the International Conferences center (AICC or HOTEL77). Lack of the effective geo information systems application, has *created three basic land problems or conflicts* together with hunger and/or drought as refereed to, Prof. Misana & Mr. Nyaki, 1994.

- Land conflict between agriculturist and pastoralists.
- Land conflict between agriculturist and game conservation authority.
- Land conflict between pastralists and games conservation authority.

Land use planning with focus to maximum land productivity is considered as key solution in this region. Land utilization type with respect to land evaluation and EIA, will assist in predicting negative impacts of land at Loliondo area and as well many other places in Tanzania.

**Table 1. Land Use Distribution at Loliondo Division**

	Land Use Category	Area (Ha)	Percentage
1	Agriculture	8079.0	2.8
2	Forest	8850.0	3.1
3	Range Land/Game Reserve Area	236,908.0	81.7
4	Settlement/Service Infrustructure	35,963.0	12.4

Source: Agriculture department-Loliondo division 1990/91.

#### 4.1.2 Present Land Use Types in the Loliondo Division

There are four land use categories described by the NLUPC (1994) that occur in Loliondo Division: subsistence farming, unplanned livestocking, range land/game/forest reserves and settlement. Land tenure is basically under the communal property system practiced by nomadic pastoralists. The land is commonly used by herds from different Maasai families.

#### 4.1.3 Soils of the Loliondo Division

The soils of Loliondo are calcimorphic, and vertisols of lithomophic origin. Most Loliondo soils have gray and gray brown colours. The soil texture is predominantly, sandy loam with good drainage, loamy sand with imperfect drainage and loam with good drainage.

#### 4.1.4 Loliondo Land Suitability Classification

Based on the Zimbabwe/Rhodesia suitability classification, which originated from FAO (1985), three suitability classes are given for arable land.

- Highly suitable land class (S1)
- Moderate suitable land class (S2)
- Marginally suitable land class (S3)

For the non arable land there are two classes:

- . Non suitable land class (N2)
- Non suitable land class (N3)

Class N2 is defined as somewhat severe erosional land while class N3 is defined as moderately severe erosional land.

#### **4.1.5 Loliondo Land Units**

According to NLUPC 1994, four land units are distinguished in the Loliondo Division, viz the Mondorosi, Oldonyo Ogol, Angata kheri, and Serengeti land units. The land use type of the Mondorosi unit is basically subsistence farming small scale and domestic. The Oldonyo Ogolo land unit is characterized by its national park and game reserves. There is no agriculture activity except a few herds of Maasai tribes. Man with goats and donkeys. Angata Kheri unit has not been well studied with regard to its land use but the place is proposed for wildlife management. The Serengeti unit is also not clearly characterized in terms of its land use. However the place has been proposed for wildlife management and game conservation. It is also good for grazing and ranching. All this information is available from research institutions/reports can easily be put into digital format, and is valid for short-term intervention

## **5. Discussion**

### **5.1 Geo Information in Tanzania**

According to M.S. Pakipuny (1992), land of Tanzania and Loliondo Division in particular, is underutilized for agricultural production. The land in this country is naturally favoured with tropical climate hence there are good prospects for maximizing agriculture production. Pakipuny suggested an integrated and modern type of agriculture, which aims at improving people's income. It was also suggested by Auckland 1961 vol.30, in "Tropical agriculture" that crops such as maize, wheat, beans, millet, potatoes, tobacco, sorghum, cassava, and barley are very productive in Loliondo. Lane C. Swift (1989) considered Loliondo as a high potential area for cattle production, because of the richness of Loliondo's range land and its good water supply. Development of ranches and diary farms are among the suggested economic activities to improve income of Loliondo people as well as their health.

### **5.2 Traditional Practices and Modern Technologies Impact to Development of Geo Information in Tanzania**

According to M.Suleiman 1991, there is a need to diversify the traditional livestock. This if adopted will assist in minimizing the present environmental damage in Loliondo. Application of chemical fertilizers is discouraged and the application of manure and putrefied grasses are suggested instead. In 1986, Mwingira from Dodoma region, Tanzania, has discussed the need to have a special land unit in the Loliondo area, which will purposely be allocated to forest production to meet the communities' needs of firewood, building material and hedges.

The special NLUPC 'committee 1994' realized that, Loliondo area has no designed network of data collection. Land use information/data are obtained from individual Institutions, which collected them for their own purposes. It is still difficult to use the available data at Loliondo if critical decisions are to be made, because the data are not yet integrated with other aspects of social economic development in a reliable National GIS. Thus, the data collection network for land use and resource planning needs a standard structure (specification) that will suit the Tanzanian environment and be flexible to technology changes. To implement such programs better, the geographical location, culture and tradition of Tanzanians should be considered first. What has been concluded so far by many land use planners and researchers showed that there is a need to have stronger land information systems and managers in Tanzania.

**Table 2. Soil situation (sample) from the UCLAS references**

Category	Soil			Suitability	Remarks
	Type	Coverage	Depth/Colour		
1.	Saline sandy soil	570 ha	>15cm <15cm	Not suitable for agriculture production	-sandy & sandy soil -High drainage capacity -Economically potential in salt processing
2.	sandy soil	383 ha	<15 cm	Not suitable for agriculture	-poor fertility -poor water holding capacity -grass & scrubs are dominant vegetation
3.	sandy loam soil	2196.8 ha	<15 cm-darkbrown >30cm redish brown	suitable for agriculture	-moderate fertile -good water holding capacity -dominated by scattered trees & plantation
4.	sandy clay soil	270 ha	>30 cm dark brown <30 cm redish brown	suitable for (rice & sugar cane)	-watered grounds -found along river valley with deposited residual.
5	loam sandy soil	514 ha	>30 cm dark	moderate fertile	-the are have reasonable soil water -dominated by cashew nut & coconut plantations
6	sandy clay soil	10.3 ha	>30cm dark brown	not suitable for agriculture	- poorly drained soil
7	Loam soil	592 ha	>30 cm Black	-Famous in farming -Suitable for agriculture	-Moderate water holding area -charcoal burning & firewood collection activities are dominant.

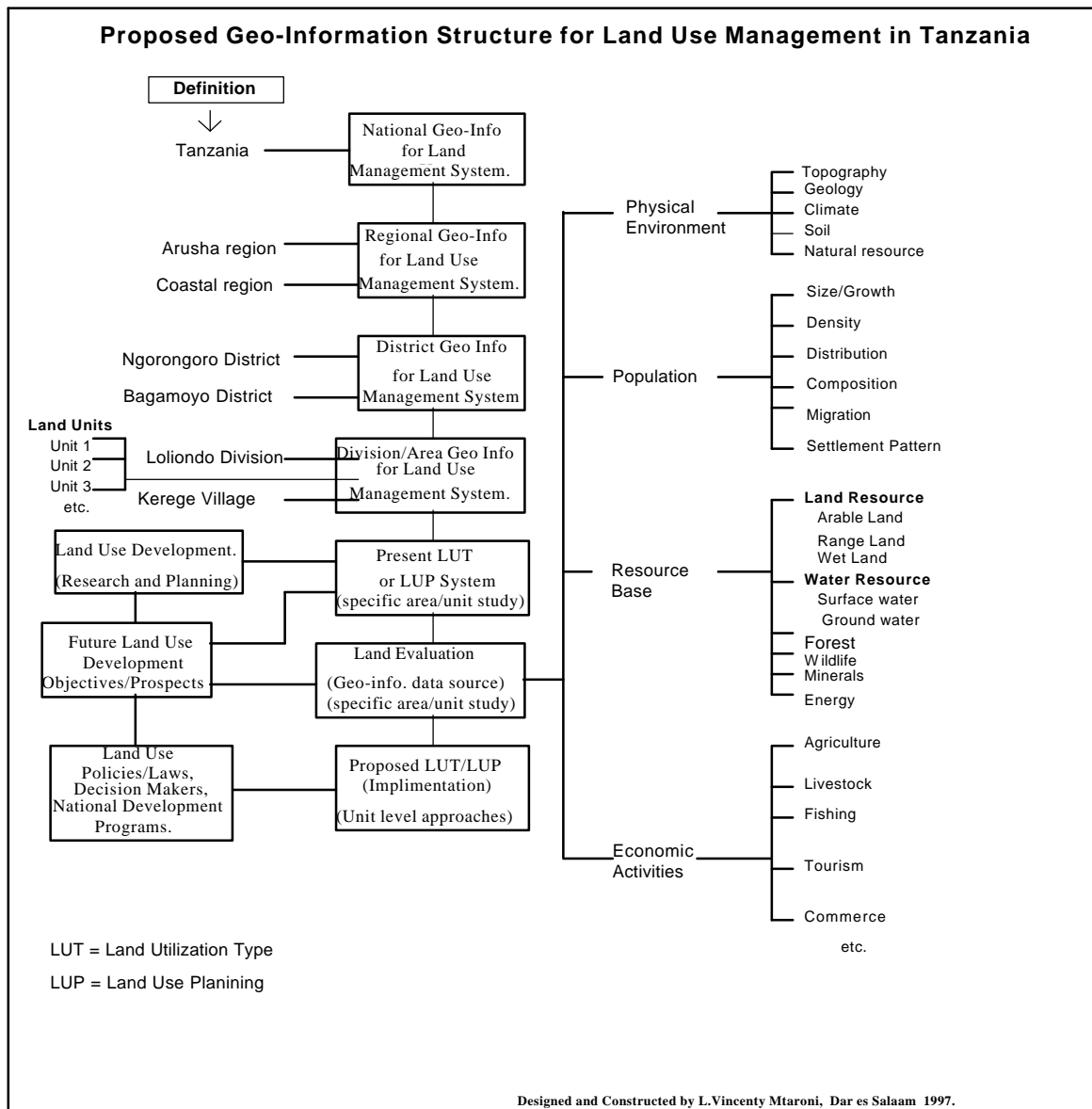
**Source.** Kerege village land use plan 1991/92 by(UCLAS). Table Designed and constructed by: L.VincentyMtaroni, 1997. Sample of Soil Suitability Analysis. (Soils at 6°30" S of the equator and 39°9"E. Bagamoyo district, Coastal region.)

## 6. Conclusion

Solutions put forward by experienced scholars or information technologists suggest to be more careful when establishing or developing GIS. The efficiency and effectiveness of a GIS may be obstructed because of many reasons.

Politicians and governmental authorities are *insufficiently* aware of the necessity to provide adequate information and are therefore reluctant to make sufficient funds available, particularly when their financial commitments have to continue for some years before the benefits become widespread. The various survey agencies are controlled by different Ministries or authorities and there is little or no co-ordination between these bodies. The political and social constraints which work against the collection of certain items of information, or, if it is collected, confidentiality constraints which prevent its full use should be minimal if not eliminated. Although there is no sense in establishing a Geo Information Systems without adequate political support, a remedy for the first problem would be to pay more attention to public relations. This means, to promote the importance of an adequate Geo. information supply at relevant levels which may also include international aid agencies.

Many Geo Information problems could be solved by the establishment of a national survey planning board or a board to co-ordinate Geo information activities. An additional problem is that many people in countries like Tanzania fail to appreciate that most operations (that involve land information mapping, and cadastrals work), are continuous and can not be sustainable without proper information management systems. For example, the high bill, paid to initiate a new land registration, is likely to be a recurrent budgeting consideration and whenever there is any data duplication this will double the cost. Hence, information requires revision mostly, and primary data collection work shouldn't remain permanently necessary if there is a well-established GIS. The GIS and its organization must be assured of the necessary funds and adequate legislation must be provided to make cadastres possible.



**Figure 1. Proposed sample geo information structure chart that could be applied in the land use management in Tanzania.**

**NLUPC** National Land Use Planning Commission  
**UCLAS** University Collage of Lands and Architecture Studies  
**GIS** Geographical Information System  
**LIS** Land Information System  
**EIA** Environmental Impact Assessment

It is important to note that, there is much more required for the establishment of a geo information system than may be thought. Public realization of the information need and willingness to collect, disseminate, keep and support the proposed land use plans, will make development fast under the modern geo information technology application. As we rely on land resources for our life, we can not escape land use. Land and its dynamics demand research that could be very well linked to the GIS. The land vegetation mapping program completed in the mid of this year in Tanzania by Hunting Technical Services from the U.K for FRMP, created for the 1st time a National digital data base which is crucial for the development of a Geo Information System for sustainable land development.

Figure 1 presents a typical proposed Geo Information structure that could be adopted in Tanzania. Focusing to the National level GIS, regional, district and then divisional levels, criteria set for sustainable land use will make data/information interactive. Assumption here are that, a uniform data structure will simplify information network and hence efficiency land use system now and in the long run towards 21st century.

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