INTEGRATION OF REMOTE SENSING AND GIS IN LANDUSE PLANNING FOR SUSTAINABLE NATURAL RESOURCE MANAGEMENT WITHIN THE MOUNT CAMEROON REGION-WEST AFRICAN.

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ABSTRACT

Population growth in developing countries is a key factor to environmental degradation. The mount Cameroon region in West Africa is one of the sites where the equatorial rainforest is disappearing at a fast pace due to agricultural plantation expansion and urban development . We shall see how remote sensing data and GIS can contribute in finding solutions to pertinent problems in land use planning.

The mount Cameroon is located at latitude $4^{o}10$ and longitude $9^{o}20$. It covers an area of 250.000 hectares with a variety of land use patterns. It is the highest peak in West Africa (4100m). There are many activities leading to environmental degradation carried by the local populations.

It is for this reason that the government of Cameroon with assistance from international NGOs has created a project to develop and implement a landuse plan for the sustainable management of natural resources within the mount Cameroon region. There are many land cover types and a multiple of uncontrolled uses. The Cameroon Development Corporation (CDC) is the major stakeholder within the study area and occupies 85 374 hectares of land. Part of this land is developed with industrial agriculture, dwelling units, infrastructures and the other part is covered with rainforest for future plantation expansion. This creates a conflict between economic development and natural resource conservation.

A base map of the project area was developed and all the land use patterns were mapped as individual thematic layers.
Administrative boundaries, forests, plantations, settlements, coastal zones (mangroves), water courses, road network, soil type and wildlife.
Significant achievement in participatory land use planning within the project region is from the result of remote sensing and GIS applications as is presented in this paper. The method of data acquisition and input in the GIS database will be discussed.

The paper will also elucidate how GIS and remote sensing techniques are applied in urban planning, agriculture and nature conservation. Spatial data acquisition and dissemination methods will be discussed.

All stakeholders interest were generated in thematic layers (overlays) in the GIS database and presented as maps used in planning meetings at village and regional levels.
The land use map shows the best options as decided by the communities concerned; It responds to the following questions:

- What should be done, the selected changes to land and where they should be implemented?

Mapinfor 4.1 and ArcInfo Gis software were used to generate spatial solutions to these problems.

Finally land is rationally used according to the plan conceived and agreed by all stakeholders and the resources are now managed for the benefit of the present and future generations.

INTRODUCTION:

In Cameroon the concept of landuse planning just started some few years ago initiated by conservation projects working on natural resource management. Bilateral cooperation signed by the Cameroon government with developed countries Germany and Britain has come to the assistance of local populations within the Mount Cameroon region to develop a landuse plan for the sustainable management of natural resources. Through their technical services such as GTZ and DFID working in collaboration for a common goal on Mount Cameroon, there was a need to develop a base map of the project area at scale 1:200000 and a current land use map at scale 1:75000.

1. The Project Region:

For administrative and management purposes, the project region is defined by administrative units boundaries. This include six subdivisions and one district as follows:
Mbonge subdivision, Buea, Tiko, Limbe, Bamusso and Idenau district where we find Debuncha the second wettest place in the world after Chiranpunji. These boundaries are natural (water courses, hills) or artificial boundaries (bench marks).

2.1. Landuse types in the Project Region:

Landuse has been classified in a manner that will be handled in the GIS database. This include: Agriculture (Industrial, Subsistence,) wildlife, forest, (protected and Communal forest), settlements, water course network, road network.

2.2. Landuse Allocation

2.2.1 Agriculture:

This comprises industrial, commercial, and subsistence agriculture.
Industrial Agriculture is developed by the Cameroon Development Corporation (CDC) and plantations PAMOL du Cameroun. The CDC is the major stakeholder in the study region and deals with; oil palm, tea, pepper, rubber and banana, planting and exporting. This is also the second employer after the Cameroon government. Commercial agriculture is managed by individuals who plant and market rubber (latex), cocoa , palm oil and also foodstuff.

As it concerns subsistence agriculture, it is actually difficult to have farmers solely working for consumption because every one has been constraint by the economic crisis to generate income for subsistence thus making farmers to always sell part of their foodstuff.

2.2.2 Wildlife:

This has been considered a landuse type because of the socio-economic impact it has on the national economy and ecotourism. Most endangered wildlife species are found on mount Cameroon.

The location of hunters'camps on the mountain according to Global Positioning System (GPS) mapping are within the elephant grazing range .

2.2.3 **Forest**:

Two main categories of forests exist within the study area. Protected forests managed by the state for production and conservation purposes and communual forests which belongs to the local Community Settlement are built-up areas, they are either rural or urban settlements, these include : villages, cities, towns.

2.2.4 **Water Courses:**

These are rivers, lakes, ocean., River Mungo, Lake Barombi Kotto, Barombi Mbo , River Meme and Atlantic Ocean.

2.2.5 **Road Network:**

Is the landuse type that links one village, city or town to another. The various categories in the GIS database are listed below.

3.0 **Development of the base map for the project region.**

Field mapping was undertaken by the landuse planner and the cartographer. During the field work, meetings were held with the local and administrative heads who showed the limits of their administrative units. This information was marked on an existing IGN map of scale 1/200.000 and contained the following thematic layers:

- Principal tarred roads.
- Principal untarred roads.
- Foot paths.
- Secondary road
- Plantation road
- Administrative Boundaries
- Settlements (towns, villages)
- Water Course (water network)
- Contour lines.
- Roads network
- Protected Forests.

This information was digitized using PC Arc/Information software and a new project map was produced at scale 1:200.000.

With the project region map now available in digital and hard copy formats, there was a need to update. the base map with new data from various components of the project. During the previous years of the project pilot phase, many data was collected with the G.P.S., some from old maps at various scales others from existing literature. There was now a need to install a Geographic Information System (GIS) unit in the project.

3.1 Stakeholders in the study area .

- The Government of Cameroon GOC.
- Fishermen
- Mount Cameroon Project MCP
- Cameroon Development Corporation (CDC)
- International NGOs GTZ, DFID,GEF
- Local Communities, NGOs
- Farmers
- Hunters
- Tourists
- Timber Exploiters
- Honey Collectors

3.2 Landuse Conflict in the Project Region:

The CDC plantations were created in 1947 by the Germans. They have demarcated these plantations with property beacons. The plantations cover 85374 hectares of land of which 2/3 of this area is within the Mount Cameroon Project Region.

This land begins from 0-1800meters above sea level and most of it still under forest cover. The Cameroon Development Corporation (CDC) intends to expand the plantations within their leasehold boundaries, Mount Cameroon Projects intends to conserve biodiversity within the CDC land and farmers are encroaching in the protected forest for agriculture plantations development. There is a need to use GIS and remote sensing technique to find a solution

4 Remote Sensing application:

To better understand the present landuse, remote sensing data is required. A landsat TM 1986/87 Scene of the project region was ordered. The existing plantations and forest cover were mapped. Information gathered from CDC estate managers showed that suitable growing attitude for oil palms is from 0 – 400m above mean sea level. This was particularly around the West Coast near the Atlantic Ocean where there is a high quality equatorial rain forest. From the image spectral signature, different types of forest were mapped (dense forest, montane, degraded forest). This landsat image is used as a raster background for further interpretation. The image is in digital format on CD-Rom and hard copy at scale 1:75.000 in an Arc/info format. Although the image was quite old, it was the only image of Mount Cameroon with less than 30% cloud cover.

5. The Mount Cameroon GIS database

Mapinfo 4.1 is the software used in the MCP GIS and located in the folder named “GIS data” in the root directory of the hard disc drive C.
The data tables are as follow:

Data Table 1

Folder/Sub-Folder	Content
C:\GIS data	Workspaces for print layouts
C:\GIS data\GPS data	GPS Point files
C:\GIS data Layout	Scalebar tables
C:\GIS data Scans	Scanned maps and map Info registration
C:\GIS data Theme	Thematic map tables
C:\GIS data\topo	Topographic map table.

6. GIS in Landuse Planning

Landuse planning is originally concerned with what should be done, where. Hence maps form a key element in the presentation of results.

6.1 Natural Resource Management

6.1.1 Community Forest Development:

With the overlay of the CDC leasehold boundary and the altimetric theme, it is clear that the leasehold gets up to 1800m above mean sea level which is an area of high quality forest.

An overlay of the crops thematic layer with the topographic layer (altitude) showed that crops have been planted up to 150m above sea level and this area has been tested suitable for crops (oil palm) from 0 – 400m above sea level. The suitable area for plantation expansion was digitized and stored in the GIS database as a thematic layer. A map was produced showing the boundary of the leasehold and the suitable areas for plantation expansion was very visible on the map. This map was brought to the (EIA) Environmental Impact assessment of CDC plantation expansion meeting attended by all stakeholders within the study area.

It was evident that though, the area in question falls within the CDC leasehold land, it was not useful for plantation expansion. It was agreed in the meeting that a protected forest should be developed within this area not suitable for plantation development.
GIS technology has brought the forest to a common table of discussion.

Forest reserves are in the study area table 2

Year of creation	Name of Forest reserve	Area (Hectares)	Remarks.
1939	Bomboko Forest reserve	26 677ha	Hunting, poaching, production FR Partly degraded for farms with a foodstuff market in it.
1952	Mokoko river Forest reserve	9065ha	Production forest reserve .
1952	Bakweri Forest reserve	9324ha	Production forest reserve not existing again occupied by farmland
-	Meme river forest reserve	28ha	existing.
1953	Buea fuel plantation	300 ha	Planted with eucalyptus trees. exploited for fuel wood

6.1.2 Agriculture sites location:

One of the themes in the GIS database is the soil map of the mount Cameroon region produced by IRA Ekona (Institute de la Researche Agricole). This map was digitized and serves as a background for \various crops location. By overlaying the crops on the soil map, it is visible that certain crops, like oil palm, tea, rubber and banana have specific soils on which the yield is high. The GIS will assist to locate some soil types as potential areas for similar crops development. Pixel dusters will be created based on similarity of multispectral reflectance characteristic of the image to locate various soil types and their suitability for plantation development.

6.1.2 Urban Planning:

6.1.3 With the high cost involved in aerial photography, remote sensing data and GIS are important tools in urban planning. Buea, headquarters of the South West Province is looking forward to using Spot images in mapping its urban expansion and landuse.

This image will be at scale 1:25000 and will be available in digital and analogue formats. Essential foundations of planning for long-termed measures of urban development can be gained very promptly by remote sensing. Development measures cannot be planned in a well-founded way if there is no basic inventory of the present land use potentials and limiting factors. Remote sensing is advantageous because optical information can be received with a temporal overview and a sectoral overlap. The monitoring of urban expansion and the analysis of settlements without planning can be accessed from

remote sensing data. Initiated by the author and the Delegate of Urban affairs, it will be the first time that remote sensing data will be used for Urban development studies in Cameroon. If this project will be successful then many other towns in the Country will benefit from the technology. Satellite imagery mapping is fast and with a 10 meter spatial resolution, buildings Yards, roads, property boundaries, farm fields, and tree stands can be located.

6.1.4 Wildlife managements.

GIS offers powerful modeling tools for wildlife managers. A special model used to predict elephants distribution on mount Cameroon was based on GPS mapping. Wildlife guides of the mount Cameroon project were trained to use a GPS receiver. They made many trips up the mountain and within the rainforest on the mountain to identify wildlife grazing range and sightings. (mountain elephants, antelopes, monkeys , chimpanzees and birds). Most of the rainforests of the equatorial region of Africa are contiguous across the boarders of six central African Countries: Zaire, Gabon, Equatorial-Guinea, Cameroon, Congo and the Central African Republic and comprise one third of the range of the African elephant . To draw a management plan for wildlife management on Mount Cameroon, there was a need to map the distribution of wildlife sighting, movement tracks, hunters camps location and caves. Since this information can not be derived from the landsat satellite image, GPS mapping was the only technique available at the project office. GPS data was collected periodically by field staff who went to the mountain and forest. This data described the geographical location of each site in longitude and latitudes followed by a remark or observation . This data was later input in the GIS database on the base map of the project area in the computer.

Farms were mapped and plotted on the Bomboko forest reserve map digitized using the CAMRIS GIS software. (computer Aided Mapping and resource Inventory system).

GPS MApping table 3.

Way Point No.	GPS Location Longitude (E) Latitude (N)	Mapping Description	Remarks
091	9^o 16 E 4^o 12 N	Bonakanda Village	This is the highest village located on mount Cameroon
092	9^o 12 E 4^o 17 N	Lava Track	The lava track width at this point is 800m
093	009 12.E 04 17.N	Lava track	The lava track width at this point is 800m
094	009 12 637 E 04 17.706 N	Lava track	Hunting camp grouping hunters of Bonakanda village
095	009 11. E 04 17.621 N	Bonakanda 1 hunting village	
098	009 11E 04 17 646 N	Elephants	Seven elephants were grazing here
099	009 10. E 04 16 N	Lava track (1.5km)	1.5 km wide
100	009 10 E 04 16. N	Lava track	
101	009 10 N 04 16 N	End of lava	

103	009 09 E 04 16 N	Bonakanda II hunting village	Six huts and one hut behind in this camp.
104	009 09 N 04 16 E	Stream *(Maliba ma mussingele)*	This is an all season stream with a small waterfall. The only steam flowing on mount Cameroon
106	009 11 N 04 18 E	Bonganjo hunting village	Hunters of Boganjo village assemble here after hunting
108	009 10. E 04 18 N	Elephant track	This is an area where elephant food points were found.
109	009 10. E 04 18 N	Elephant track	Very recent elephant traces
110	009 10 E 04 17 N	Elephants	Two elephants were seen this point.

One of the herbal preparations produce in Europe to treat prostate problems (benigh prostatic hypertrophy and benign prostatic hyperlasia) is produced from barks of the tree *prunus africana.*. Prunus Africana has a distribution in Africa and Madagascar. Limited to afromontance forest which are generally above 1500-2000m attitude. The barks of this medicinal tree exported from Cameroon in 1995 is 1,116 kg by the Groupe Fournier in France owner of Plantecam in Mutengene Fako division Cameroon. With the high demand of this product, villages around the Mount Cameroon are involved in the unsustainable exploitation of the tree barks for commercial purposes. The barks extract are used medically to treat prostate gland hypertrophy has led to the overexploitation of this plant which is a course for concern due to the exceptional importance of Afromontane forest for plant ,bird and mammal conservation. For this reason an inventory of the distribution of ***prunus africana*** on Mount Cameroon is necessary.

Remote sensing and GIS could be used to carry the inventory . This inventory is also possible using GIS overlays by mapping the corresponding growing altitudes 1500-2000m . the possible growing range of the species is mapped and sample plots randomly selected on the field within the growing range is extrapolated to the image to have an approximate number of prunus africana stands within the study area.

This method was used by the author to map the degraded parts of the Bomboko forest reserve using a GPS receiver. Hunters and farmers were used as resource persons to locate the last plantations location in the forest reserves. Hunters were very instrumental because they have to go through all farmland before seeing the wild animals.

6.1.5 METHODOLOGY:

Remote sensing data for forest resource an image mapping of the area with a good spectral resolution is ordered ground truthing is done with many waypoints recorded with a GPS within the areas of high ***prunus africana*** population. These waypoints are down loaded from the GPS to the computer and points are created according to geographic locations. The distribution of these points will serve to interpret the image and the areas of ***prunus africana*** can be mapped on –screen from the digital data.

7.0 INSTITUTIONAL SETUP OF GIS IN CAMEROON

GIS technology in Cameroon is mostly limited to conservation projects and international Ngo's. Apart from CETELCAF in Yaounde that produces maps based on digitizing and updating. Government institutions are still backwards in the application of GIS and remote sensing technology.

In 1998, the author installed a GIS software Mapinfo on the computers in the National Advanced school of Public Works Buea –annex. If this is well developed the university of Buea can also be a beneficiary of this technology. International donors in the field of GIS development in developing Countries should assist in the promotion of this technology in Cameroon.

8.0 CONCLUSION.

Data for the GIS database was got from existing maps digitized and converted in a digital format, field observation with the GPS and remote sensing data available on CD-Rom and hard copy map. Remote sensing and GIS technology has contributed in solving a landuse conflict between biodiversity conservation and plantation expansion. This has brought the forest to a discussion table with individual thematic layer overplayed one after another to show the possible areas of natural resource conservation. GPS application and GIS was the simplest means to illustrated the distribution of hunters camps within the forest reserve. This also enable to show the distribution of the elephant grazing range within the study area. The introduction of Land use planning within the Mount Cameroon region has led to the creation of a provincial land use planning Committee headed by the provincial governor. This committee has to replicate de Mount Cameroon example in the whole province.

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