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INTEGRATING GEOGRAPHICAL INFORMATION SYSTEMS AND REMOTE SENSING TECHNIQUES TO ANALYZE LAND COVER/USE CHANGE BETWEEN 1992 AND 2002 IN NYANYADZI COMMUNAL LAND, ZIMBABWE.

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Abstract

This paper explores the integration of Geographical Information Systems (GIS) and Remote Sensing in analyzing the land use/cover changes between 1992-2002. Furthermore; it is argued that the decline in plant species in the Nyanyadzi Communal Area cannot be attributed to nature, but to anthropogenic factors. Thus sought to answer three questions:

1. *Have vegetation changes occurred between 1992 and 2002?*
2. *If changes have occurred ,why and how have these happened and*
3. *What is the trend for land utilization?*

Population pressure, crafting, construction, overgrazing and expansion of cropped land have been cited as major causes of land degradation. Increased human pressure has led to shortage of enough land for cultivation thus threatening vegetation conservation. We also explore the need to reinforce urgent intervention to the rate of utilization of vegetation in arid and semi arid communal. We make use of GIS and Remote Sensing techniques and TNT MIPS software to analyze and process data, thereby establish land use/cover maps. Base information has been generated from 1:250 000 topographic sheets from the Surveyor General of Zimbabwe. Eight major land use categories have been interpreted from the land sat images. Our results conclude that afforestation, agro forestry techniques and enforcement of environment laws need to be implemented in order to curb the situation of over utilization of natural vegetation in the Nyanyadzi Communal Area.

Introduction

Since the beginning of the 19th century, vast portions of the earth's surface have been modified, whole ecosystem destroyed and global biomes altered or vanished. The information about the present land use and land cover is necessary to know about its sustainability. In water scarcity areas, crops requiring less water should be grown and the new methods of irrigations such as drip or sprinkler must be adopted to optimally utilize ground water resources and at the same time not affecting the yield of the crops. Nyanyadzi being dry land and receives less than 750mml/year of rainfall, land use/land cover information is necessary for planning and decision making on developmental projects to be implemented. There is need to monitor performance of the Nyanyadzi irrigation scheme, since it is the soul source of food and livelihood of the local people. With the use of GIS and remote sensing techniques, land use/land cover change of this area is determined for the period 1992-2002.

Conventional methods used to generate information on land use/ land cover are not only time consuming, tedious, costly and labor intensive; but also impractical for monitoring dynamic changes over shorter periods, due to subjectivity and time constraint. Satellite data with synoptic view, repetitive coverage and multi-spectral viewing has brought very positive changes in the land use/ land cover study.

This paper aims to give a detailed natural resources utilization trend in the lower part of the Nyanyadzi communal area. In this context, we also reveal the impact of rangeland encroachment to the water bodies. The paper also intend to develop a collective analysis of the vegetation condition threats as a way of increasing awareness and buy-in of service providers to assist the Nyanyadzi community in developing rangeland management projects. In today's dynamic situation, accurate, meaningful and current data on land use/cover is essential for sound and feasible planning for natural resources for sustained use. The theme of the United Nations environmental programme in 2006 on dry lands focuses on how best dry lands can be sustainably utilized in order to support the surrounding communities and reduce natural resources depletion. The theme and its focus prompted us to study Nyanyadzi communal area as it falls under the natural region 5 which receives less than 500mm of rainfall. This paper took an analysis of how natural resources have been utilized and at what rate. Thus, this information becomes useful to all the stakeholders as this identifies trends, gaps and weakness towards utilization and management of these natural resources. The information from this paper is valuable to organizations, planners and local community in project identification, implementation and management.

The paper also demonstrate the capabilities of GIS and Remote sensing techniques in carrying out detailed analysis of how vegetation and land has been utilized between 1992 and 2002.This, then establishes trends and rates of utilization. The main objective of this paper is to produce a land cover/use change map for Nyanyadzi that would aid:

- To examine land use patterns/trends for period between 1992 and 2002
- To establish/estimate the rate of deforestation taking place in the miombo woodlands
- To recommend future rangeland use in the Nyanyadzi communal area

The main resource controlling primary productivity for terrestrial ecosystems can be defined in terms of area of land available, land quality and the soil moisture characteristics. Land cover and land use represent the integrating elements of the resource base. Changes in land cover and land use affect the global systems. Land cover is the expression of human activities and any changes or alterations and these affect the environment. People have reshaped the earth continually, but the present magnitude and rates are unprecedented. Nowadays, it is very important to know how land cover has changed over time in order to make sound assessment of the changes one expect in the near future and the impact these changes that it may have on people's lives.

As people are the main users of the land, it is important for any system to be oriented towards them. Viewing the Earth from space has become essential to comprehend the cumulative influence of human activities on its natural resource base. In times of rapid and often unrecorded land use/change; observations from space provide objective information of human utilization of the landscape.

Remote sensing and Geographic Information Systems (GIS) are providing useful tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of earth-system function, patterning and change at local, regional and global scales over time. Such data also provide a vital link between intensive, localized ecological research and the regional, national, and international conservation and management of biological diversity.

Land Use/Cover Change

Land use affects land cover and changes in land cover affect land use. Changes in land cover by land use do not necessarily imply a degradation of the land. However, many shifting land use patterns, driven by a variety of social causes, result in land cover changes that affect biodiversity, water and radiation budgets, trace gas emissions and other processes that; cumulatively, affect global climate and biosphere. Land cover can be altered by forces other than anthropogenic. Natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover. Globally, land cover today is altered principally by direct human use: by agriculture and livestock raising, forest harvesting and management, urban and suburban construction, and development.

Changes in land cover driven by land use can be categorized into two types:

- Modification and
- Conversion.

Modification is a change of condition within a cover type; for example, unmanaged forest modified to a forest managed by selective cutting. Significant modifications of land cover can occur within these patterns of land cover change. Conversion is a change from one cover type to another, such as deforestation to create cropland or pasture.

Conversion land, cover changes such as deforestation. It is an unfortunate, but fact of life that deforestation occurs on numerous expanses and at varying scales around the globe. This paper focuses on the conversion of woodlands to irrigation and establishment of community gardens in a localized, rural setting in hopes that awareness of such occurrences may be further publicized and this can be evidenced by the establishment of Nyanyadzi irrigation scheme and establishment of community gardens along Sabi and Odzi Rivers.

Remote Sensing and Innovative Mapping Technologies

Remote Sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with object, area, or phenomenon under investigation. Within the scope of this paper, the focus of remote sensing is the measurement of emitted or reflected electromagnetic radiation, or spectral characteristics, from a target object by a multispectral satellite sensor. Land use and land cover mapping procedures often rely heavily on the differences of spectral characteristics of the landscape for separation into meaningful land use and land cover classes. Multispectral reflectance data, or remotely sensed imagery, from satellite sensors serves as surrogate data representative of landscape features or attributes. Different objects/features reflect light differently giving rise to different colors, which are then used to classify land use/land cover.

Each band measures unique spectral characteristics about the target. A spectral band is a data set collected by the sensor with information from discrete portions of the electromagnetic spectrum.

Land Use and Land Cover Classification Systems

A primary component of mapping land use and land cover is adopting or developing a land cover classification system. Many current land use and land cover classification systems are designed specifically for use with remotely sensed data. Many of these classification systems often resemble or incorporate other classification systems in order to maintain cohesiveness and allow for data integration. A hierarchical framework is often implemented within a classification system. This type of framework allows the level of detail to vary for different project scopes and for the creation land use and land cover categories that are compatible with other classification systems. We used a hierarchical land use and land cover classification system for utilization with remote sensor data which has been adopted by the U.S. Geological Survey for 1:250,000 and 1:100,000 scale land use and land cover mapping of the United States

Image Classification Techniques

In this paper, image classification is defined as the extraction of distinct classes or themes, land use and land cover classification categories, from satellite imagery. There are two primary methods of image classification utilized by image analysts, unsupervised and supervised classification.

In this paper we used the unsupervised and visual image classification. Unsupervised image classification is a method in which the image interpreting software separates the pixels in an image based upon their reflectance values into classes or clusters with no direction from the analyst. Once this process is completed, the image analyst determines the land cover type for each class based on image interpretation, ground truth information, maps, field reports, etc… and assigns each class to a specified category by aggregation. Supervised image classification is a method in which the analyst defines small areas, called training sites, on the image which are representative of each desired land cover category. The delineation of training areas representative of a cover type is most effective when an image analyst has knowledge of the geography of a region and experience with the spectral properties of the cover classes. The image analyst then trains the software to recognize spectral values or signatures associated with the training sites. After the signatures for each land cover category have been defined, the software then uses those signatures to classify the remaining pixels.

Accurate assessment and validation is an important step in the processing of remote sensing data. It determines the information value of the resulting data to a user. Productive utilization of geo-data is only possible if the quality of the data is known. Furthermore, integrated processing of different types of geo-data cannot be effective if the data quality is not known. The error matrix and kappa coefficient have become a standard means of assessment of image classification accuracy. This method of determining image classification accuracy resample classified imagery against ground truth field samples often obtained with a global Positioning System (GPS).

Methodology

In this paper we adopted two methodologies: Firstly, secondary data sources were used to provide an initial overview of the study area and to provide general information on the rangeland resource base, land use, problems and past experiences in rangeland resource management. Secondly, primary data collection (land sat images analysis using TNTmips software, ground truthing and observations). Lastly, questioners and interviews were used to extract information from the respondents. Observations were enhanced by taking the pictures of the current conditions using a digital camera. Nyanyadzi communal area is divided according to wards and villages. The study area selection was done through consideration of wards that have documented and have severe problems of land degradation. Administration boundaries of these areas were used to demarcate and extract the study area. The area occupied by these wards represents 40% of the whole Nyanyadzi communal area.

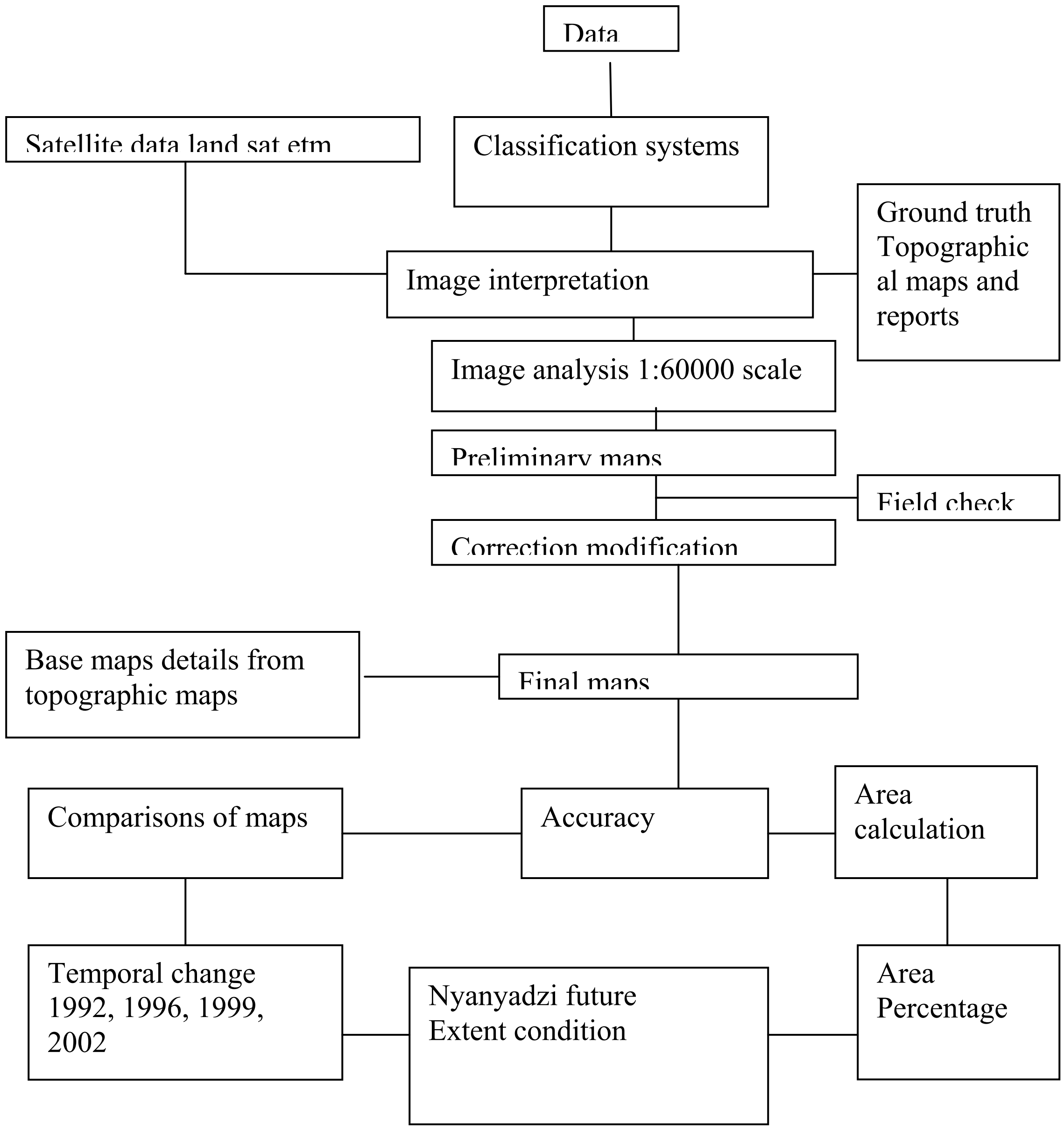

Figure 1, Flow Chart Showing Summarized Methodology Used.

Data Acquisition

Land sat images were acquired from South Africa. The data was in digital format and cover Nyanyadzi Communal Area.

Table 1, Land Sat Images   Scenes Used

Scene ID	PATH	YEAR&DATE
Land sat 7	168 074	June 1992
Land sat ETM	168 074	June 1996
Land sat ETM	168 074	June 1999
Land sat	168 074	June 2002

Geo-referencing

Table 1 relates to the correction of the relative position of an object in an image. The absolute correction of the position implies that every pixel has the correct position in units of latitude and longitude, i.e. in geo-coordinates (=geo-referencing). The satellite data 4 scenes were downloaded into the computer and then geo-referenced using image to image geo-referencing.

Image Enhancing and Conversion

The first step was a conversion process from geotiff format to Tiff format. The geometric and radiometric corrections were undertaken because 1G level product of Land sat data were used, so it was not necessary to do pre-processing. The next process was image enhancement and combination through color compositing. Several combinations and enhancements were done and the results examined. Bands 4, 5, 3 and 5, 4, 3 for red, green, and blue were combined respectively for unsupervised classification.

Image enhancement consists of processes designed to improve the visual appearance of an image .The 4 land sat scenes were linear stretched in TNTmips software. Linear stretch converts the original digital values into a new distribution using new minimum/maximum values specified by the operator. The algorithm then matches the old minimum to the new minimum and the old maximum to the new maximum. All the old intermediate values are scaled proportionately between the new minimum and the maximum values.

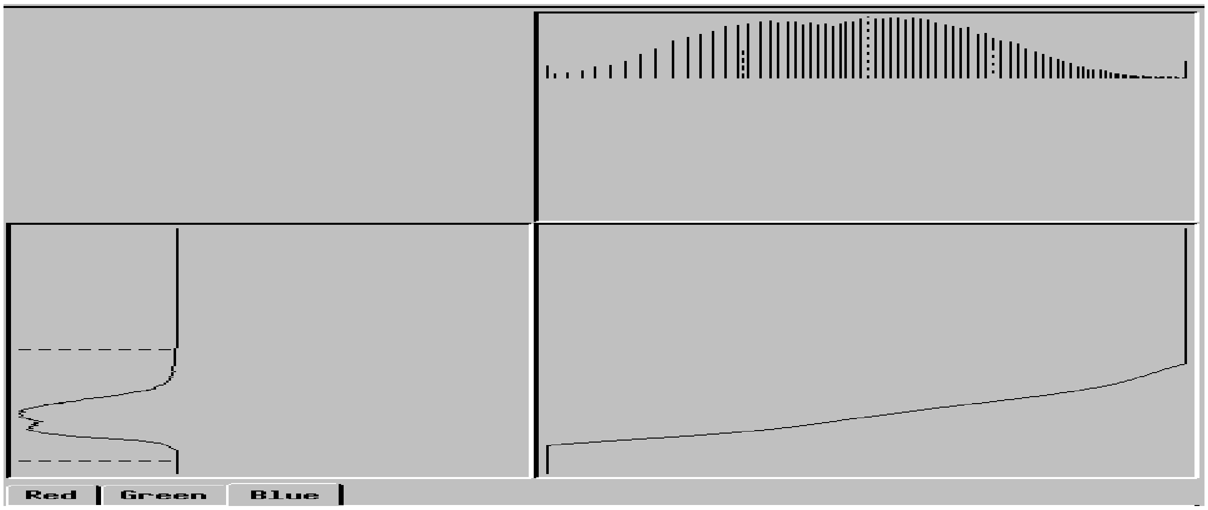

Figure 2, Linear Stretch

Figure2 shows how bands were linear stretched and normalized in TNT mips.

Band Combination Selection

The bands selected for visual interpretation for land sat images is 4, 5 and 3. This combination forms a false color composite. In this combination vegetation shows variations in red owing to the high infrared response associated with vegetation, soils show as bluish-green and sometimes yellowish tones and water shows as black and deep blue depending on its pureness.

Classification Scheme Definition

Before image interpretation was carried out, the vegetation legend had to be defined. The vegetation classification used was adopted from author in conjunction with observation made during the ground truthing campaigns. The classification scheme is based on the floristic and physiognomic of the vegetation cover.

Data Merging

These procedures are used to combine image data for a given geographic area with other geographically referenced data sets for the same area. The purpose of data merging being to combine remotely sensed data with other sources of information in the context of a geographic system for example images are often combined with soil, topographic ownership, zoning and assessment information. The 1: 250 000 topographic map of Chimanimani was imported into TNTmips software and geo-referenced to universal traverse mercator. Layers of rivers, points and roads were then extracted and digitized. Finally the layers were over-layered with the image data.

Information Extraction – Classification of Imagery

Images covering the Nyanyadzi communal area were classified using the unsupervised classification techniques; which are used when little or no information is available. Use a clustering technique and the analyst/interpreter has little control over the establishment of a decision region. Involves the use of an algorithm that examines a large number of unknown pixels and divides them into a number of classes based on natural groupings present in the image values i.e. values within a given cover type should have similar DN`S. Results in spectral classes-analyst then needs to identify information for each class. Several land use/land cover classes for Nyanyadzi were established namely woodlands, grassland, water body, settlement and cultivation.

Data Analysis and Vegetation Classification

Statistical data collected from key informants and partner organizations was analyzed, thus statistical graphs were then established. A map showing land use/land cover is also produced considering observations and coordinates collected using Global Positioning System (GPS). Table 2 shows Nyanyadzi Ground Truthing Form with crucial date used in this paper.

Table2, Nyanyadzi Ground Truthing Form

Image	**Date**	
No of test site	Field team	
UTMx	UTMy	
Relief position	Gentle	
Altitude	Aspect	
Interpreted woody cover	**ground truthing result**	
	X-coordinates	Y-coordinates
1 Water Body	7815214.38	438427.23
2 Woodland	7815024.80	439930.02
3 Bush land	7816246.10	439660.81
4 Irrigation	7813076.94	439156.03
5 Grassland	7814273.52	439883.38
6 Bare Ground	7817277.97	439056.17
7 Riverine Vegetation	7814909.23	438356.92
8 Cultivation	7813654.32	439381.86
9 Wooded Grassland	7814602.50	439648.45
10 Settlement	7813170.09	439813.40

Results

The results achieved in the LNRCA are summarized in the tables, graphs and maps below.

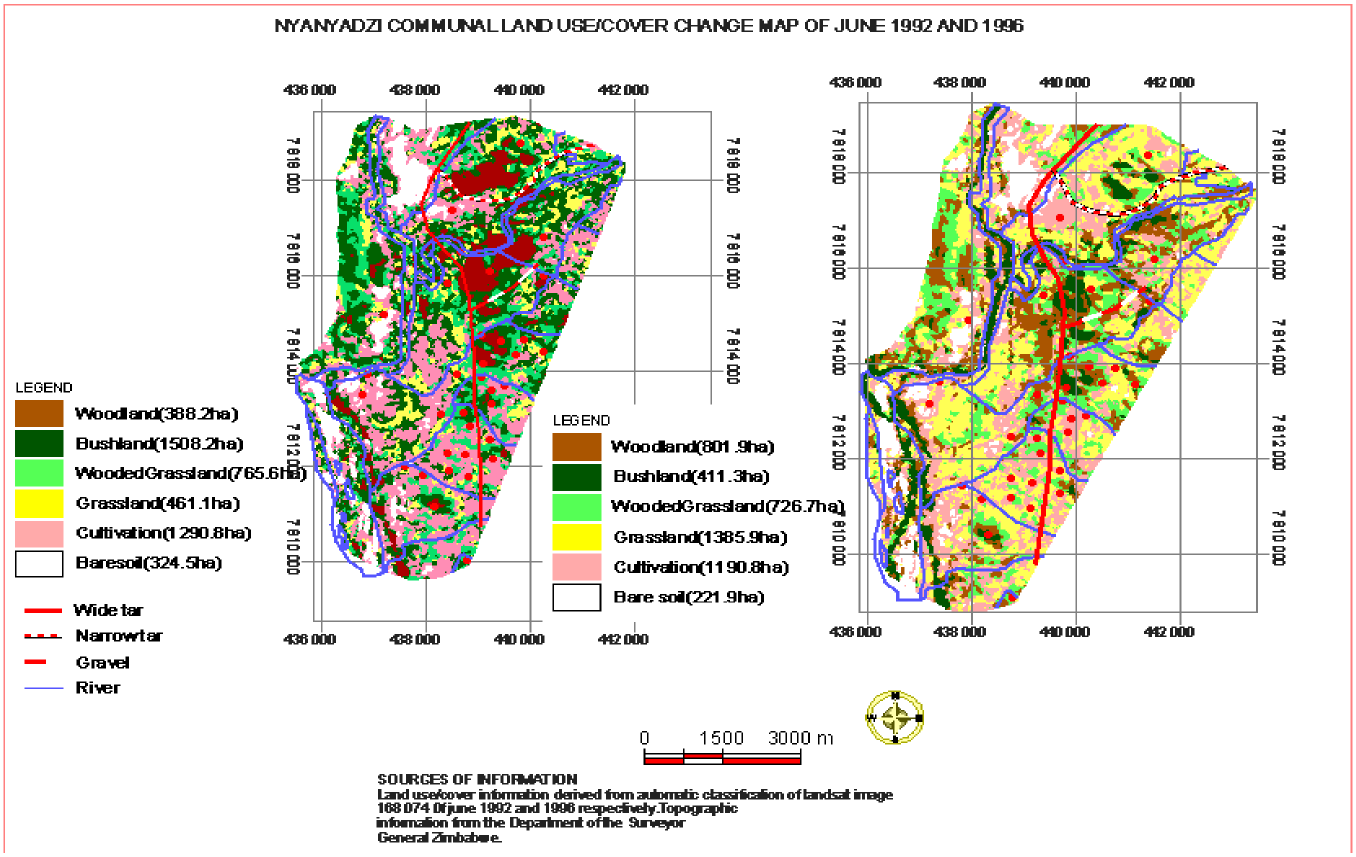

Figure 3 Map layouts comparing 1992 and 1996

Figure 3 shows land use/cover maps for 1992 and 1996 and helps in establishing land use patterns and rates of change. There is high increase in woodland hectrage. A significant decrease is noted on bush land.

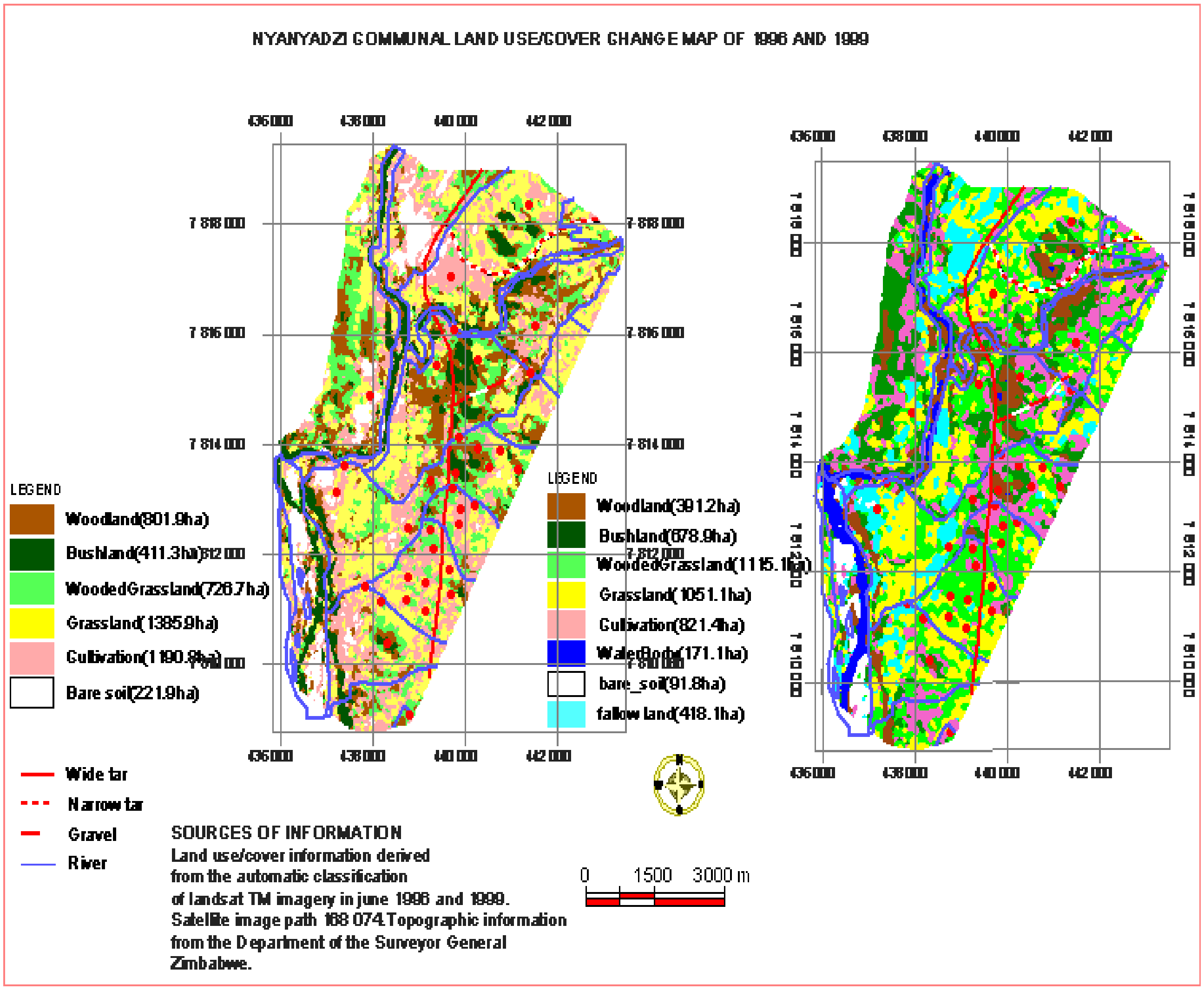

Figure 4 Map layouts showing comparison of 1996 and 1999

Figure 4 Land use/cover maps for 1996 and 1999. Our analysis of these two maps revealed that there is a decrease in woodland hectrage; while there is an increase in bush land hectrage. In 1996 almost all land that was set aside for cultivation was utilized whilst in 1999 a significant size of land was not utilized for cultivation.

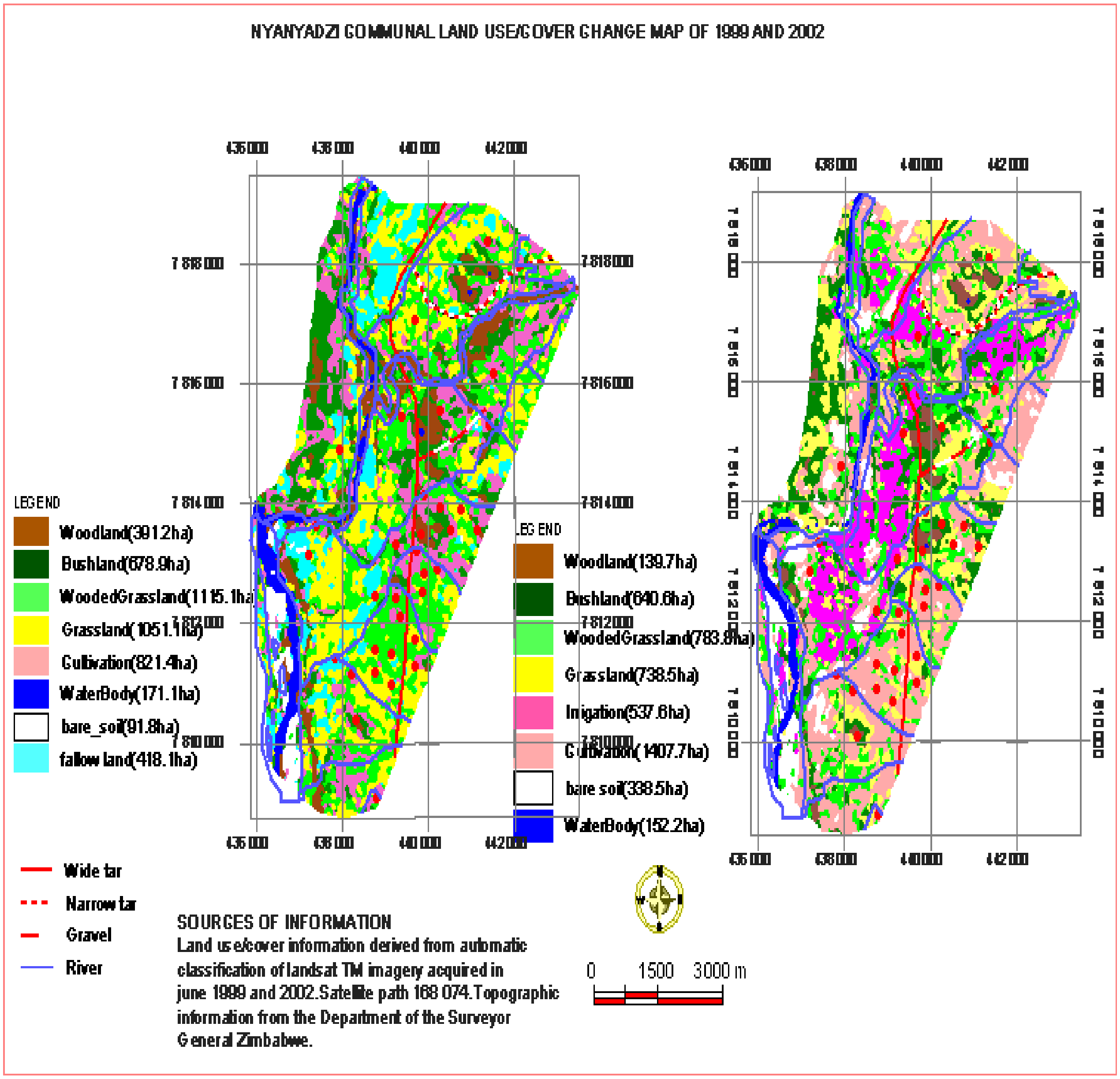

Figure 5, Map layouts showing comparison of 1999 and 2002

In figure 5, a comparison of land use/cover maps of 1999 and 2002 indicates that there is a significant decreased in the use of woodland, grassland and wooded grassland while there is an increase in use of land for cultivation.

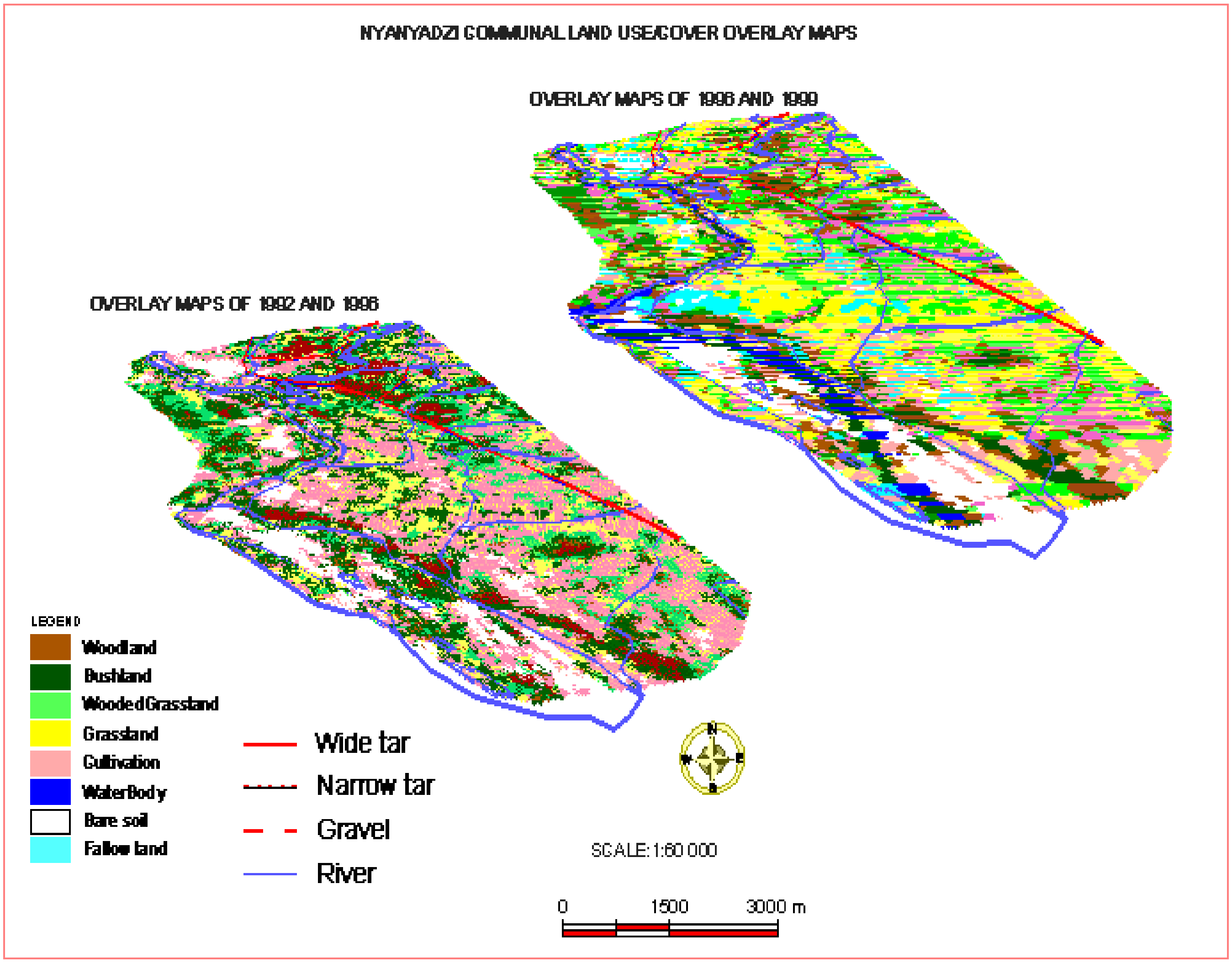

Figure 6, 3-D Overlay map layouts for 1992, 1996 and 1999

Figure 6 shows the 3D-map overlay, which help in illustrating the marked increase, decrease and also to some extent; encroachment for different land use/cover categories.

This 3 D perspective is very useful, especially to farmers because it is quite easy to understand as it depicts the true picture as it appears on the ground.

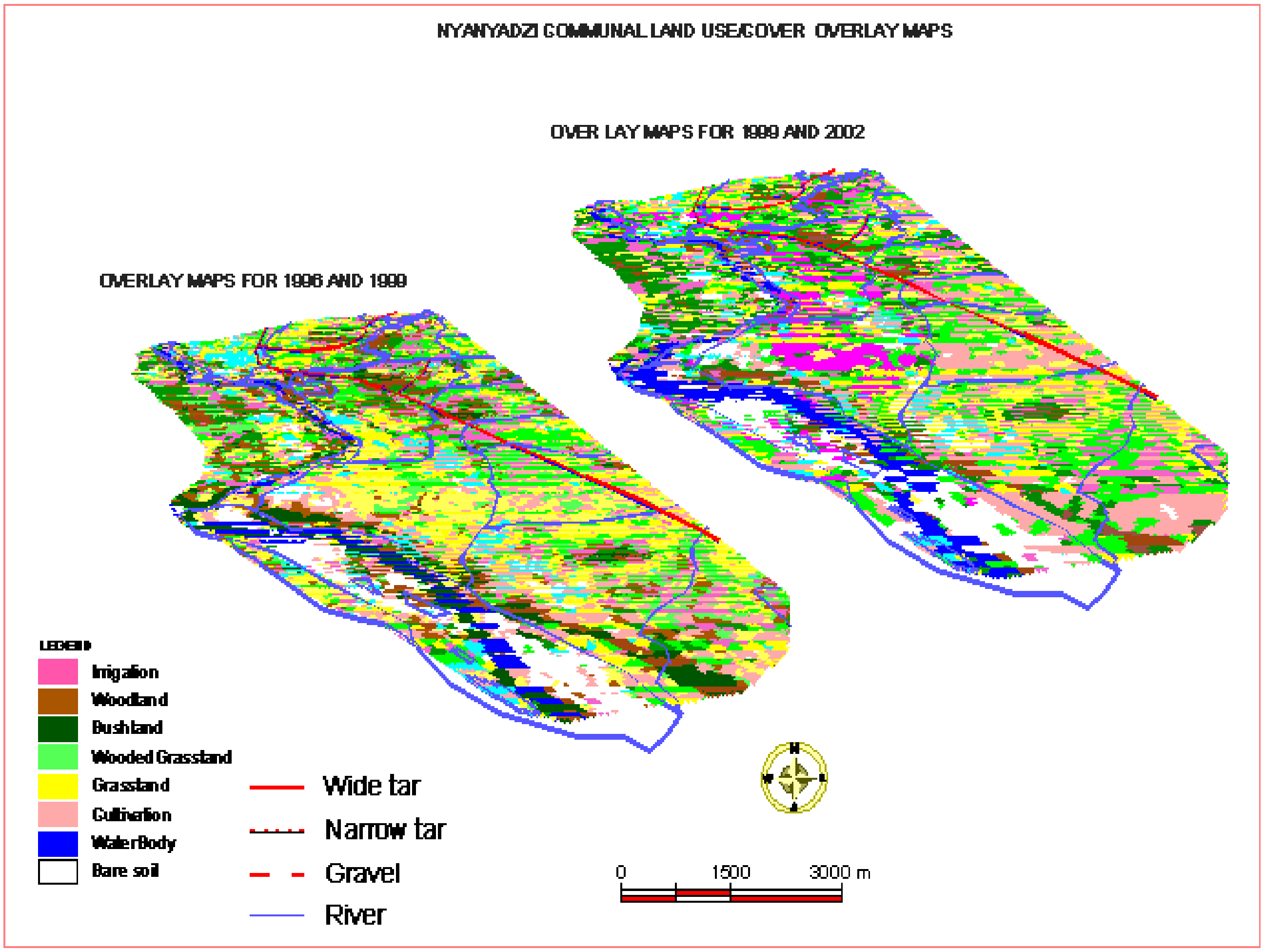

Figure 7: 3-D Overlay map layouts for 1996, 1999 and 2002

Overlay between 1996 and 1999 in figure 7, shows that some parts of bush land in 1996 have become woodlands in 1999. However, on the overlay of 1999 and 2002 wooded grassland in 1999 were converted into agricultural lands in 2002 indicating the over-utilization of natural resources pressure for land, leading to land degradation.

Statistical Analysis of Remote Sensed Data

Accuracy assessment and validation is a very important step when dealing with remote sensed data because this helps in knowing the usefulness of the data. I this paper we carried out various assessments of our remote sensed data which include error matrix determination, co-occurrence, co-variance matrix and Khat statistic.

Table 3. Statistical Analysis and Accuracy Assessment for Land Sat Images.

Year	Error-matrix (%)	Co-variance (%)	Khat Statistic (%)	Overall accuracy (%)
1992	100	94	100	100
1996	96	85	96	96
1999	98	90	98	98
2002	100	100	100	100

Table 3 indicates that land classes were correctly classified and there is high degree of spatial association. The overall accuracy is within the range of the standard accepted values; hence the classification is accurate comparing the information on the ground and that on the satellite images. Co-occurrence analysis was determined and overally; for both images, there was a positive co-occurrence indicating the existence of a high degree of spatial association of classes.

The Correlation Model

We used a correlation model to analyze the extent to which some variables are related with changes in time. The variables that were correlated are; Size of woodland (X) and Size of bushland (Y), Size of grassland (X) and Size of cultivated land (Y), Size of woodland (X) and Size of cultivated land (Y), Year (X) and cultivated land (Y), Year (X) and Bare soil (Y), Year (X) and Grassland (Y).

The Calculations are done as follows:

$r = SPxy/\sqrt{(SSxx*SSyy)}$, *where*

r = Relationship of variables (X and Y)

SPxy = Sum of products of X and Y, and

= Σxy - n+x+y

SSxx = Sum of Squares of X, and

= Σx2 - n+x2

SSyy = Sum of Squares of Y, and

= Σy2 - n+y2

n = Number of observations

The hypothesis to be investigated by the data is;

H0 **-** there is a significant relationship between rangeland utilization trends and trees abundance in the LNRCA and,

H1 **-** there is no significant relationship between rangeland utilization trends and trees abundance in the LNRCA.

Table 4: Computed Correlation Values for the Period 1992 To 2002

Land class	**woodland**	**Wooded grassland**	**bush land**	**grassland**	**bare soil**	**water body**	**Cultivation**
Correlation value	0.84	0.73	0.98	0.67	0.56	0.82	0.92

According to our correlation analysis in table 4, there is a significant correlation (r = 0.84) of woodland for period 1992 to 2002. It further shows that woodland hectrage has fluctuated widely over time, and significant trends are evidenced. However, there is a significant population growth (r = 0.99) with time. Similarly, the relationship between cultivated land and households shows that there is a strong linear relationship (r = 0.99) between the two. Thus, the amount of variation in percentage cultivated land can be attributed to increased number of household. The regression model between cultivated land and households is also significant, with R2 (Coefficient of determination) 1 = 97.02%, meaning that the two have a strong linear relationship.

Figure 8 and Figure 9 shows different land use/cover distribution from 1992 to 2002. This illustrates fluctuations in terms of hectrage as time changes.

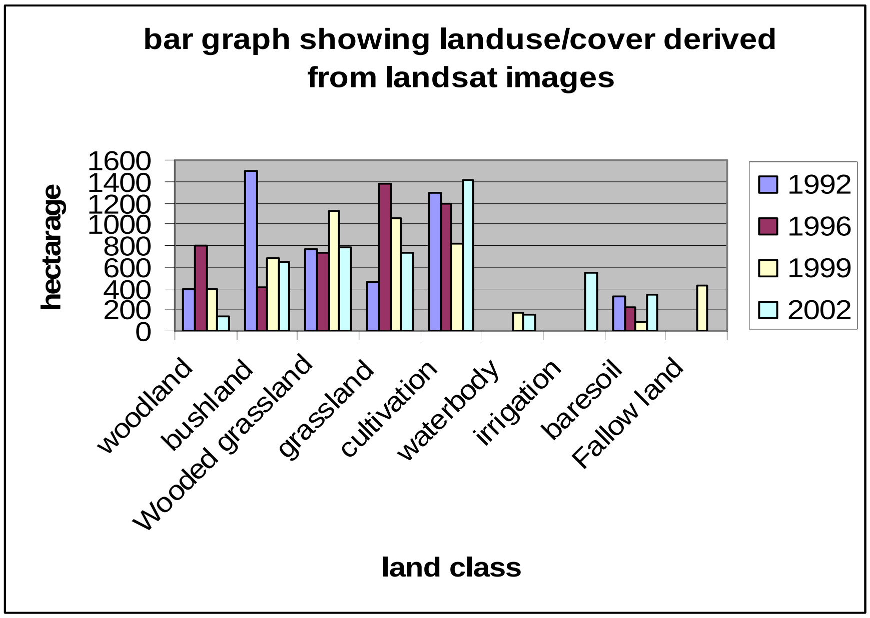

Figure 8: Land Use/Cover Patterns

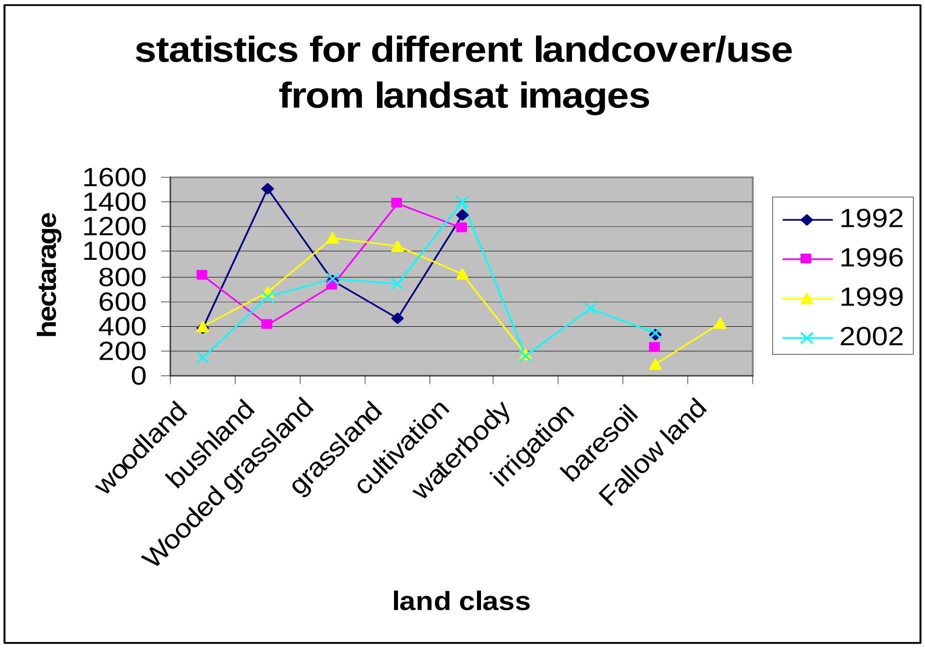

Figure 9: Line graph on patterns of land use/cover.

Table 5: Land Cover/Use Change.

	1992 -1996		1996-1999		1999-2002	
Land class	**Ha**	**% Δ**	**Ha**	**% Δ**	**ha**	**% Δ**
Woodland	↑413.715	↑106.56	↓410.772	↓51.22	↓251.449	↓64.28
Bushland	↓1090.561	↓72.62	↑267.648	↑65.08	↓38.329	↓5.65
Wooded grassland	↓38.895	↓5.07	↑388.371	↑53.42	↓331.372	↓29.72
Grassland	↑924.826	↑2000	↓334.9	↓24.16	↓312.562	↓29.73
Cultivation	↓100.00	↓7.74	↓364.463	↓31.02	↑586.363	↑71.38
Water body					↓18.88	↓11.03
Irrigation						
Bare soil	↓102.615	↓31.62	↓130.062	↓58.61	↑246.701	↑268
Fallow land						

Key:
↓ decreased by---- ha
↑ increased by
% Δ change ↓↑

The table 5 illustrates the percentage and hectrage increases/decreases of different land use/cover categories. It also quantifies the extent of increase and decrease of land use/cover categories.

Table 6: Woodland Cover

Year	Hectrage
1992	388.234
1996	801.949
1999	391.177
2002	139.728

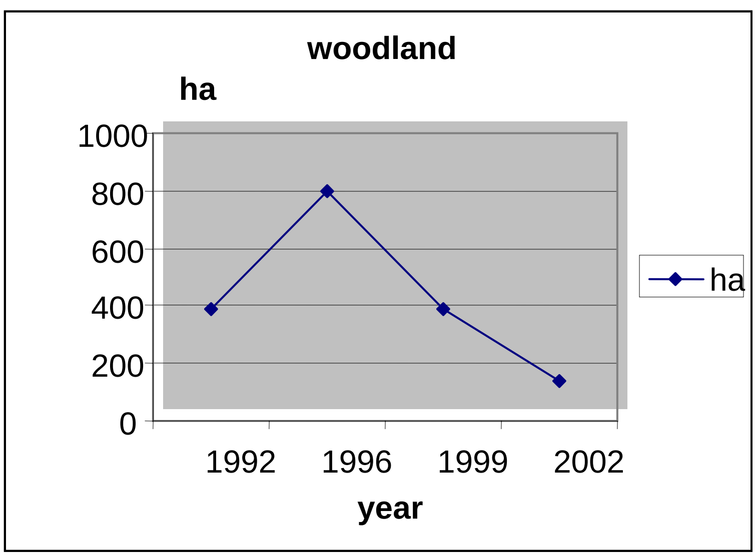

Figure 10: Woodland Hectarage Variations over the Years

The figure 10 shows that there is an increase in woodland hectarage between 1992 and 1996 and there after, it decreases. Between 1996 and 2002 there is a sharp decrease in hectarage. This is also evidenced by statistical figures given in table 6.

Table 7: Bush land Cover

Year	Hectrage
1992	1501.82
1996	411.259
1999	678.907
2002	640.578

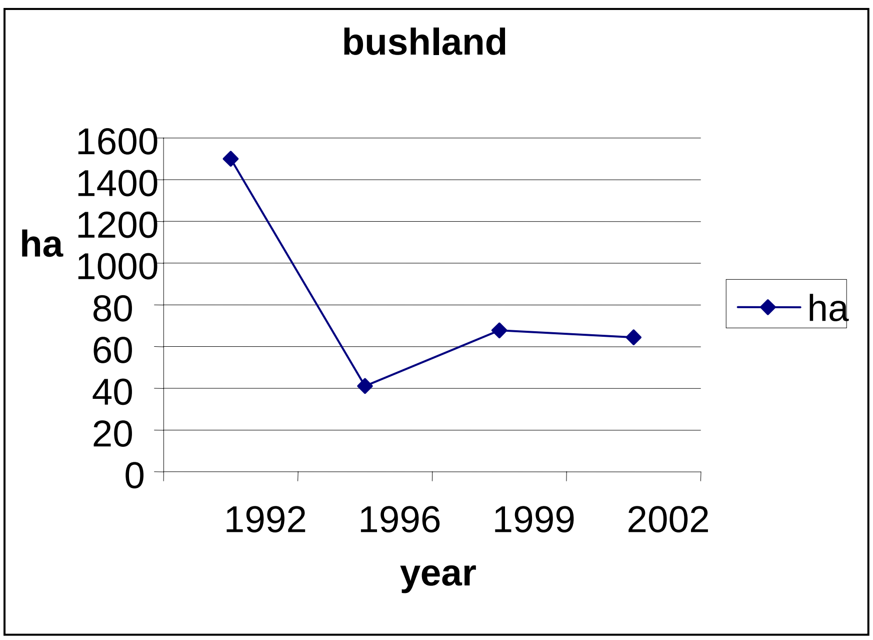

Figure 11: Bushland Hectarage Variations

Figure 11 shows the sharp decline in bush land hectarage between 1992 and 1996. However, it increased between 1996 and 1999 and then decreased in 2002. This is further, evidenced by statistical figures given in table 7.

Table 8: Cultivation Area

Year	Hecterage
1992	1290.844
1996	1190.83
1999	821.377
2002	1407.73

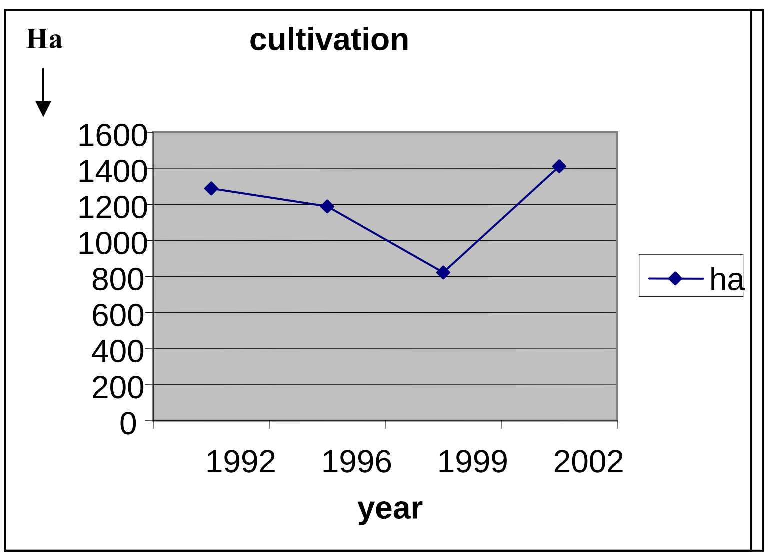

Figure 12: Cultivation Hectare Variations

Figure 12 and table 8 shows that cultivation declined between 1992 and 1996 and it further decline between 1996 and1999. However, a sharp increase in cultivation was evidenced between 1999 and 2002.

Table 9: Grassland Cover

Year	Hectarage
1992	461.134
1996	1385.959
1999	1051.056
2002	738.498

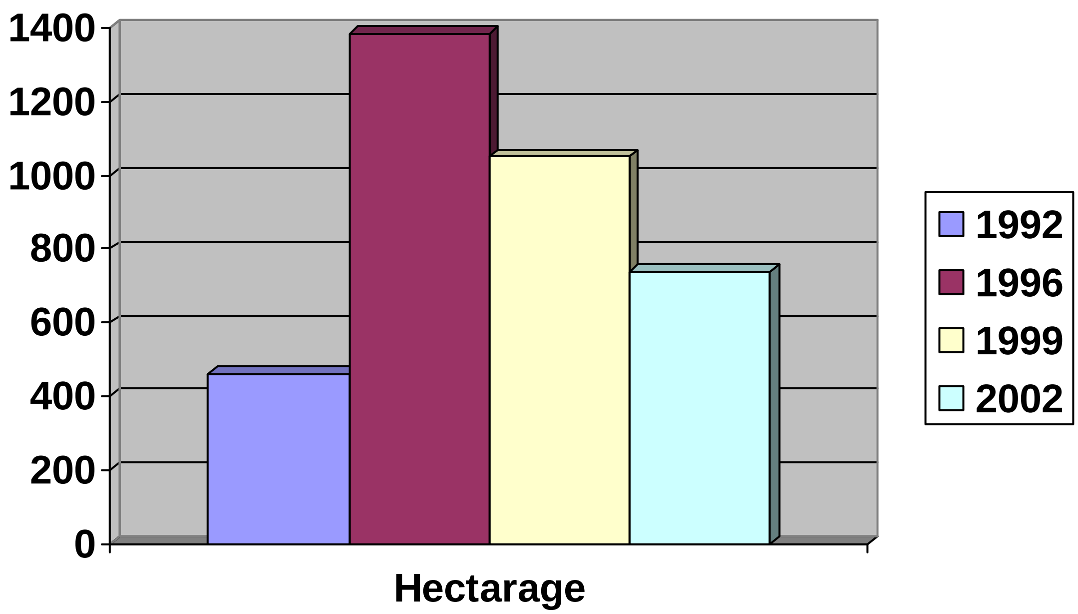

Figure 13: Grassland Hectarage Variations

The figure 13 shows that land under grassland sharply increased between 1992 and 1996. However, between 1996 and 2002 there was significant decrease.

Table 10: Demographic Characteristics of Respondents

Age Group(years)	Male	Female	Total
< 12	0	0	0
12 – 18	3	0	3
19 – 35	2	3	5
35 >	6	6	12
Total	11	9	20

Table 11: Exploited Tree Species in Nyanyadzi and Changazi.Wards

Species		**Exploitation Ranking**	**Uses**
Common name	**Scientific name**		
Mahogany (Mukamba)	Afzelia quanzensis	1	Craft ware, fuel wood
Baobab (Muuyu)	Adansonia digitata	2	Bark is weaved into mats
Musharu (Mopane)	Cholophospemum mopane	3	Fuel, Building, fencing
Thorny Species.	Acacia sp.	4	Fencing
(Mutohwe)	Azanza gackeana	5	Edible fruit, fencing material.

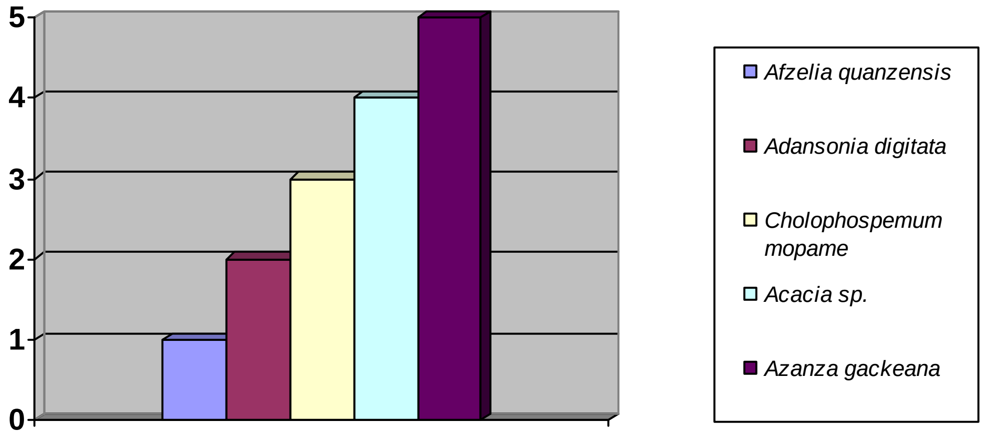

Figure 14: Tree Species Use Distribution

Both table 11 and figure 14 shows that Azanza gackeana is mainly used for carvings whereas afzelia quanzensis is least used. Azanza gackeana is the most exploited species because of its numerous uses: fencing poles and as fruits.

Table 12: Frequency of use of Woodland Species

Category of species uses	**Number of users interviewed from the community**	**Male**	**Female**
fuel wood	100	50	50
Construction	60	40	20
Woodcarving	20	12	8
Medicinal	5	1	4
brick curing	7	6	1

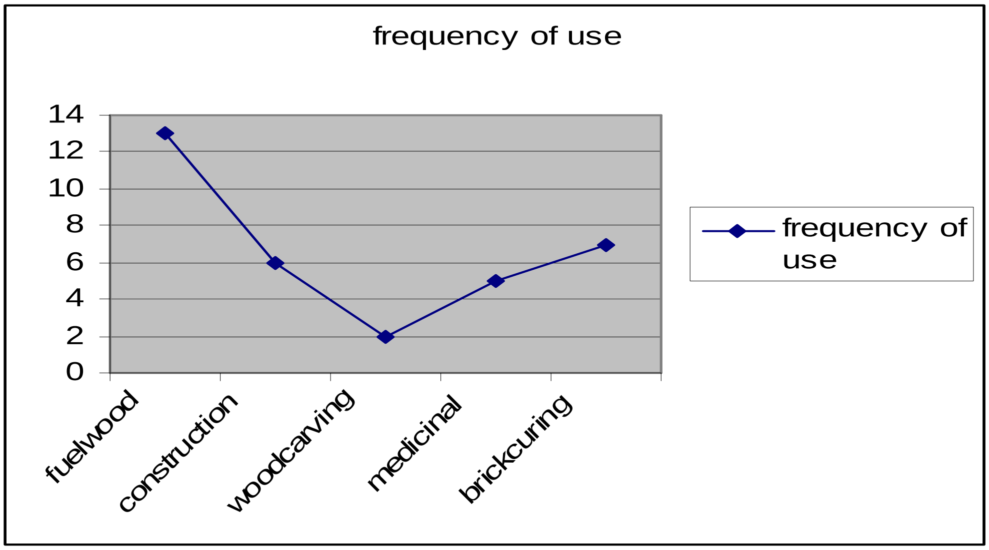

Figure 15: Frequency of use of tree species

Figure 15 shows that trees are mainly cut for fire-wood, construction of homes and garden fencing purposes.

Cultivation

The increasing demand for agricultural land per household means that there is a correspondingly decrease in rangeland size. Dwellers seek to satisfy short term needs as compared to long term benefits that could be derived from the natural rangelands. In 1992 the area under cultivation was 1290.844ha and it occupies 27.19%, whereas in 1996 it has decreased to 1190.839ha, representing 24, 25% decline. This decrease may have been caused by poor rainfall and drought which was caused by El Nino. Even though 1992 was the worst drought year, in the whole southern region of Africa, the Nyanyadzi Communal Area people managed to cultivate more land than in 1996. In the year1999, cultivation decreased to 821.377ha, representing 17.28%. This could be due to about 418.68ha of land which was fallow whereas in 2002, it increased to 1407.738ha, representing 29.59%. This increase in cultivation may be attributed to good rains received in the first months of planting season of year 2001 even though the season was declared a drought year. In 2002 about 537.618ha of land was put under irrigation and this is because there was plenty of water in Sabi, Odzi and Nyanyadzi rivers.

The irrigation scheme is divided into Blocks A-D and total hectarage is 412.34ha with 578 plot holders. Crops that are grown include sugar beans, tomatoes, onions, maize, leaf vegetables, tomatoes and okra. Poor utilization of irrigation is attributed to shortage of water and pumps because there is heavy siltation in Save, Odzi and Nyanyadzi rivers.

Water Body

In 1992 there was no sign of flowing water in Sabi, Odzi, Nyanyadzi and other rivers. This is due to drought because little rainfall was received that year. Whereas in 1996, there was no water seen flowing and this is because of dense reverie vegetation and aquatic plants. In1999 and 2002, there was large volumes of flowing water in all the rivers and this depicts a good rain season.

Woodland

There was 388.234ha of woodland, representing 8.23% of land in 1992 and it increased to 801,95ha (16, 90%) in 1996. This could be due to strong enforcement of by-laws, which resulted in bush land becoming woodlands. This can be supported by a decrease in bush land hectarage in these years. In 1999, woodland hectarage decreased to 391.177ha and to 139.728ha in 2002.This was due to the increase in population, resulting in increased consumption in trees for firewood, construction of community gardens, wood carvings, crafting of mats and brick curing. According to Arex Officer, this was attributed to the above five community projects.

From the information obtained during interviews, discussions and observations, there is heavy dependency by dwellers on natural resources for self sustenance; hence some of the woodlands were cleared for agricultural expansion.

Grassland

For the year 1992, grassland was 461.134ha (9.76%) and it increased to 1385ha (27.93%) in 1996. This was due to decrease in cultivation resulting in uncultivated lands. Whereas in 1999, it decreased to 1051.056ha (22.07%) and further decreased to 738.498ha (15.56%) in 2002 .This is because there was an increase in cultivation activity brought about by high rainfall experienced.

Wooded grassland was 765.69ha (16, 16%) in 1992 and decreased to 726.79ha (15.48%) in 1999; but increased to 1115.137ha (23.41%) in 1999. Finally, it decreased to 783.768ha (16.57%) in 2002. We found that there was a massive increase in livestock in the area and unselective tree-cutting which resulted in increased overgrazing and deforestation in woodlands and bush lands.

Bare Soil

Statistics showed that there was 324, 51ha (6, 89%) in 1992 and decreased to 221.899ha (5.94%) in 1996. This decrease is attributed to increased cultivation. In 1999, it further dropped to 91, 84ha (2.06%); whereas in 2002, it increased to 152.238ha (3, 28%). This increase is also evidenced by a decrease in woodlands and bush land; thus deforestation is leading to creation of bare sites. Barren areas also include the presents of bare rocks, dwalas and rocky outcrops. Furthermore, bare sites indicate the evidence of deforestation.

Azanza gackeana and colophospermum mopane are the two species mainly used for wood carvings. This is attributed to its high quality products and due to its accessibility. Colophospermum mopane is maily used for fencing; mainly because of its abundance in the area and robustness to termites and weather attack. Besides cultivation, crafting, brick curing and carvings are the main communal projects that sustain the community; and these result in the over utilization of woodlands. According to our findings, there is no sound enforcement of laws in order to curb the massive and unselective depletion of natural resources in Nyanyadzi Communal Area. Environmental Africa carried an awareness campaign in this area on how best to protect the over utilization of Afzelia quansensis and adansonia digitata species. Despite that, adansonia digitata is under severe threat because its barks are used for making mats and there is great evidence of them dying after bark-striping. We also found that the villagers experience poor yields because they allocated too small areas.

Conclusions

Our analysis indicates that there is over utilization of natural resources leading to land degradation. Specifically, there is a marked decline in woodland hectarage and the high demand for cultivation land is mainly attributed to the increase in population within the area.

A total of 248.506ha of woodland, which is equivalent to 5.2% of the total area under study, was lost or converted to cultivation lands in Nyanyadzi Communal Area from 1992 to 2002. Furthermore, statistics also revealed that 413.715ha or 8.38% of the total area under study of woodland was regenerated from fallow pastures and bush lands.

For the period 1992 – 2002, the rate of deforestation is 24.8%. Therefore, there is massive deforestation taking place in woodlands of Nyanyadzi Communal Area. It is mainly caused by cutting down of trees for fencing gardens, wood carvings, weaving mats and for firewood. The nature of vegetation in arid and semi arid communal areas and their rates of utilization reinforce the need for urgent intervention.

The paper also revealed that Remote Sensing and GIS are powerful tools for studying and managing land use and land cover changes in a better, accurate and efficient manner.

We finally conclude by recommending the Nyanyadzi Communal Area dwellers to consider land reclamation through reaforestation and using paddocks for their cattle grazing.

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