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# Land cover change and its impact on human-elephant conflicts in the Zimbabwe, Mozambique and Zambia (ZiMoZa) Transboundary Natural Resource Management Area

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Abstract

Land cover change is a characteristic reflection of a human society interacting with the physical environment. The Zimbabwe-Mozambique-Zambia Transboundary Natural Resources Management Area is a human settled area endowed with a variety of wildlife (elephants, lions, and buffalo) and wild lands (Dry forests and Miombo ecosystems). However, human-elephant conflicts are known to occur whenever these two species inhabit the same area, which poses serious threat to elephant conservation.

The study mapped the extent of land cover changes over a 19-year period (1989, 2001, and 2008). Landsat™ satellite images were analysed to interpret and detect spatial and temporal land cover changes. Relative to change detection analysis the community perception on the state and cause of human-elephant conflicts and the role of conservation policies were captured through targeted questionnaire guided discussions.

Deforestation, cultivation, and human-elephant conflicts increased over the period under review and forest classes decreased while the cultivation class increased. Human-elephant conflict hot spots increased, predominantly in areas where cultivation, settlement, and water sources coincide. Agriculture for livelihood was the major factor driving agricultural extensification in ZiMoZa. Weak policing, poor user rights, and pseudo decentralisation of power were policy issues found influencing community resentment towards conservation initiatives in ZiMoZa. The study concluded that extensification of agriculture and human-elephant conflicts will continue to increase in the study area and suggests the need for a paradigm shift from agricultural based livelihood to conservation-based livelihood.
Key words: Change detection, geographic information system (GIS), human-elephant conflicts, land cover, policy.

# Contents

# Introduction

## Deforestation and human-wildlife conflict

Deforestation is one of the many agents of land cover change. Wunder (2000) defined deforestation as the "elimination of trees and shifts to other land uses" including "different types of degradation that reduce forest quality (density and structure, ecological services, biomass stocks, species diversity, gene pools)". FAO (1999) simplified deforestation as the non-temporary change of land use from forest to other land use or depletion of forest crown cover to less than 10 percent. The increase of deforestation is a problem in many tropical forests worldwide (Sayer 2005).

World Bank (1992; in Sayer 2005) rather described causative forces of deforestation in the tropics as complex and cited poor economic policies, poorly defined property rights, under pricing of resources, perverse incentives and neglect of invaluable social benefits. However, Margulis (2003) found extensification of agriculture especially cattle ranging, accounting for 80 percent of Brazilian Amazonian converted forests.

There are many consequences of deforestation and they can be positive or negative (be it economical, ecological, biological, political, physical and social; Margulis 2003). Consequences of deforestation include the loss of habitats for biodiversity, destruction of livelihoods of native communities, soils erosion, flooding valleys and decreasing atmospheric carbon sequestration, to mention a few. Deforestation alters and fragment natural landscapes into biodiversity semi- or non-habitable areas (Newton 2007). Richardson (1998) described deforestation as one of the major factors influencing species loss globally.

Many studies have found connection between species loss and the quality (size, composition, and structure) of forest. Gascon *et al.* (1999) and Jha *et al.* (2005) reported strong negative correlation between forest size, density, structure, and quality to the number of species using it. There is consensus among researchers on the need to conserve remaining forest patches (Collinge 1996) in order to reduce species loss. Since underlying forces of deforestation are complex, there is need for increased understanding. Bancroft *et al.* (1995) suggested quantifying the spatial pattern and aerial extent of deforestation so that well-informed conservation remedies are established.

Deforestation is a characteristic reflection of the human society interacting with the physical environment (Campbell 1996). Limited resources and extensive interaction leads to high competition that usually degrades into conflicts between the society and other habitat-sharing organisms. The phenomenon of human-wildlife conflicts are widely discussed (Laurance 1999), and IUCN SSC (2001) defined it as any human-wildlife interaction which results in negative effect on human social, economic or cultural life and on wildlife conservation or on the environment.

Muruthi (2005) highlighted conflicts between humans and wildlife today as undoubtedly ranking amongst the main threats to conservation of biodiversity in Africa. Hoare (1995), Kiiru (1995) and Naughton *et al.* (1999) described human population growth, land use transformation, species habitat loss, fragmentation, development, ecotourism, increasing livestock populations, competitive exclusion of wild herbivores, abundance, and distribution of wild prey and increasing wildlife population as sources of conflicts.

In Southern Africa, humans still depend mostly on natural resources for their income, shelter, and food. The rapidly increasing human population is evidently resulting in greater pressure for land between arable cropping and wildlife (Hoare & Du Toit 1999). When humans harvest natural resources, they have certain preferences based on need. Mopani (*Colophospermum mopane*) woodland is harvested for structural poles, firewood, and charcoal.

Charcoal production in lower Zambezi valley especially on the Zambian side and Chidumayo (1991) estimates charcoal production accounting for 50 percent loss of the total woody biomass. Osborne (2005) further relates this reduction of Mopani woodland as a precursor to loss of elephants' (*Loxodonta africana*) preferred habitats. These results imply that conservation and economic development are conflicting, since deforestation for cultivation and infrastructural development accounts for the most forest fragmentation, isolation, and habitat loss for wildlife in Southern Africa. Hackel (1999) blamed poor conservation in Africa on severe social and economic problems such as poverty, long standing economic stagnation, rapid population growth, and environmental deterioration.

Elephants are often used as indicator species for depicting human-wildlife conflict (Hoare *et al.* 1999, Kioko *et al.* 2008). This is mainly because of the size, feeding habits, migratory behaviour, and destruction tendencies of the species. Elephants are bulk feeders and an adult bull can demand 100 to 300 kg of forage per day (Nellemann *et al.* 2002). Furthermore, elephants have a crop-raiding tendency with capacity of becoming skilful and habitual crop thieves (Mupangwa *et al.* 2000). They are not only crop raiders but also known to destroy their own habitats by rampant tree felling and over-grazing. Aarde *et al.* (1999) described it as a natural phenomenon when populations increase above carrying capacity.

## Land use planning

The poor pattern of land use planning in history cannot continue on the expense of extinction threat on biodiversity (Tilman *et al.* 1994). Richardson (1998) argued that some policies and instructional constraints hampered historical move towards wildlife conscious land use pattern. Accordingly, prompt policy measurement should seek to re-address and promote efficient land use allocation with minimum threat to biodiversity.

Kangwana (1995), O'Connell-Rodwell *et al.* (2000) and Zisadza & Mandima (2007) proposed land use planning approaches that attempt to separate agricultural activities from wildlife habitats and movement corridors. The plan should account for key elephant habitats in order to reduce human-wildlife conflicts. Omondi *et al.* (2004) further suggested land use planning that entails identification and zonation of separate areas for farming, settlement, community hunting areas, wildlife habitats, and restriction of agricultural development in known wildlife corridors.

The problem to achieve sustainable conservation is very complex and old to science as Herdin (1968) since announced that there is no critical formula best for achieving sustainable conservation. Wunder (2000) and Sayer (2005) agreed that there are multiple underlying factors (social, physical, and political) affecting optimum balance of development and conservation. In addition, Jivetti (2004) also highlighted that game reserves and protected areas have failed to sustain the wide home range for elephants, and the idea of increasing the present size of protected areas is not feasible.

World Bank (2001) highlighted elephants as known migrants from protected areas to human communities where they cause damage to crops, structures, and property, in some cases even causing injury and death. Humans are mostly blamed and tagged as threat to biodiversity conservation (Geisler 2002) and usually policies are crafted in a way that attach higher premium on wildlife over humans (Hackel 1999). This has further increased the resentment of communities towards conservation activities.

Mburu *et al* (2003) described the need for community compliance and stopping unplanned cultivations in wildlife movement corridors in Zimbabwe and other forms of infringement (habitat conversion, and habitat fragmentation) into known elephant corridors. This can only be achieved if government realises causative underlying factors which World Bank (1992) in Sayer (2005) pointed out as poorly defined property rights, undervaluing natural resources and perverse natural resources market incentives.

## Effects of increasing human and elephant populations to conservation in Southern Africa

Studies of human and wildlife population change are important for developing a biodiversity conscious land use plan especially in areas where humans and wildlife coexist (Hoare & Du Toit 1999). Human population in Southern Africa is increasing (Earth trends 2003) at a rate that significantly alters vegetation, thereby causing negative impact on biodiversity. There is a rapid increase in the human population in rural areas of Zimbabwe; 2.9 percent annually according to Earth trends (2003).

Hoare & Du Toit (1999) argued that increasing human population in areas where elephants and human coexist reduces elephant home ranges. They further related increase in human population with increased deforestation for settlements and cultivation. Ervin (2003) and Songorwa (2004) described this scenario as threatening to wildlife through increased habitat destruction, encroachment and poaching.

Zimbabwe together with other Southern African member states acceded and ratified the Convention of International Trade in Endangered Species (CITES) which restricted the trade of ivory and other elephant products. The populations of elephants started to increase after the trade ban and now populations have reached levels above landscape carrying capacity, causing a lot of destruction and conflicts with humans (Thouless & Sakwa 1995).

Zisadza & Mandima (2007) reported that elephant population has been increasing by five percent in Zimbabwe and Dunham (2004) estimated elephant population density of 0.73 per square kilometre in Zambezi Valley, a figure well above the carrying capacity estimated for Kruger National Parks (0.32 elephants per square kilometre) by Aarde *et al.* (1999). The positive elephant population trend in Southern Africa is surprising given that Hoare & Du Toit (1999), Murombedzi (1999), and Zisadza & Mandima (2007) noted major habitat losses and corridor conversions. Kangwana (1993) further highlighted increased elephant poaching. Murombedzi (1999) described the increasing trends of both human and elephant populations as clearly indicating the increasing perpetual problem of resources management between humans and wildlife in Sub-Saharan Africa.

Elephant population control measures are still debated internationally and to date there is no outright solution. Aarde *et al.* (1999) described culling of elephants in Kruger National Park as a failed method to totally depress elephant population densities, apart from the method being unacceptable internationally (Foggin 2003). Aarde *et al.* (1999) studied elephant population trends over a period of culling seasons in Kruger and found that elephants tend to have a compensatory response to culling by increasing reproduction index (i.e. females prematurely attains sexual active stage) soon after culling. However, Aarde *et al.* (1999) further argued that if elephant populations are unchecked they only increase to a certain threshold density and thereafter stabilises.

Elephant densities of 0.37 per square kilometre discovered to be the ceiling density (maximum population size) and if the population grows above this density, it is truncated. On the other hand, Hoare & Du Toit (1999) reported densities of 15-20 people per square kilometre as threshold density where elephants and humans can coexistence. Hoare (2000) wrote, "The future persistence of elephants over the 80 percent of the species' range outside protected areas is increasingly uncertain in many parts of the continent".

## Underlying factor causing spatial land use overlaps between humans and elephants.

Spatial overlaps occur when humans and elephants are sharing same territory, a scenario driven by the availability of a resource preferred by both species. The human-elephant spatial overlap idea assumes that the spatial heterogeneity of vegetation (composition and distribution) determine the distribution of elephants as reported by Murwira & Skidmore (2005). The spatial distribution of vegetation is determined by two important factors namely, underlying geology (Du Toit 1993) and availability of ground water but not limited to these factors. However, the same factors also affect where people develop settlement and cultivation resulting in land use overlap with elephants, a situation that leads to human-elephant conflicts.

Guy (1977) and Du Toit (1993) pioneered the vegetation characterization of Zambezi valley, by characterising and mapping five major vegetation classes and their associated geology. Du Toit´s (1993) found that the Zambezi valley has very poor soils, as they are mostly sands with shallow depth and poor moisture retention capacity. Agriculture in this region yields better on more moist soils and commonly cultivation proliferates close to the rivers. Forest classes like riverine woodland, Jesse thicket, and dry forest thicket occurring close to rivers are often cleared for cultivation purposes.

Nellemann *et al.* (2002) investigated the links between terrain characteristics and forage patterns of elephants in Northern Botswana and they found terrain ruggedness, distance to water and density of *Combretum spp.* significantly determining where elephants browse. Earlier research by Guy (1976) indicated that *Combretum* species are preferred as elephant forage and later Nellemann *et al.* (2002) confirmed *C. apiculatum* and *C.* elaeagnoides to be favoured elephant forage.

Osborn (2005) studied the habitat selection by bull elephants in central Zimbabwe and revealed that elephant bulls use all habitat classes relatively equal to their availability though with seasonal preferences. *Julbernardia-Vellozia* woodlands, grasslands, *Brachystegia-Compretum* bush, and Mopani mixed woodland scored positive selection in relation to their availability. Many studies have found surface water very important determinant of elephant distribution (Nellemann *et al.* 2002, Chamaille-Jammes *et al.* 2007, de Beers & van Aarde 2008), meaning that the potential of human-elephant spatial overlaps on landscape parcels with water sources are high. An overview of these studies clearly indicates the availability of surface water and the vegetation heterogeneity index as major underlying factors influencing spatial land use overlaps between human and elephant.

## Effects of policies on conservation and land use

The role of policy in influencing the way a particular land is used today and in future cannot be over emphasised. Several studies (World Bank 2001, Margulis 2003, Sayer 2005) have indicated that science alone cannot combat the problem of conservation and land use but with integration of good policy environment. However, most governments in the Southern Africa adopted policies from their former colonial governments (Wolmer 2003), which are often referred as incompatible with community set up as they lack integration of human societies. Hoare (2000) referred to these policies as out dated and they lack mechanism for addressing human-elephant conflicts. In addition, poor resources available for these governments have further affected the policy administration and enforcement (Wolmer 2003). Therefore good policy environment that integrates communities living in wildlife areas will further increase efficacy of all conservation efforts.

## Aim of the study

The aim of the study was to: **1)** analyse land cover changes in Mbire, Magoe & Zumbo and Luangwa districts in the Zimbabwe-Mozambique-Zambia (ZiMoZa) Transboundary Natural Resource Management Area (TBNRM) for the period 1989 to 2008, **2)** evaluate potential human-elephant conflicts in the area, guided by the vegetation change analysis and questionnaire survey, and **3)** highlight potential conservation policy shortfalls that may influence the utilization of natural resources in the study area.

The conceptual framework on Fig. 1 illustrates the study problem statements with focus on causative underlying factors and the resultant situation in the study area.

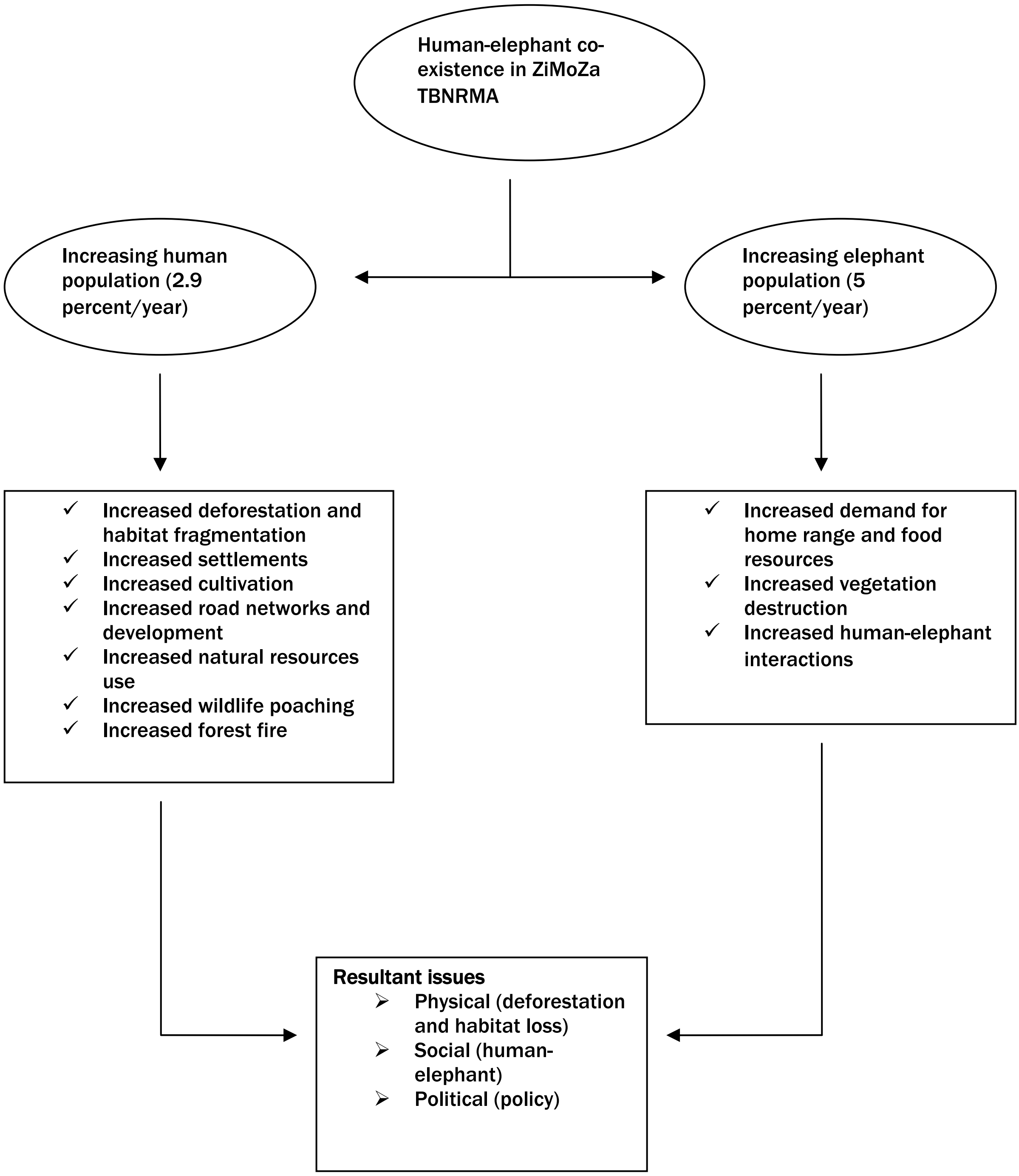



Fig.1. Conceptual Model showing the resultant human-elephant conflicts in ZiMoZa area. Elephant and human populations are increasing whilst human induced forest conversions to other land uses are also increasing.

# Study area

The ZiMoZa TBNRM landscape transcends three countries namely Zimbabwe, Mozambique, and Zambia. It consists of four districts, which are Mbire in Zimbabwe, Zumbo, and Magoe in Mozambique, and Luangwa in Zambia. The International Union for Conservation of Nature (IUCN) founded the ZiMoZa initiative in 1999 (the idea was initially raised by the Zimbabwean deputy minister) with the objective to have the three countries share their responsibility of ensuring long-term conservation of the environment and natural resources through community based management, infrastructural development, and policy harmonization (IUCN 2001). The initiative is directed by an intergovernmental steering committee. So far, they have developed a draft Transboundary Natural Resources Management agreement that awaits respective governments to sign and ratify. The draft was developed after wide stakeholder consultations, which include the communities living in ZiMoZa area.

The ZiMoZa area is bordered by the Chewore Mountains in Zimbabwe on the west and Dande Safari Area on the south. In Zambia, Rufunsa Game Management Area borders to the west, and the escarpment to the north of ZiMoZa. In Mozambique, Manyame River borders to the east, and the escarpment to the north of ZiMoZa. It is located in the Zambezi valley at the confluence of the Zambezi River and Luangwa River where the three countries share political boundaries.
Average annual rainfall is 400mm and average altitude 340 m above sea level. The vegetation is predominantly of Miombo structure and the area has very rich and diverse habitats, wildlife movement corridors, and wildlife home ranges (elephants, buffalo *(Syncerus caffer*)) that overlap the three countries. The total study area for this project is 257 769 ha just a smaller portion of the greater ZIMOZA TBNRM according to IUCN.

Core forests in the area include the riverine woodlands, dry forests, Mopane, Brachystegia and Acacia dominated woodlands among others. Wildlife in the area includes elephant, buffalo*,* lions *(Panthera leo),* and baboons (*Papio anubis)* among others. The area has four major rivers that play a vital role in human settlement development and these rivers are Zambezi (shared by all three countries), Luangwa (shared by Zambia and Mozambique), Mwanzamutanda (in Mbire, Zimbabwe), and Manyame (in Magoe, Mozambique).

The Zambezi river system provides many livelihood opportunities for the communities including fisheries. Core groups of indigenous communities occur along the rivers with a long history of interaction between each other dating back before establishment of political boundaries (Macacule 2000). The vaChikunda and vaDoma tribes dominate on the Zimbabwean and

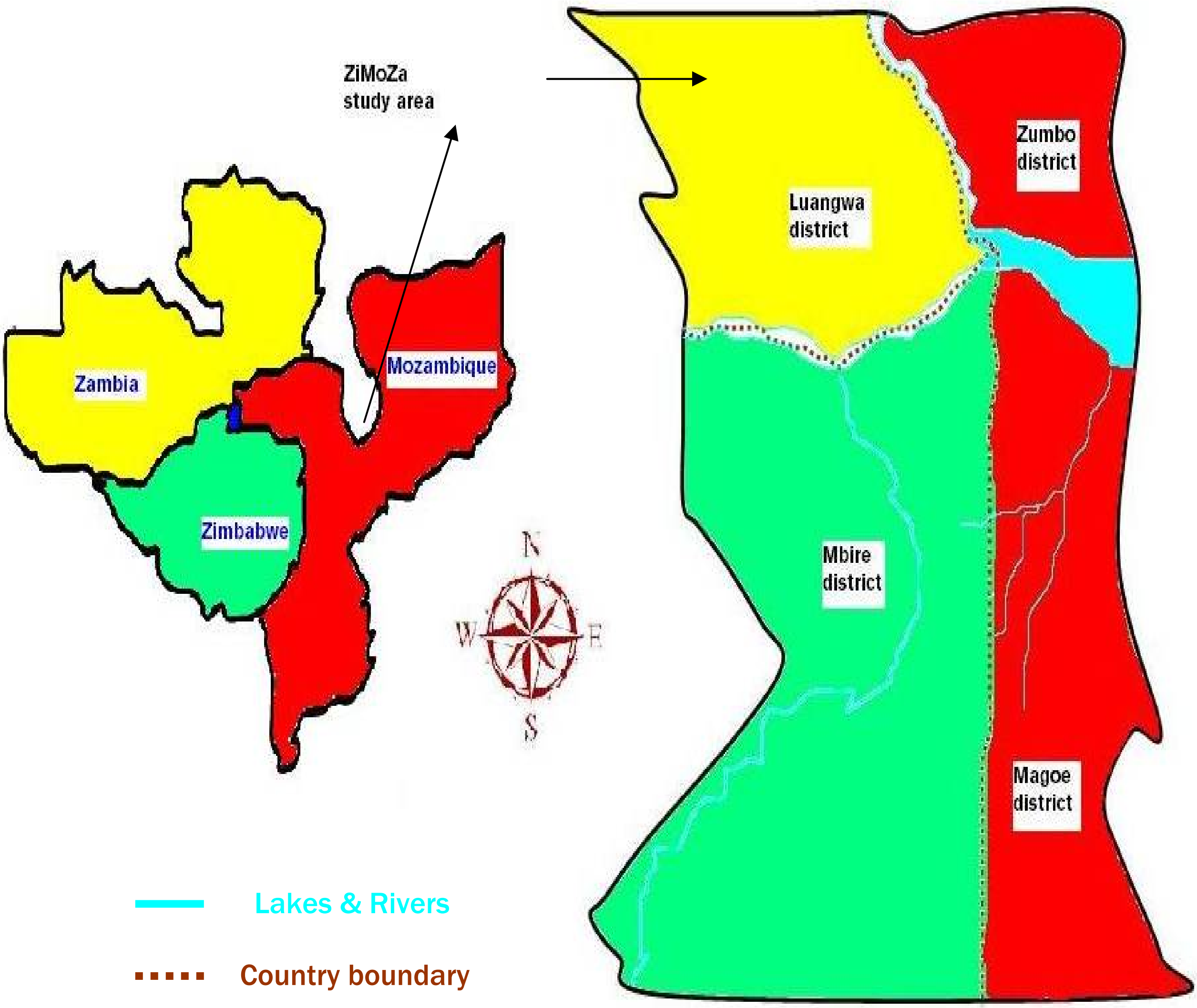
Mozambique areas in the study site. VaChikunda people invaded the land of vaDoma in Zimbabwe and to date they hold the chieftainship and their spirit medium sprouts from Mozambique (C. Majaya, Mbire Rural District Council, personal communication.). Mozambique also has Matande, Mastenga and Vasena tribes apart from vaChikunda and vaDoma tribes. Ironically all tribes on the Mozambiquean side are believed to be migrants from Zimbabwe, lead by the spirit medium into Mozambique (Venzere T., pers. Comm.).

Historically, human habitation in the area was minimal due to high tsetse fly *(Glossina sp.)* infestations that cause sleeping sickness to humans and trypanosomosis to livestock. In the late 1970s to early 1980s, a regional tsetse fly control programme funded by European Union managed to eradicate the tsetse fly infestation thereby making the area habitable to humans. This led to human population increasing and subsequent development of the area.

The community introduced drought tolerant crops like cotton *(Gossypium spp.),* maize *(Zea mays),* groundnuts *(Arachis hypogaea)*, millets *(Pennisetum glaucum),* sunflower *(Helianthus annuus),* and sorghum *(Sorghum bicolour)* for improving livelihood. Cultivation land comes from clearing forest especially riverine class that is largely favoured for their alluvial soils and good water retention capacity. Fig. 3 shows a topographic map extract of the study area.

The map in fig 3 shows the four study districts. The three states political boundaries converge at the middle of the confluence of Zambezi and Luangwa rivers. The states are also separated physically by rivers on the northern parts of ZiMoZa. However, there is free movement of wildlife in the area on Mbire and Magoe district while elephants have known crossing point along Zambezi river and Luangwa river in order to access Luangwa district on the Zambian side.

Fig. 3: The study area; Mbire district Zimbabwe, Luangwa district Zambia and Zumbo & Magoe Mozambique.



# Methodology

## Satellite image analysis

Vegetation change detection analysis was done for the entire study area over a period of 19 years. For the purpose of this analysis, images from 1989, 2001, and 2008 were visually interpreted and processed to map the changes. The basic data source was Landsat Thematic Mapper ($^{TM}$) satellite images; their scene identity was path 170 and row 071 with 30 m spatial resolution. Landsat™ images for June 1989 and August 2001 used in this study were sourced from World Wide Fund for Nature (WWF) and September 2008 image was downloaded from the United States Geological Survey website.

Dates of the images acquired were analysed using the false colour composite bands 4, 3, and 2. The sourced images fell within the dry season, which is a good season for change detection because of its phenological stability and it enhances spectral separability. Free from cloud cover, humidity and smoke were considered as criteria for selecting images in order to reduce misclassification error (Singh 1989).

Data processing involved image enhancement to sharpen spectral signatures and discriminate between tones purporting to represent different vegetation types. Images were then geo-referenced in Universal Transverse Metacar (UTM), Zone 36 south, and Datum: WGS84. The post classification change detection method (Weismiller *et al.* 1977, Wickware & Howarth 1981) was used to detect habitat/vegetation change over the 19 years period. The method involves independently classifying two images from different dates (Jensen 1996, Yuan & Elvidge 1998).

Table 1 shows the VegRIS classification scheme which was used as land-cover classification system in this study (the scheme was derived from Boughey (1957), Rattray (1961), Du Toit (1993) and CIRAD-EMVT (2004)).
VegRIS is a vegetation classification scheme used by the government of Zimbabwe under the Forestry Research department. The scheme has more classes than those used in this study since the omitted classes do not occur in ZiMoZa. Most of vegetation-linked researches in the study area used VegRIS classification and adopting the scheme for in this research would make results comparable with other researchers and easy to adapt for further research by others.

Visual interpretation was used through on-screen digitizing (i.e. creating vectors (polygons) with the imagery in the background on computer. See Appendix I for 1989, 2001, and 2008 digitized images. Different vegetation classes were picked up for each image separately creating vegetation cover maps and polygon statistics were computed using TNT (This New Thing) and ArcGIS software. The percentage area covered by each vegetation type for each date was recorded. The digitising of the three Landsat™ scenes was the basis for the development of the vegetation interpretation maps for the years 1989, 2001 and 2008.

Table 1: The classification scheme used to classify land uses in the ZiMoZa area.

| Class | Vegetation type | Description |
|---|---|---|
| 1 | Dry Forest Thicket | Vegetation growing away from riverine influence but have common species characterised with tall trees and under storey-height 25m-15m-5m |
| 2 | Cultivation | Land being used for agricultural cropping. |
| 3 | Jesse Thicket | Dense understory, tall trees present and tend to merge into riverine because of common species height 5m-15m |
| 4 | Water body | Water body e.g. pools forming river courses of Zambezi, Angwa rivers including dams/lakes |
| 5 | Combretum Bushland | Vegetation of the species of height 1m-5m |
| 6 | Grassland (Alluvium) | Alluvium refer to soil deposits along rivers hence the grasses which grow on them namely *Phragmites mauritianus* (Tsanga) which is Grassland (Alluvium) |
| 7 | Mopane-Combretum Woodland | A combination of species with Mopane dominating thus Combretum is understory within height of 5m-15m |
| 8 | Riverine Forest | Vegetation along rivers/streams on alluvial deposits -height 5m-15m |
| 9 | Miombo-Combretum Bushland | Vegetation of the species of height 1m-5m |
| 10 | Settlement | Built up area for human habitation |
| 11 | Open Mopane Woodland (Rocky) | Vegetation of the species Mopani of height 5m-15m growing on sandstone and mudrock. |
| 12 | Miombo-Mopane Woodland | A combination of species Miombo (*Brachystegia spp*) and Mopane of height 5m-15m |
| 13 | Air strip | Grassland/bare ground |
| 14 | Combretum Woodland | Combretum species of height 5m-15m |
| 15 | Mopane Woodland | Vegetation of the species Mopane of height 5m-15m |
| 16 | Mopane Bushland | Mopane vegetation of height 1m-5m |
| 17 | Escarpment Miombo Woodland | Dominant Brachystegia species of height 5m-15m e.g. on Zambezi escarpment or on other escarpments in the study area. |

Classification adapted from Du Toit (1993) VegRIS classification system

Transition (change) matrices were generated after the interpreted maps for 1989, 2001, and 2008, were converted to raster grid format. The raster maps were then compared on pixel-by-pixel basis. The area of land cover changes was queried using raster calculator tools in Arc Map 9.x. Ms Access was used to generate the matrix table and the cross tabulations to calculate land cover changes were done in Ms Excel. However, it is important to note that the post-classification method used inherently carries every error in the individual classification maps to the final change detection map and this affects the final product if there were classification errors.

The annual rate of deforestation was computed using equation (1) which was adopted from FAO (1995). The calculated annual rate assumes that the magnitude of land cover changes is the same for the 19 years under review.

$$p = \left[ \left( A_2 / A_1 \right)^{1/(t2-t1)} - 1 \right] * 100 \qquad (1)$$

where *P* is the percentage loss per year, $A_1$ and $A_2$ are the forest area at time $t_1$ and $t_2$ respectively.

## Ground truthing

On ground truthing, all 17 classes adopted by this study had reference data collected. 72 sites were selected: 50 percent of the revision test sites were taken from the Zimbabwean side, 35 percent and 15 percent was from Mozambique and Zambia respectively. The 2008 desktop interpreted image map was used for verification. Ground truthing was done to verify the mapped unit attributes (the correctness of desktop visual interpretation). Test sites were 50 m radius circular plots selected based on accessibility and its value to the research goal. At each test site, X and Y coordinates was recorded using GPS unit and the desktop assigned attribute checked against the scene on the ground. Additional observations were recorded on a field observation form. (See appendix VII for the observation form).

The main purpose of ground truthing was to verify the digitised classes against the ground scenario. It was not possible to ground truth the whole landscape dues to accessibility and security concerns, but verification covered all the land cover classes used in this study. Coordinates and their attributes recorded on the observation form were then captured in excel and later displayed as point map which was then overlaid on the computer based preliminary interpreted imagery. The researcher revised initial classification errors and corrected them by assigning the correct ground truthed attribute on the earlier visually interpreted map. The revision of classes was localised and specific to ground truthed points, since the procedures used for classification did not use tone signature. Use of tone signature in this study proved difficult and yielded many overlaps since the classification scheme used had closely related classes (tones). The classification relied on the extensive knowledge of the study area and use of GIS experts (from Forestry Research Unit and World Wide Fund for

Nature) who have been working in the study area for more than 10 years now. The study also used topographic map published in 1976 by the then government of Rhodesia and results from du Toit (1993) on Zambezi valley vegetation reconnaissance survey for ground truthing. Unfortunately there was no new topographic map produced after the 1976 map but the map is still valid since more than 80 percent of the area is still intact even up to date. For this reason, it made it possible to use the map for interpreting the land cover states observed on the 1989, 2001, and 2008 maps. However, it was a bit difficult to use the map on classes that changed from the original (1976) state. Instead, ground truthing was more on those classes that experienced changes from the original state. It could have been much better and more accurate if newer topographic maps were available for the study area.

A confusion matrix was generated based on Jensen (1996). The interpreted polygon map and ground truthed were first converted polygons to raster grid format in Arc Map 9.x. The raster maps were overlaid and the overlay map attribute table was then exported to Ms Access to generate the matrix. Cross tabulation to produce overall accuracy, class accuracy, and KAPPA ($K_{hat}$) index were done in Ms Excel. The following equation (2) was used to calculate ($K_{hat}$) index.

$$K_{hat} = N\sum_{i=1}^{r} X_{ii} - \left[\sum_{i=1}^{r}\left(X_{i+} * X_{+i}\right) / \left(N^2 - \sum X_{i+} * X_{+i}\right)\right] \qquad (2)$$

where *r* is the number of rows in the matrix, $X_{ii}$ is the total number of correct cells in a class, $X_{i+}$ is the total for row *i*, $X_{+i}$ is the total for column *i*, and N is the total number of cells in the error matrix.

## Questionnaire guided discussions

The study pursued a questionnaire-guided discussion method (See appendix IX for the questionnaire used) in order to collect data on the state, causes, and community perceptions of human-elephant conflict in ZiMoZa The questionnaire guided discussions targeted specific officials who are actively involved in the management of wildlife resources and or involved in the local community governance. The study assumed that targeted officials represent communities in the study area and their response reflects the situation in their community. In addition, personal communication with some community members was done as complement method. They were used as follow up method to validate some important or controversial issues raised by officials during questionnaire-guided discussions. The analysis of the survey depended on the officials' level of responsibility, level of knowledge, experience, gender, and age. This survey was carried out in the beginning of wet season (November 2008). No official survey done in Zambia, (Luangwa district) due to some logistical constraints and in Mozambique (Zumbo district), since targeted officials were not readily available to participate. Appendix VIII shows institutes based in Mbire and Magoe districts that formally participated in the discussions.

## Prediction of human-elephant conflict hot spots

In order to map conflicts in the study area some parameters were used to defined area with high probability for human-elephant conflict occurrence. Conflict hot spots were defined as a land parcel that has a mixture of the following land cover classes: settlement, cultivation, and water body. These defining parameters were drawn from the survey information, direct observations, and land cover map interpretations. The survey indicated that human-elephant conflicts were occurring on cultivated lands. Settlements were observed to be located in cultivated areas during field assessments and confirmed land map interpretation (Fig 3). Water body was used in line with Nellemann *et al.* *(*2002), Chamaille-Jammes *et al.* (2007) and de Beers & van Aarde (2008) who reported high elephant population densities close to water sources.

# Results

## Land cover change analysis

The land cover maps for 1989, 2001 and 2008 were produced (from Landsat TM images) and are displayed in Fig 3. The overall accuracy of the land cover map for 2008 was 74 percent and, the overall user and producer's accuracies were high (Appendix II). The KAPPA index was 0.72; therefore, the accuracy was sufficient to carryout land cover change detection analysis. (Appendix II shows details of the cross-tabulated error matrix).

Maps displayed in Fig 3 show the spatial extent of cultivation, marked in black circles for 1989, 2001, and 2008. The dark green colour increased for the period under review in the study implying that cultivation land increased in the study area for the period under review. Cultivation activity is prominent on areas that area along the rivers and tributaries (coded by light blue) of ZiMoZa. Forest classes were mostly converted to cultivation and dominant conversions were on, Dry forest (coded red), Jesse thicket (coded light brown), and Mopani bush land (coded purple) classes.

Table 2 shows the summary statistics for land cover change computed from the land cover change matrix of 1989 and 2008 maps. Consult appendix III to see the whole land cover change matrix. From the table presented in the appendix III, it is clear that considerable land cover changes occurred during the 19-year period. Land area under Dry Forest thicket and Jesse thicket decreased the largest over the period under review by 4 235ha and 3 724ha respectively. However Combretum woodland and Jesse thicket had the largest change in proportion to their initial total area by 36 percent and 34 percent respectively from their initial 1989 state. Cultivation and Grassland classes gained the largest land area, they gained 12 518ha and 809 ha respectively. Cultivation and settlement classes gain the largest land area in proportion of their initial total area by 107 percent and 1843 percent respectively and the two classes were the fastest increasing classes in ZiMoZa as they have an annual change rate of two percent and 17 percent respectively.

In appendix IV there is a bar graph showing the change pattern and distribution of land cover classes in ZiMoZa for the dates 1989, 2001, and 2008. On the graph Mopane-Combretum woodland, Dry Forest thicket, Mopane bushland and Mopane woodland are the most abundant classes in the study area.

Fig 3. ZiMoZa area land cover maps for 1989, 2001 and 2008 showing the spatial extent for 17 different land cover classes. The black circles indicate areas with large proportion of cultivation land.

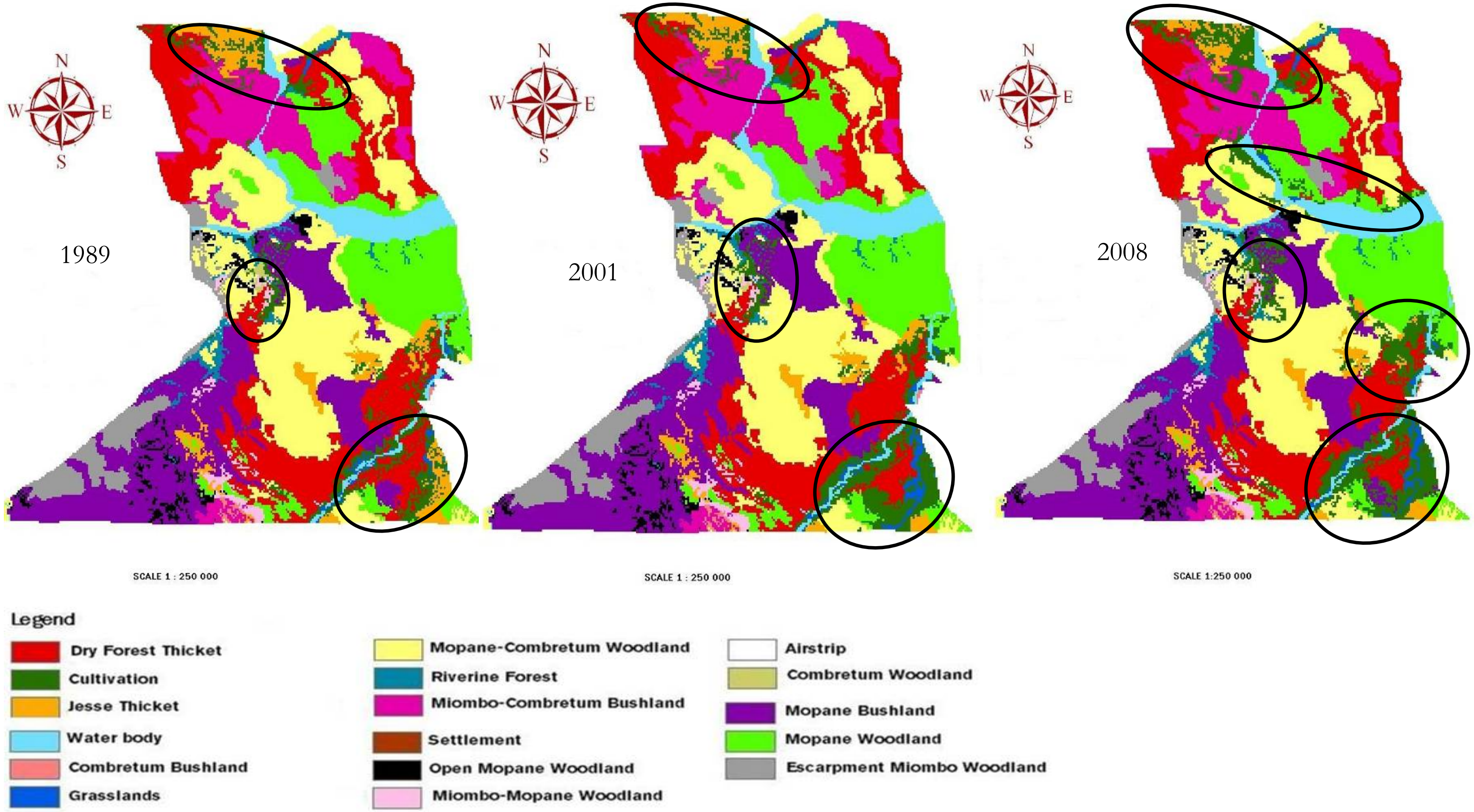


Table 2. Summary statistics for land cover changes from land cover change matrix for 1989 and 2008

| Land cover changes | WB | EMW | CW | AS | MCB | CB | DFT | JT |
|---|---|---|---|---|---|---|---|---|
| 1989 Total area (ha) | 11 688 | 12 090 | 431 | 23 | 22 178 | 519 | 47 331 | 10 917 |
| 2008 Total area (ha) | 11 792 | 12 085 | 277 | 22 | 21 330 | 478 | 43 096 | 7 193 |
| Change (ha) | 104 | -4 | -154 | -1 | -848 | -41 | -4 235 | -3 724 |
| Percentage change (%) | 0,89 | -0,04 | -35,64 | -5,67 | -3,83 | -7,90 | -8,95 | -34,11 |
| Annual change rate (%) | 0,03 | 0,00 | 0,00 | -0,38 | -0,21 | -0,35 | -0,25 | -1,27 |

WB (Water body), EMA (Escarpment-Miombo woodland), CW (Combretum woodland), AS (Airstrip), MCB (Miombo-Combretum bushland), CB (Combretum Bushland, DFT (Dry-Forest-thicket, JT (Jesse thicket)

Table 2. *continued…*

| Land cover changes | Cult | Sett | RF | Grass | MW | OMP | MCW | Mop B | MMW |
|---|---|---|---|---|---|---|---|---|---|
| 1989 Total area (ha) | 11 750 | 13 | 3 909 | 1 268 | 32 889 | 4 086 | 51 405 | 44 632 | 2 638 |
| 2008 Total area (ha) | 24 268 | 252 | 3 781 | 2 077 | 31 709 | 4 086 | 49 097 | 43 587 | 2 638 |
| Change (ha) | 12 518 | 239 | -128 | 809 | -1 180 | 0 | -2 308 | -1 046 | 0 |
| Change (%) | 106,53 | 1 842,56 | -3,27 | 63,76 | -3,59 | 0,00 | -4,49 | -2,34 | 0,00 |
| Annual change rate (%) | 2,24 | 16,90 | -0,02 | -0,39 | -0,21 | 0,00 | -0,23 | -0,01 | 0,00 |

Cult (Cultivation), Sett (Settlement), RF (Riverine Forest), MW (Mopane woodland), OMP (Open Mopane woodland), MCW (Miombo combretum woodland), MopB (Mopane bushland), and MMW (Miombo Mopane woodland)

In appendix V (a) there is a (1989-2001-2008) change map showing the geographic location of class change and the systematic temporal sequence of change for cultivation, settlement, and grassland classes for the period 1989-2001-2008. Important highlights of the map shows that Dry Forest Thicket and Jesse Thicket classes were mostly converted to grasslands (2001) and then cultivation (2008). However, a small proportion was converted to settlement and grassland classes by 2008. The map also shows that settlement class predominantly come from the Mopane woodland class. The overall interpretation of the change map indicates that no forest classes were regenerated over the period under review.

## Human-elephant conflicts and community perceptions

The perception from questionnaire-aided survey indicated that human-elephant conflicts increased in the 19 years under review also indicated that most conflict incidences were experienced on cropland.

The discussions pointed out several sources of conflict between humans and elephants in the study area. The respondents identified conflict types as Human-wildlife, land tenure, policies, and Institutional conflicts. However, this section put much emphasis on human-elephant conflicts. Conflicts were reported to be very high and perennial on croplands. Elephant were ranked the most problematic (conflict) animal in the study area.

The Chief Executive Officer (CEO) for Rural District Council highlighted the successes of trypanosome-causing agent of human sleeping sickness and trypanosomosis in livestock eradication program in Zambezi valley in the late 70s to early 80s. He further elaborated that the eradication program led to the sudden influx of human settlement and farming activities in the area. Before this eradication program, agricultural activities were very low in the study area. The CEO further pointed increased human-elephant conflict situation in ZiMoZa area since early 80s to date (2008).

Respondents pointed out that farmers in the study area grow crops such as maize, cotton, sunflower, groundnuts, millets, and sorghum on fields of 2-3 ha in size. They all agreed that cultivation was a major source of livelihood. Crop yields were noted to be very low and the discussants blamed poor rains and lack of resources to manage soil fertility. Elephant crop raids were reported to be most problematic just before harvesting, with maize preferred more than other crops. As a result, several communities were reportedly left food insecure after elephants destroyed their crops.

Discussants reported an increase in cultivation area especially under cotton. They ranked cotton as a cash crop doing well in the study area. Farmers were reportedly keen to increase their cultivation land. Cotton produce is sold to generate income that they then use to buy maize, sorghum and other food items in order to sustain their livelihood. It also came out of discussions that there are commercial cotton companies promoting cotton cultivation. These companies engage communities into contract farming by providing them with seeds, pesticides, and extension services. All officials agreed that cotton farming has been increasing for the past two decades and one third of them agreed that cotton production pays better than the economic incentives shared from Community Based Natural Resources Management activities like CAMPFIRE in Zimbabwe and Tchuma tchatu in Mozambique.

Respondents reported crop damages to occur both in the wet and dry seasons, although most incidences occur in the wet season when there are many crop fields. Risky crop raids were reported to occur at night, a situation that makes deterring elephants difficult.

Human-elephant clashes were reported to occur in the study area with serious casualties on both fronts, some communities were reported to team up to retaliate against the elephants, and in some cases, the animal is killed.

According to most respondents, it came out that elephants or small groups of elephants that develop a habit of raiding with time acquire techniques for avoiding deterrents. These elephants usually do crop raiding. The researcher in this study found out through discussions that communities in the study area have developed methods for deterring elephants from their crops. Table 3. shows the human-elephant conflict mitigation strategies used in the study area. These methods were categorised as passive and active methods and few remarks capturing the community prescribed methods' active ingredient.

Table 3: Methods used for deterring elephants from crop raiding in ZiMoZa categorised as passive and active methods.

| | Human-elephant mitigation methods | Remarks |
|---|---|---|
| **Active Methods** | **1) Beating drums and tins**<br>**2) Cracking whips**<br>**3) Yelling and whistling** | **These methods have elements of noisemaking and surprise and it requires people to engage and getting close to the animal.** |
| | **4) Firing catapults and throwing stones**<br>**5) Throwing burning sticks**<br>**6) Spears at the crop-raiding elephants** | **These methods has an element of inflicting pain on the elephant and people have to actively engage themselves** |
| **Passive Methods** | **1. Creating barriers of thorn branches or piles of logs and sticks around the edges of fields**<br>**2. Creating barriers tying bark ropes from tree to tree hanging pieces of white cloth on the rope** | **These methods have a concept of using barrier materials to block elephant entry. The method works without any person actively involved.** |
| | **3. Burning fire**<br>**4. Burning plastics and rubber to create a noxious smoke that deters elephants** | **These methods have an element of fire, light, and smoke. The method works without people actively engaged but has a risk of starting wild fires** |

Most discussants agreed that none of the methods could stop a determined, skilled, and habituated crop raider elephant. However, farmers reported to still use them as they may have some deterrent effect to non-habituated elephants. They also reported that they alternate different methods in order to keep confusing elephants and delay their ability to learn skills of avoiding the control method.

Officials who participated in the discussion highlighted the poor land use planning as one of the factors driving human-elephant conflicts. People were reported to build homes and clear land for cultivation in areas that are known to be elephant home.

## Prediction of human-elephant hot spots based on land cover results, field observations and questionnaire aided survey

Predicted human-elephant conflict hot spot maps were produced for the 1989 and 2008 land cover maps and they are shown in fig 4. The predictions are for the wet season when fields are cropped in the study area.

Fig 4 shows conflict hot spots on land cover maps of 1989 and 2008. The conflict hot spots are those areas with mixed proportion of cultivation, settlements, and water body. The criteria used assumed that elephants are using cultivation, settlements, and water body classes more than other classes in the wet season as observed in field and confirmed through questionnaire-aided discussions. The probability of human-elephant encounters in these classes during wet season is higher as compared to other classes. Figs 4 also show that there is increased likelihood for more human-elephant conflicts in 2008 as compared to 1989, mainly due to increased cultivation and settlement area in 2008 map.

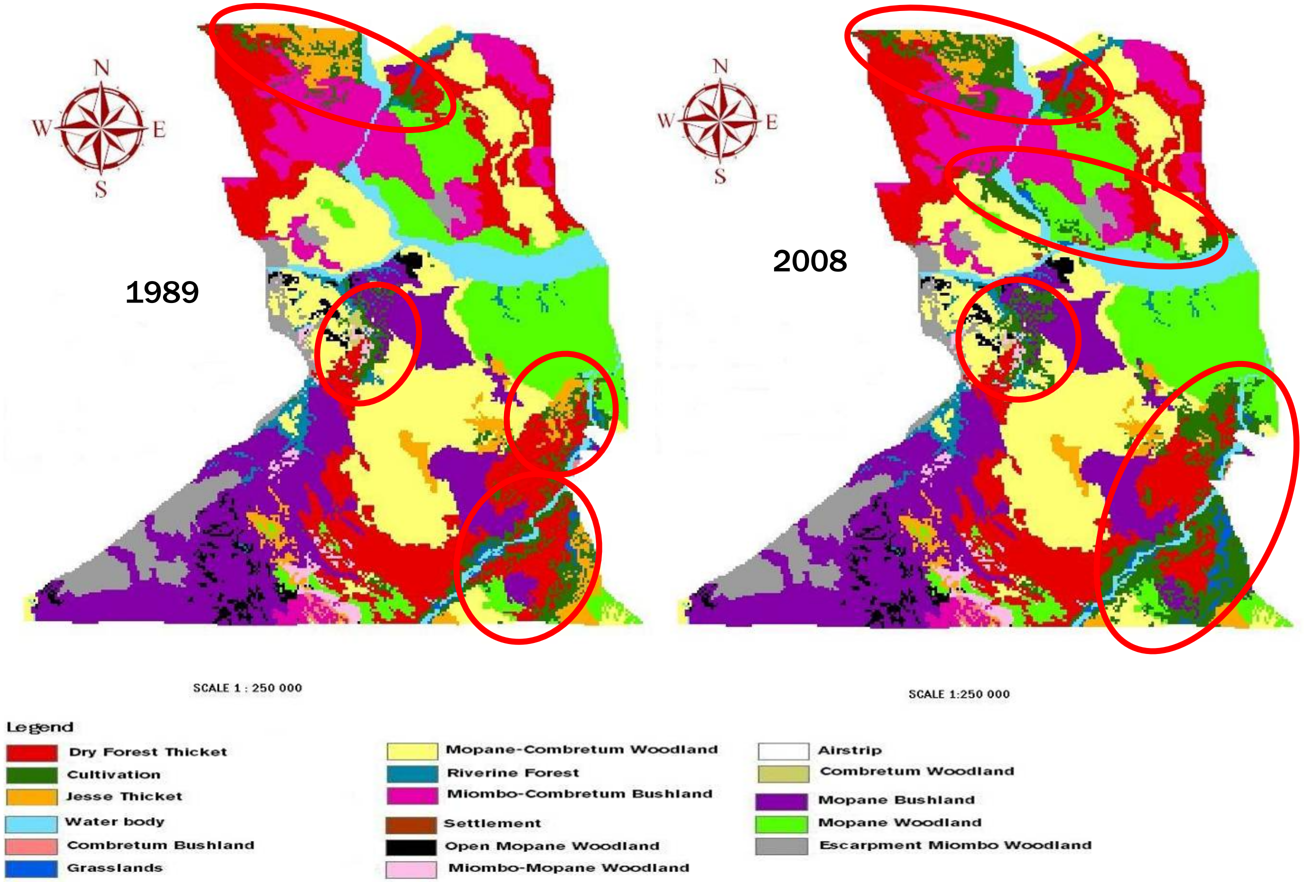
See also appendix V (b) to see the sequence and extent of cultivation changes (for 1989, 2001, and 2008 maps) that occurred on conflict hot spot areas. These maps are extracts of three different communities in Luangwa district (along Luangwa river), Mbire district (along Mwanzamutanda river) and Magoe districts (along Zambezi and Angwa river).

## Community perceptions and their understanding of conservation policies

The land cover change and human-elephant conflicts situation in the ZiMoZa area may indicate policy shortfalls in the area and this section highlights potential policy weaknesses as highlighted by officials interviewed in the study area. See appendix VI for a brief synopsis of all policies mentioned in this section.

The survey indicated that communities in ZiMoZa area perceive natural resources as state property. The respondents pointed out conservation policies that restrict communities to access their natural resources. It was noted through discussions that the three states in ZiMoZa have developed Forestry acts, Parks and Wildlife acts. These legislations largely facilitate the protection of parks and wildlife and they stipulate that parks and wildlife belongs to the state and restricts access for utilization.

Fig. 4. The 1989 &2008 predicted human-elephant conflicts hot spots (coded in red circles) during wet seaso in the ZiMoZa area.




Land parcels with high likelihood of human-elephant encounters defined the conflict hot spots (mixture classes of Settlement, Cultivation, and Water body).

Respondents reported that law enforcement by state agents was uncompetitive and officials cited economic constraints as a major reason for poor law enforcement across the three states. Discussants pointed out poor policy enforcement issues, for example: In Zimbabwe the forestry act, wildlife, and parks act and rural land act, (to mention a few) were amended under the Environmental Management Act (EMA) of 2003, which stipulates that the mandate to enforce this amended act preside with the Ministry of Environment and Tourism. The officials pointed out their perception that Ministry of Environment and Tourism did not have enough capacity to enforce all amended acts under EMA adequately.

It was picked in most of the discussions that existing legislations on land tenure system influence how land is accessed and utilised in the study area. There is customary land that is under the custody and control of traditional authorities in all three states of ZiMoZa. Traditional leaders were reported to have power to allocate land to people in their communities for cultivation and settlement purposes. In this type of tenure system, the discussants pointed out that land belongs to the state and communities have communal ownership rights or user rights. Communal area residents indicated that they do not have legal ownership in form of title deeds but have user rights that are controlled and regulated along traditional or customary law regimes (usufruct system). Zimbabwe Communal land act of 1981 was cited as an example of this type of tenure where state agencies like RDC, National Parks and Agricultural Rural Development Agency (ARDA) manages all state land. In addition, Zambia was reported to have freehold land tenure that gives private titles deeds as 99-year terms leaseholds and it is state's prerogative to issue this type of deeds.

## Power decentralisation on natural resources management

CAMPFIRE, Tchuma tchatu and ADMADE were agreed by most discussants as good initiatives towards natural resources management. However, several officials raised the issue that these initiatives lack clear mechanism that enables communities to start benefiting from their resources.

Some examples used by respondents to illustrate community perceptions include: The three countries strictly prohibit commercial logging under their forest acts and restrict communities from hunting and unwarranted killing of wildlife through wildlife acts. This means that communities cannot have direct benefit from their resources but indirectly through tourism for instance. Tourism projects require initial capital investment but the Community Based Natural Resources Management (CBNRM) policies are not clear on funding such initiatives. Instead, all three countries have legislation that allows controlled exploitation of wildlife in form of safari hunting. The legislations are very strict and only give access to registered Safari operators to hunt.

The legislation is open to any safari operator and does not require the operator to be native to the community, practically meaning that only private operators have rights to use wildlife resources since communities cannot afford to register and administer safari operations. Safari operators are obliged to share their earnings with communities, (for example remitting a certain percentage of earnings to the community).

Most of the discussants were not content with benefits from these CBNRM activities and they perceive agriculture as the only possibility for better livelihood. However, communities still perceive CBNRM activities as potential solution for their livelihood but they feel that power devolution has not yet reached to community levels and they still lack the ability to unlock the potential income from natural resources initiatives.

# Discussion

## Land cover change analysis

This study characterises land cover changes in ZiMoZa area, during the period 1989-2001-2008. It was found that the areas under Dry Forest thicket and Jesse thicket decreased the largest land area, while that of Cultivation and Grassland classes increased the largest area. This means that deforestation is predominantly occurring on Dry Forest thicket, and Jesse thicket classes. The Combretum woodland and Jesse thicket classes decreased dramatically in proportion to their occurrence for the period under review. Interpretation of land cover maps indicates that deforestation was mostly concentrated in areas where Water body and Settlement class coincides and it was preceded by cultivation. This can be clearly seen on settlements along Zambezi river, Luangwa river and Mwanzamutanda river on fig 3 . Deforestation and cultivation increased almost in equal proportions. Moreover, the class transition mechanism was unidirectional, which means that only forest classes were converted to other land cover classes and no forest regeneration or reforestation occurred during the period under review.

Geist & Lambin (2002) highlighted the drivers of deforestation as complex and amongst the list agricultural expansion prevailed. Wood *et al.* (2004) also found agriculture extensification in south central Senegal as a dominant predecessor of deforestation. Cultivation activities are the major drivers of deforestation in the ZiMoZa area and there is high risk of gradual depletion of these forests. This study results therefore agrees with Geist & Lambin (2002) and Wood *et al.* (2004) that agricultural activities are the major drivers of deforestation.

The land cover producer and user class accuracies were reasonably high, the sampled ground truthing points were few which could have affected the overall accuracy. However, the most affected were Escarpment-Miombo woodland, Combretum woodland and Open-Mopani woodland classes. The overall accuracy of 74 percent and a Kappa index of 0.72 indicate low level of map accuracy as compared to other studies (Wilkinson *et al.* 2008, Deng *et al.* 2009, & Thapa *et al.* 2009). The low map accuracy level denies the study to draw conclusive results on the actual extent of land cover changes (Deng *et al.* 2009). There is need to try different classification methods in order to produce maps with higher accuracy levels.

## Human elephant conflicts

### Predicted human-elephant conflict hot spots and the characteristic underlying factors

The finding that deforestation, cultivation, and human-elephant conflicts increased in the study area is worrisome. The conflict maps show conflict hot spots on proximate areas of cultivation, dry forests, settlements, and rivers. Further interpretation of conflict hot spot maps for 1989 and 2008 indicates an increase in cultivation and settlement. This means that the probability of human-elephant conflict incidences increased from the 1989 map date to the 2008 map date.

The map-based prediction of human-elephant conflicts hot spots agrees with the survey results, which indicated that human-elephant conflicts were high in cultivation area. The results further indicated that conflicts were most prominent during the wet season. The following factors: the availability of surface water, the characteristic increase of Cultivation and Settlement from 1989 to 2008 and the increasing human and elephant populations can explain the temporal and spatial occurrence of human-elephant conflict hot spots in the study area.

Human-elephant conflicts could be a function of both surging human and elephant population densities in ZiMoZa. Zisadza & Mandima (2007) reported a 5 percent annual increase of elephant population in ZiMoZa and Earth trends (2003) reported 2.9 percent annual increase of populations in Zimbabwean rural areas. The population increase could be one of the factors fuelling conflict incidences as the probability of conflict occurrence increases with population increase.

Availability of surface water has been widely reported in literature as a one of determinants of spatial elephant distribution. Chamaille-Jammes *et al.* (2007) and de Beers & van Aarde (2008) reported that elephant numbers tend increase close to water sources. Therefore, it can be deduced that, if cultivation and settlements are increasing along water sources while elephant densities are expected to be high close to water sources then the likelihood of conflict occurrence is also high.

The seasonality of human-elephant conflicts in the study area is not new, Jackson (2008) reported elephant crop raiding as a function of season in Botswana. The seasonality of crop raiding in ZiMoZa can be attributed to elephants' response to differences in vegetation and landscape heterogeneity in different seasons. The effect of vegetation and landscape heterogeneity on elephant distribution is widely researched. Murwira & Skidmore (2004) and Chamaille-Jammes *et al.* (2007) found that elephants prefers areas with high vegetation and landscape heterogeneity. In the wet season, the landscape and vegetation heterogeneity indices in cultivated areas is high due to high diversity of crop fields and the abundant surface water, resulting in elephant populations "dispersing" (Kerr & Fraser 1975, Osborne & Parker 2003) into cultivated area. Osborne (2004) also described the seasonal pattern of elephant crop raiding as common and attributed it to declining quality of wild forage or triggered by crop ripening. The results concur with cited authors above in the sense that elephants are likely to be in cultivated landscapes during wet season. This situation further expedites the problem of human-elephant conflict in the study area.

The area predicted to be conflict hot spots agrees with Zisadza & Mandima (2007). They mapped elephant corridors found in ZiMoZa and their corridors overlaps with areas predicted as conflict hot spots in this study. This confirmed that elephant use the mapped conflict areas.

### Underlying factors driving cultivation extensification in areas predicted as human-elephant conflict hot spots.

ZiMoZa area has poor soils and receives low rainfall and only drought tolerant crops can perform well. The results of the land cover change detection analysis and the survey show that cultivation is increasing despite the drought conditions in the study area. The survey results further revealed that some agricultural companies were promoting cultivation by providing cheap farming credit facilities and this could explain why forest conversion to cultivation is increasing in the drought prone ZiMoZa area.

Binswanger (1991) found agricultural credit system as a factor accelerating deforestation in the Amazon and he further advocated for their removal as they create economic distortions, which act as pervasive incentives. Sayer (2005) and Galloway & Stoian (2007) indicated that poor designed policies and perverse incentives increase the rate of deforestation. The provision of pervasive incentives drives cultivation increase and this accounts for why deforestation is increasing in the study area. Expansion of cultivation area results in high human to elephant home range encroachment and this further increase the chances of human-elephant conflict in the study area.

The other factor causing expansion of agricultural area in the study area could be linked to poor farming practices as it was revealed that farmers lack supplementary fertilizers (both manure and artificial fertilizers). The continuous cultivation of the same area without managing soil fertility depletes all soil nutrients, which often result in crop yield reduction. However, the only option farmers have is to increase cultivation land in order to increase yield (Wood *et al.* 2004), this situation leads increased deforestation. Woodhouse (1997) confirms by saying, "Cropland expansion has been a primary method by which Africa's agriculture has been increasing." The finding that cultivation is increasing at the expense of forest in ZiMoZa increases chances of humans encroaching into elephant home ranges and further expedites the human-elephant conflict situation.

The survey results show that cultivation in the study area is a major source of livelihood as compared to conservation programs like CAMPFIRE, ADMADE and Tchuma tchatu. This means that communities prioritise cultivation more than conservation programs and this situation portrays communities' perception on conservation. Hackel (1999), attributed community based natural resource management as a business and communities can easily shift if a better one is to be presented.

However, Richardson (1998) and Sangarwe (1998) established that forest and wildlife utilization strategies potentially yield significantly higher as compared to agricultural land uses. The fact that farmers prefer farming to CBNRM initiatives in the study area clearly indicates that the community is not well informed and they lack the real value appreciation of their natural resources. Deforestation and habitat loss for elephant ranges will keep on increasing, if the potential conservation value keeps locked and with cultivation continuing to pays more in ZiMoZa. The state of human elephant conflicts will continue to escalate until such a point that elephants are displaced in the area.

### Human-elephant conflict mitigation strategies in ZiMoZa

The questionnaire-guided discussions have indicated that human-elephant conflicts are increasing in the study area. Communities adopted some active and passive mechanisms to mitigate the human-elephant conflict situation, which they reported less effective. Sitati & Walpole (2006) revealed that no method was fully effective and most methods are more effective if they used in combinations with a little variation

after a certain period. Sitati *et al.* (2005) also highlighted the importance of using combinations as elephants can quickly learn how to avoid them. However, Sitati *et al.* (2005) discovered that active methods work better than passive barrier methods. This agrees with what respondents pointed out in the study that they use different methods to confuse the elephant and also that no single method was solely effective and, they had to use different methods in combination
Graham & Ochieng (2008) found these community-based methods effective though not different from the control (fields without mitigation strategy employed). The author further indicated that the subjectivity and wide variability of practices limits conclusive research on mitigation methods. Sitati & Walpole (2005) indicated need for further research on efficacy of different methods. Sitati *et al.* (2003) reported that understanding the spatial correlation of human-elephant conflict is useful for deployment of appropriate conflict migration strategies.

## Policy gaps and poor enforcements

The results from this study highlight restrictive (fortress) type of policies as underlying factors contributing towards increased land cover conversion and human-elephant conflicts in the study area. Communities in ZiMoZa are reluctant to support conservation initiatives and instead increase deforestation for cultivation. This agrees with Ravenel & Grandoff (2004) who also described deforestation as a policy problem that has arisen from the failure of the fortress type of conservation. These policies give very little room for adapting to human-wildlife conflicts and its failure attributed to lack of participation of communities in conservation activities (Petrova *et al.* 2009).

The results also indicate that policing of natural resource use is poor in the study area. Meaning that unsustainable use of resources can occur in the area unabated. This concurs with Ravenel & Grandoff (2004). They analysed the commercial illegal logging in the tropics and found that laws that govern forest use often exist but governments lack the capacity to enforce them. Studies by Zisadza & Mandima (1999) and Hoare & Du Toit (1999) also show how incompatible land-use policies in the ZiMoZa area have influenced or compounded the problem of habitat loss (deforestation) through inconsistent settlement pattern and unplanned settlements. However, Aung (2007) advocated for several policies to be re-examined, though the author acknowledged that legal issues of natural resources management are complex and divided between different agencies that often have competing interest.

The institutionalization of land tenure systems at national level and across the ZiMoZa area has generated spatially explicit response in the landscape. Poor land use property rights lacks accountability as reported by McElwee (2004) in Vietnam. Luoga *et al.* (2005) clearly attributed the continued deforestation in the tropics as a sign of failure of common property rights and they advocated for well-defined property rights. Gould (2006) also described common property regimes in economical terms as one of the factors that affect valuation of land and this has a repercussion on how the land is used. The tenure system in the study area should be strengthened a way that increases the resource ownership rights and user rights, so that an economical value can be attached on natural resources.

## Pseudo power devolution

The results highlight the institutionalization of CAMPFIRE, ADMADE and Tchuma tchatu as one of the steps governments in ZiMoZa have taken to decentralise power and ownership of natural resources to communities. These types of initiatives were presented, "as an antidote to the colonial 'fortress conservation' discourse, which undermined people's control over their environment and criminalised their use of game," (Wolmer 2003)
Nyamapfene (1985) also described power devolution under CBNRM initiatives as a way to rationalize fortress type conservation policies, in order to promote community benefit driven conservation (Matzke & Nobane 1996, Mehta & Heinen 2001). The principle of these institutions has not only been reported successful in the countries in the study area but also in other countries where the same principle is used (Wolmer 2003). However, these institutions can be strengthened if real and tangible benefits are given to communities in order to stimulate positive attitude towards conservation (Mehta & Heinen 2001). Murombedzi (1999) declared, "If CAMPFIRE programme is to be effective then a further devolution of authority is required so that producer communities, those who live directly beside wildlife, are given full control of the natural resources on their lands".

The questionnaire-guided discussions illustrated that CBNRM initiatives still lack the mechanism for funding communities to start benefiting from their natural resources through projects like community cooperatives and safari. Meaning that communities have the power over their natural resources in principle but practically they cannot benefit from it due to their limited capital resource. However, van Kooten (2008) noted that African states with elephants lack the financial capacity to fund conservation activities and the author advocated for international support as a potential solution.

The licensing of private actors into the area further takes away the power from communities to private actors. The situation creates a community-private actors dependency syndrome and leaves the success of benefit driven conservation depending on the private actors who in some cases exploit communities. This may have a long-term sustainability problem since conservation is depending on private actors who are business entities and they can move out of the area leaving communities not benefiting from their resource. Therefore, the situation may lead to failure of the concept of benefit driven community management programs (Murombedzi 1999).

# Conclusions and Recommendations

There is need for a paradigm shift on community perception from agricultural oriented livelihood to other income generating activities (O'Connell-Rodwell *et al.* 2000) and, governments, donors and international community should provide a funding mechanism for community empowerment. Empowerment in this case entails capacitating of communities in a way that enable them to unlock the potential value of conservation. Capital injection promoting income-generating projects like safaris, fishing camps, lodges and game drive companies to mention a few will help conserve elephant habitat in ZiMoZa. This way community perception shifts from cultivation extensification to conservation and forest regeneration programs, as they stand to benefit true ownership and tangible benefit from their resources.
In situations of high human-elephant conflicts on cultivation land, O'Connell-Rodwell *et al.* (2000) suggested two interventions; the first was to developing a comprehensive system of crop protection in human-elephant conflict areas as a conflict migration strategy and the second intervention concurred with the above recommendation of replacing subsistence farming with livelihood based entirely on wildlife related revenues.

Land-use planning approaches to human-elephant conflicts should attempt to separate agricultural activities from elephant habitats (Hoare 2000, Sitati 2007) by demarcating areas for cultivation, settlement and wildlife habitats and home ranges or corridors. Communities should participate since they absorb the risk of living with elephants and the best starting point will be through community participatory research, where communities map their resources including settlement, cultivation, wildlife corridors, and vegetation. Communities should carryout cost-benefit analysis identifying landscapes important for conservation, cultivation, and settlement. In other words, communities should be given a chance to design their own proposed land use plan.

Given that this is a Transboundary landscape, there is need for increased sharing of information, open up the political boundary ideology (Wolmer 2003), and prioritise landscape biodiversity conservation. This involves working together to share lessons and expertise, finding common solutions and pooling of financial resources (Hoare 2000). Transboundary management agreements should be instituted with a conservation funding mechanism and member states should be willing to consider developing shared legislation (Wolmer 2003) that seeks to harmonize goals for conservation.
The ZiMoZa concept still lies in the concept phase and lacks the political commitment. The initiative should be give a chance by member states through signing and ratifying the treat. This will set an environment with can answer most of the concerns raise in this research and also increases the chances for securing donor or international funding

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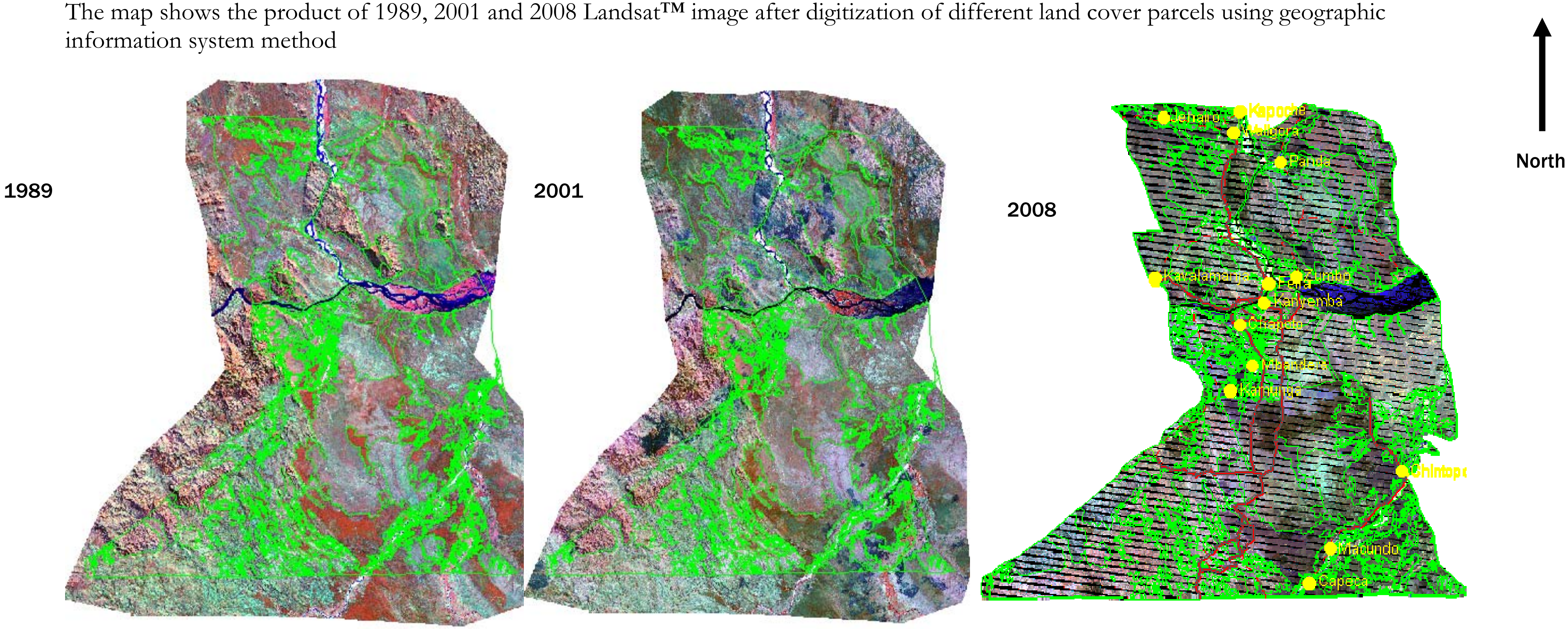
# Appendix I LandsatTM image after digitization

The map shows the product of 1989, 2001 and 2008 Landsat™ image after digitization of different land cover parcels using geographic information system method




Scale 1: 250 000

# Appendix II Classification error matrix for 2008 imaged interpretation

| Interpreted 2008 map | WB | EMW | CW | AS | MCB | CB | DFT | JT | Cult | Sett | RF | Grass | MW | OMP | MCW | MopB | MMW | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WB | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 8 |
| EMW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| CW | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| AS | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| MCB | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| CB | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| DFT | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| JT | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 |
| Cult | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| Settl | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| RF | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Grass | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 6 |
| MW | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 5 |
| OMP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | | 2 |
| MCW | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 4 |
| Mop B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | | 6 |
| MMW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| Totals | 8 | 1 | 2 | 2 | 4 | 2 | 6 | 3 | 9 | 7 | 3 | 6 | 3 | 3 | 2 | 6 | 5 | 72 |
| Producer's accuracy | 75 | 0 | 100 | 50 | 75 | 100 | 67 | 67 | 78 | 71 | 67 | 67 | 100 | 67 | 100 | 83 | 60 | - |
| User's accuracy | 75 | 0 | 67 | 100 | 75 | 100 | 67 | 40 | 100 | 83 | 67 | 67 | 60 | 100 | 50 | 83 | 100 | - |
| Overall accuracy | 74 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Khat | 0,72 | - | - | - | - | - | - | - | - | - | | - | - | - | - | - | - | - |

The table shows the error matrix for the 2008 image interpretation. Escarpment Miombo wood land lacked sufficient data to obtain a producer and a user accuracy value. The lack of data affects the overall accuracy as the calculation included all 17interpreted classes. The interpreted map can only be used with the understanding that land parcel interpretations are 74 percent correct.

# Appendix III Land cover change matrix for the 1989 and 2008 maps

The land cover matrix show that Dry Forest thicket, Jesse thicket, Mopane woodland, Miombo-Combretum woodland and Mopane bushland lost area to cultivation. The table also show that Grasslands gained area from water body, Dry Forest thicket, Jesse thicket and Cultivation. The 383ha converted to Grassland from by 2008 date can be explained in two ways, it was either cultivation land abandoned (under fallow) or cultivation area wrongly picked as grasslands between the two dates. The 94 ha lost to water body could be explained by the differences in water levels between the two dates. The 2008 image was taken in September and the 1989 image was taken in June and usually the month of Septembers is drier that the months of June. Therefore, the observed change could be riverbanks picked as Grasslands.

| 1989 | WB | EMW | CW | AS | MCB | CB | DFT | JT | Cult |
|---|---|---|---|---|---|---|---|---|---|
| WB | 11 494 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| EMW | 0 | 12 085 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CW | 0 | 0 | 277 | 0 | 0 | 80 | 0 | 0 | 8 |
| AS | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 |
| MCB | 0 | 0 | 0 | 0 | 21 330 | 0 | 0 | 0 | 764 |
| CB | 0 | 0 | 0 | 0 | 0 | 398 | 0 | 0 | 121 |
| DFT | 182 | 0 | 0 | 0 | 0 | 0 | 43 006 | 0 | 3896 |
| JT | 0 | 0 | 0 | 0 | 0 | 0 | 89 | 7 193 | 3381 |
| Cult | 96 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 271 |
| Sett | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RF | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 190 |
| Grass | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 123 |
| MW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1160 |
| OMP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MCW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2308 |
| Mop B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1046 |
| MMW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2008 total | 11 792 | 12 085 | 277 | 22 | 21 330 | 478 | 43 096 | 7 193 | 24 268 |

WB (water body), EMA (escarpment-miombo woodland), CW (combretum woodland), AS (airstrip), MCB (miombo-combretum bushland), CB (combretum bushland, DFT (dry-forest-thicket, JT (Jesse thicket, Cult (cultivation), Sett (settlement), RF (riverine forest), MW (mopani woodland), OMP (open mopane woodland), MCW (miombo combretum woodland), MopB (mopane bushland) and MMW (Miombo mopane woodland)

## Appendix III continued…

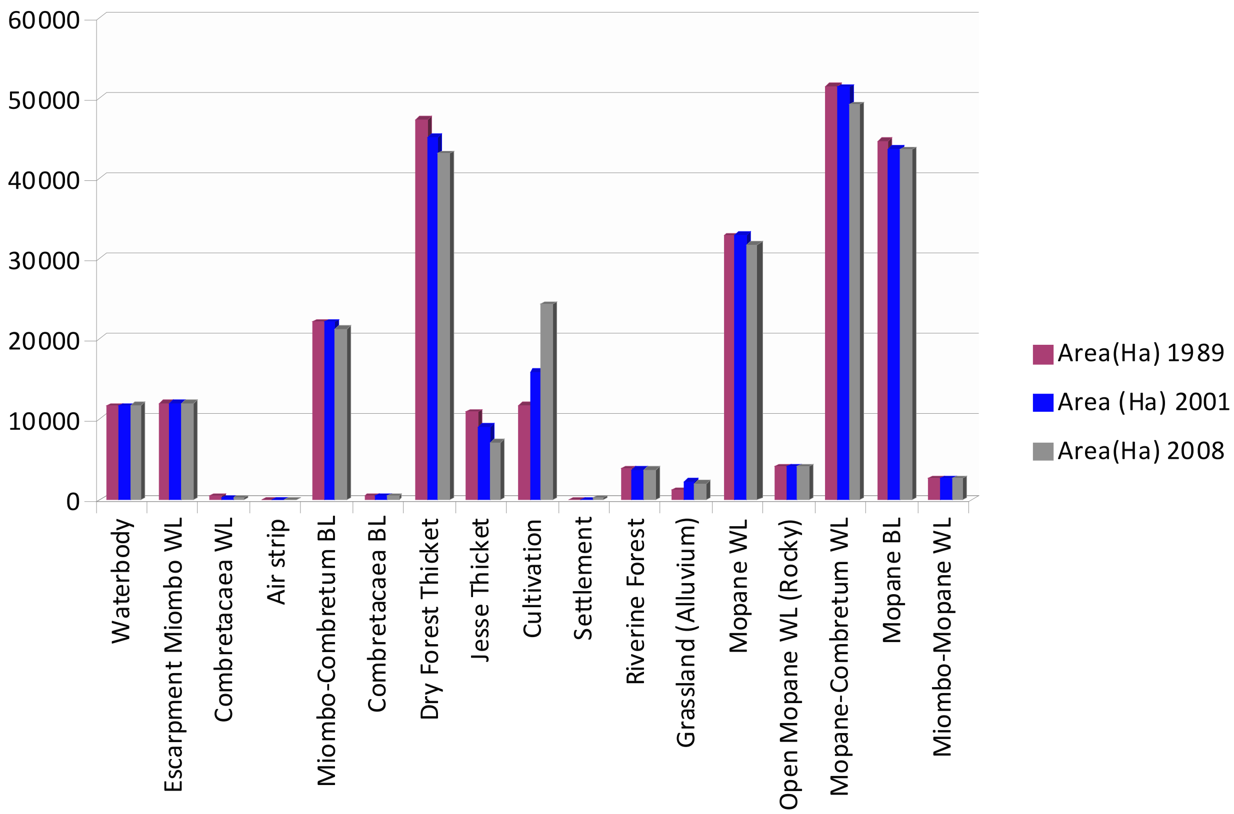
| | Sett | RF | Grass | MW | OMP | MCW | MB | MMW | 1989 total |
|---|---|---|---|---|---|---|---|---|---|
| WB | 0 | 0 | 194 | 0 | 0 | 0 | 0 | 0 | 11 688 |
| EMW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 12 090 |
| CW | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 431 |
| AS | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 23 |
| MCB | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 58 | 22 178 |
| CB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 519 |
| DFT | 127 | 0 | 119 | 0 | 0 | 0 | 0 | 0 | 47 331 |
| JT | 0 | 0 | 254 | 0 | 0 | 0 | 0 | 0 | 10 917 |
| Cult | 0 | 0 | 383 | 0 | 0 | 0 | 0 | 0 | 11 750 |
| Sett | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 |
| RF | 0 | 3 719 | 0 | 0 | 0 | 0 | 0 | 0 | 3 909 |
| Grass | 0 | 0 | 1 125 | 0 | 0 | 0 | 0 | 0 | 1 268 |
| MW | 20 | 0 | 0 | 31 709 | 0 | 0 | 0 | 0 | 32 889 |
| OMP | 0 | 0 | 0 | 0 | 4 086 | 0 | 0 | 0 | 4 086 |
| MCW | 0 | 0 | 0 | 0 | 0 | 49 097 | 0 | 0 | 51 405 |
| Mop B | 0 | 0 | 0 | 0 | 0 | 0 | 43 587 | 0 | 44 632 |
| MMW | 0 | 62 | 0 | 0 | 0 | 0 | 0 | 2 576 | 2 638 |
| 2008 total | 252 | 3 781 | 2 077 | 31 709 | 4 086 | 49 097 | 43 587 | 2 638 | 257 768 |

WB (water body), EMA (escarpment-miombo woodland), CW (combretum woodland), AS (airstrip), MCB (miombo-combretum bushland), CB (combretum bushland, DFT (dry-forest-thicket, JT (Jesse thicket, Cult (cultivation), Sett (settlement), RF (riverine forest), MW (mopani woodland), OMP (open mopane woodland), MCW (miombo combretum woodland), MopB (mopane bushland) and MMW (Miombo mopane woodland)

# Appendix IV Dominant land cover classes

Shows that Mopane-Combretum woodland, Mopane bush land, Mopani woodland and Dry Forest Thickets were the dominant land cover classes in the study area. It also shows the pattern of land cover change in hectares for the period under review. Jesse Thicket and Dry Forest thicket lost the largest area during the period under review.

Figure The distributions of land cover classes in the ZiMoZa area and the changes detected (in hectares) on 1989, 2001, and 2008 maps.



# Appendix V Change map for land cover change between 1989-200 and 2008

Figure (a) Change map showing the temporal sequence and the location of land cover changes on a temporal scale for dates 1989-2001 and 2008.

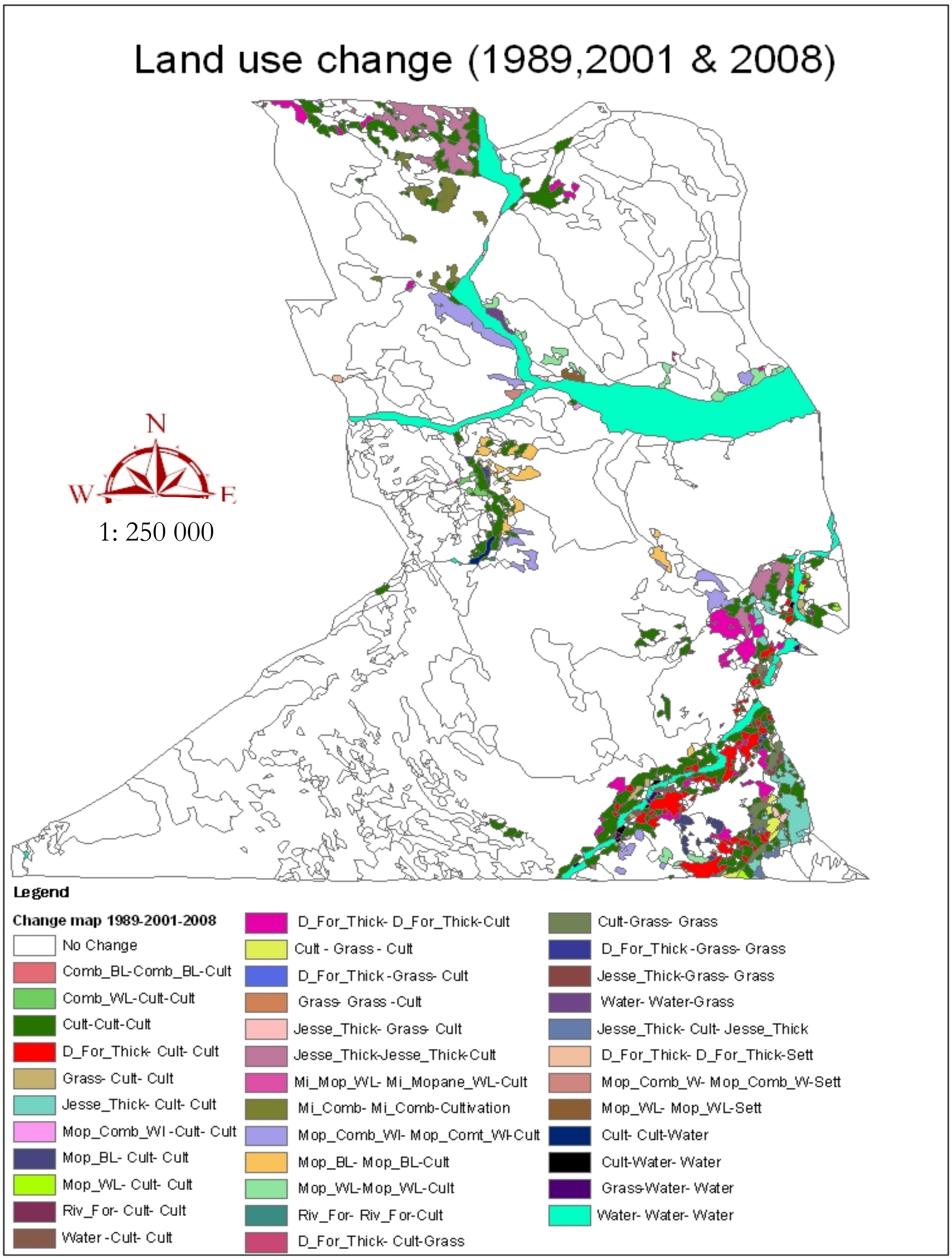
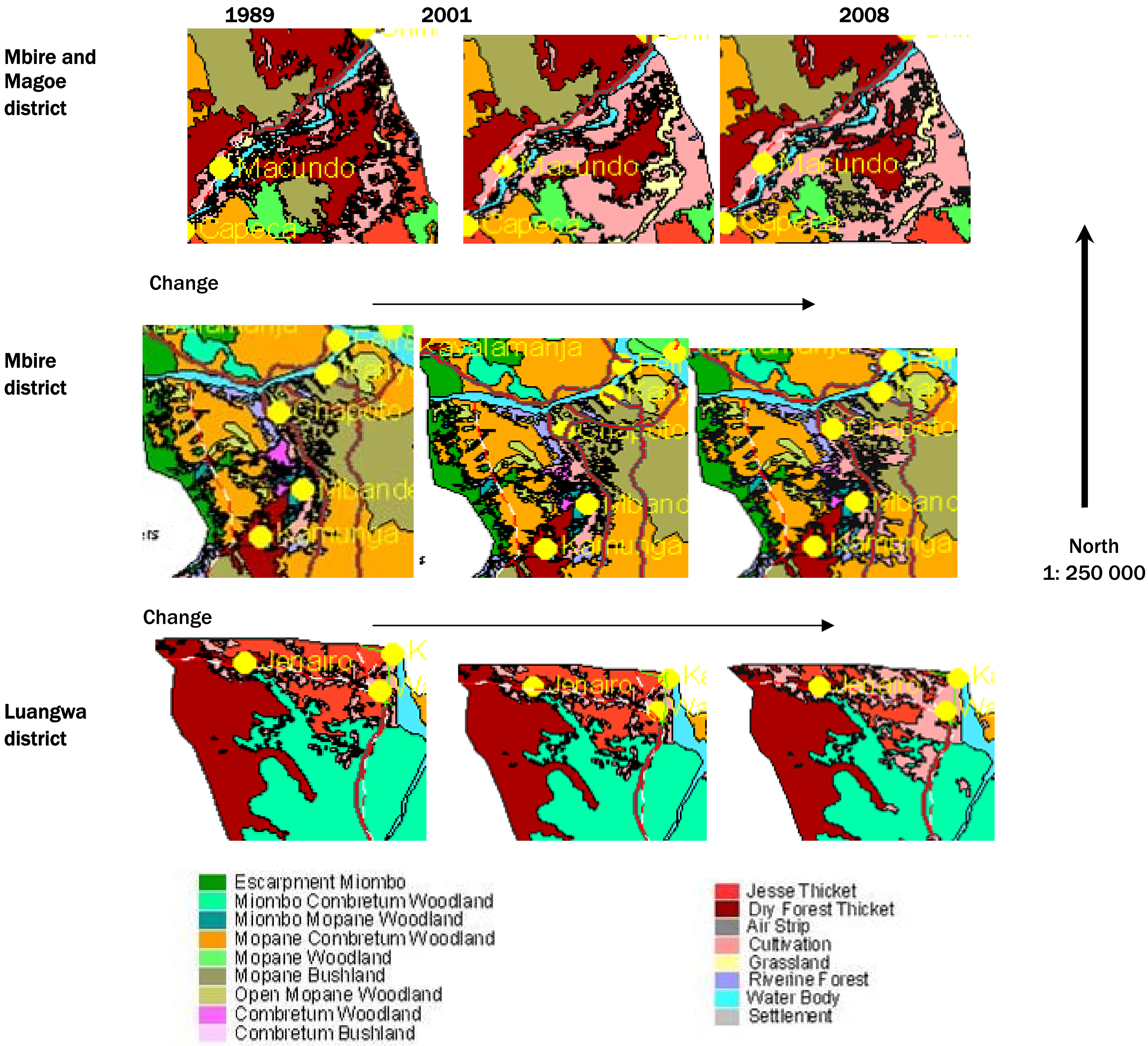



Figure (a) show the systematic temporal sequence of events that occurred on the classes until their 2008 state (step-by-step change analysis). Particular interest is in the

Dry Forest thicket and Jesse thicket, which decreased largest areas. Most of the Dry Forest thicket classes ended up as cultivation classes by 2008 though very small proportion were converted to Grassland and Settlement classes by 2008. Jesse thicket also lost most of its area to cultivation with a small proportion converted to grasslands. However, settlement class predominantly came from Mopane woodland class. There was no forest class regenerated over the period under study.

Figure (b). Potential human-elephant conflict hot spot map extracts of ZiMoZa showing the temporal sequence (1989-2001-2008) and the extent of land cover changes in areas predicted to be human-elephant conflict hot spots.




The maps in appendix V (b) shows the increasing cultivation class in areas predicted to be human-elephant conflict hot spots.

# Appendix VI: Synopsis for reviewed conservation Policies in ZiMoZa area

Each member state has its own government and sovereign rights to develop and adopt policies that best serve them. Zimbabwe and Zambia were former British colonies and most of their policies were adopted from the British system while Mozambique is a former Portuguese colony and adopted Portuguese policy system. Brief overviews of important policies that have an implication on biodiversity management and conservation for each country are carefully outlined in this appendix.

## Zimbabwe

Environmental Management Act [Chapter 20:27] – the EMA aims to provide for sustainable management of natural resources and protection of the environment, the prevention of environmental degradation and plans for the management and protection of the environment. EMA is fussed with a number of different acts amended to it, in which some of the acts are described below. The Minister of Environment and Tourism oversees the implementation of EMA.

Forest Act [Chapter 19:05] – this provides for the protection of private forests, trees and forest produce and to provide for the conservation of timber resources and the compulsory afforestation of private lands. Amended by EMA (Chapter 20:27).

Agricultural Land Settlement Act [Chapter 20:01] – allows for the lease of agricultural land by public authorities in the framework of development of agriculture and the control on the use of land. Amended by EMA (Chapter 20:27) 01 July 2005.

Communal Land Act [Chapter 20:04] – this act aims to alter and regulate the occupation and use of Communal Land. Communal land is land which before the 1st of February 1983 was tribal Trust Land in terms of the Tribal Trust Act, 1979 [Act No. 6 of 1979]. It states that all Communal Land is vested in the president who can permit it to be occupied. It further states that no person shall occupy Communal Land unless he acquired right to do so before 1$^{st}$ February 1983, and has obtained a permit to do so, or is related to a person who occupies or uses communal land. However, for agricultural purposes the RDCs are empowered to allocate land. Amended by EMA (Chapter 20:27) 01 July 2005.

Parks and Wildlife Act [Chapter 20:14] – safari areas are established to preserve and protect natural habitat and the wildlife therein (sect. 35). Mainly controls protected areas and wildlife utilization in such area—sections 44 to 47 deal with hunting of and trading in specially protected animals and with trophies. Amended by EMA (Chapter 20:27).

Rural Land Act [Chapter 20:18] – this act concerns rural land. This provides for the control of the subdivision and lease of land for farming or other purposes, limiting the number of pieces of land that may be owned by any person and the sizes of such land. Amended by EMA (Chapter 20:27) 01 July 2005.

## Mozambique

Environmental Act of July 1997 – it aims at defining the legal basis for the proper use and management of the environment and its elements in order to establish a system of sustainable development in Mozambique, this includes the principles of rational utilization and management of environmental elements.

Order No. 23.087 establishing hunting closed seasons and authorized species to be caught Forest and Wildlife Act, No. 10/99 – establishes the basic principles and norms for the protection, conservation, and sustainable use of forest and wildlife resources under an integrated management framework. In 2002, the Forestry and Wildlife Regulation of the Law approved, seeks to place forest concessions on a more secure footing, and gives greater rights and benefits to local people.

Land Act No. 19/97 – this act regulates ownership of the land and public domain, the right of use and benefit of land, powers, and responsibilities of the concerned public bodies.

Decree No. 7/778 - regulating hunting activity – the decree regulates hunting activity within the Mozambican territory. It includes sanctions for unauthorized hunting in prescribed domains.

Order No. 117/78 regulating hunting activity – the order specifies hunting activity requirements in detail. It defines type of hunting activities to be done and regulates killing of wildlife animals. This includes controls and sanctions for unauthorized hunting and gives restrictions to protected animals.

Order No. 398/73 establishing hunting seasons, quantity, and species permitted to be caught – this order establishes hunting seasons, quantity, and species permitted to be caught. It regulates hunting activity, specifying closed seasons (according to the animal species), protected animal species, quantity and species permitted to be caught, special restrictions, geographical limits of hunting areas, *e.t.c.*

## Zambia

Zambia Wildlife Act [Act No. 13 of 2001]

Charcoal (Prohibition of Exportation) Order, 1999. (S.I. No. 99 of 1999) – the order completely prohibits the exportation from Zambia of any charcoal, although it is silent about trade within Zambia.

Forests Act 1999 (Act No. 7 of 1999) – to provide for the conservation and use of forests and trees for the sustainable management of forest ecosystems and biological diversity.

National Parks and Wildlife Act (No. 10 of 1991) – it provides for the establishment of control and management of National Parks and for the conservation and protection of wildlife. It also makes provision for the creation of wildlife reserve areas, the administration of wildlife, hunting of wild animals, the protection of wild animals, and the trade in trophies and meat of wild animals.

National Parks and Wildlife (Methods of Hunting) (Restriction) Regulations – these regulations impose restriction of use of firearms for hunting, the use of compound longbow and crossbow, and the use of dogs for hunting.

National Parks and Wildlife (Elephant and Rhinoceros) Regulations – the regulation prohibits the hunting of elephant and rhinoceros throughout Zambia and cancels all licenses to hunt elephant and rhinoceros and it also bans and prohibits trade in ivory.

National Parks and Wildlife (Game Animals) Order – this order prohibits the hunting of any animal specified as 'game animals' throughout Zambia.

# Appendix VII: Field observation form

| Image | Date |
|---|---|
| Test Site Number: | Field Team: |
| Map sheet No. (1:50k): | Image Interpreter: |
| UTM X: | UTM Y: |
| Relief Position | Slope Inclination (%): |
| Altitude (MSL): | Aspect: |
| Interpreted Woody Cover | Ground Truthing Results |
| Forest plantation | Forest plantation |
| Grassland | Grassland |
| Irrigation | Irrigation |
| Woodland | Woodland |
| Bushland | Bushland |
| Cultivation | Cultivation |
| Water body | Water body |
| Rock outcrop/mine dump/quarry | Rock outcrop/mine dump/quarry |
| Riverine | Riverine |
| Wooded grassland | Wooded grassland |
| Settlements/built-up area | Settlements/built-up area |
| Clear felling | Clear felling |
| Natural moist forest | Natural moist forest |
| Canopy cover | Canopy cover |
| Tree height | Tree height |
| Total vegetation cover | Total vegetation cover |
| Dominant vegetation type (spp) | Associated spp (list abb) |

# Appendix VIII: List of organisations formally interviewed

Zimbabwe (Mbire District):

- Mbire Rural District Council (RDC)
- Game scout for Mbire RDC-Communal Area Management Program for Indigenous Resources (CAMPFIRE) programme
- CAMPFIRE project in Kanyemba Zimbabwe
- Agricultural Extension Officer for Agricultural Technical and Extension Services (AGRITEX)
- Cotton Companies
- National Parks and Wildlife Management Authority (NPWMA)
- National Parks and Wildlife Management Authority (NPWMA)

Mozambique (Magoe District):

- Traditional community administration office, Bawa and Magoe
- Game Scout for Tchuma tchatu programme in Magoe and Bawa

# Appendix IX: Questionnaire guided discussion

Vegetation Change and Habitat deterioration and its ecological effect on large mammals in ZiMoZa area.

**Introduction**

The human population of Africa continues to grow and the need to clear land and forests for cultivation, settlement, timber, and wood-uses will keep on escalating resulting in a persistent threat to habitats. Over the past two decades, there have been several policy changes, which may have influenced the rate of vegetation change and habitat deterioration. Wildlife habitats in the Zimbabwe, Mozambique, and Zambia Transboundary Natural Resource Management Area (ZIMOZA TBNRM Area) are identified to be threatened largely by deforestation. Possibly, because of forest clearance for agriculture, timber, fuel wood, and uncontrolled flush fires set by poachers.

**Objective 1:** To map out the causes and extent of vegetation change and habitat deterioration in the project area.
**Objective 2**: Establish the extent of human wildlife conflicts, with special emphasis on social and political factors.
**Objective 3.** Understanding community perceptions on the role of policy in conservation

Administered by............................................................
Name......................................................                                Sex......................
Job Title......................................................

Section A. Mapping Human-Wildlife conflicts
Question 1. Rank which animals are problematic and list them according to severity.

Question1.2 List types of problems

Question 1.3 How often does the problem occurs and highlight severity

Question 1.4 In general is it easy to hunt or to see wild animals in your area these days, compare with history.
1. Yes                                2. No Why

Question 1.5. When do you anticipate these problems (discuss season)

Question 1.6 Methods of mitigating human wildlife conflicts

Section B. Mapping Vegetation change via community common practices
Question 2. Area under cultivation, tick the estimated area

| | | Average Size of land cultivated by a family today | Size of land cultivated by a family fifteen years ago |
|---|---|---|---|
| 1 | Less than half hectare | | |
| 2 | 0,5 – 1 hectare | | |
| 3 | More than 1 hectare | | |

Explain/Narration
Question 2.1 Is it common practice that sons are allocated new stands and field to plough when they get married 1. Yes 2 No

Question 2.2 What is the general land area allocated for stand..................., and field to plough............................... per family.

Question 2, 3 Do people burn forests
1. Yes 2. No
If yes why

Question 2.3 Where is the land coming from

Section C. Vegetation change via economic changes
Question 3.1 Do you have people coming from cities or other areas allocated stands and fields.
1. Yes 2 No

Question 3.2 If yes at average how many families per year are resettled in your area......

Question3.3 Is the number decreasing or increasing in past ten years
1. Increasing 2. Decreasing

Question 3.4 What are the causes of migration?
1. Economic 2 Holiday 3. Retirement
4 Other.............................

Question 3.5 Distance walked fetching firewood ten years ago................. and that you are walking today................

Question 3.6 If the distance changes, why?

Question 2.8 Are there laws that regulates natural resources access
1. Yes 2. No
If yes, list them
Enforced by police customary or community
1...........................................................................................................................................
Which ones are working
Why…….