INFLUENCE OF CBNRM STRATEGIES ON NATURAL ECOSYSTEMS: THE MANAGEMENT OF ANTHROPOGENIC DISTURBANCE

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Abstract

Livelihoods of many people are dependent on forest products and therefore anthropogenic disturbance cannot be excluded from such ecosystems. There is evidence that human activities result in dramatic changes in the structure and composition of ecological communities either through species loss, introduction of exotics, or increase in invasive species. In addition, it has been claimed that the greatest threat to ecosystems is simplification and total loss through land use conversion which often results in patchy landscapes.

CBNRM strategies are initiated to manage and guide human behaviour so as to minimise perturbation of ecosystems. Therefore, this paper seeks to present findings of a research that sought to investigate if CBNRM strategies such as commercialisation and institutional arrangements had indeed managed to reduce the impacts of anthropogenic disturbance on ecosystems and improved their conservation status. In summary, there is very little evidence from this research to suggest that commercialisation of NTFPs has improved ecosystem conservation in Zimbabwe. However, results from this study do suggest that the success and strength of institutional arrangements contributed to ecosystem conservation by reducing the scale of anthropogenic disturbances.

1. Introduction

Local people rely on products, goods and services from natural resources, thus their management and conservation is of paramount importance. Conservation has been described by Redford and Richter (1999) as 'the management of human use of the biosphere so that it yields the greatest sustainable benefit to current generations whilst maintaining its potential to meet the needs of the future generations'. Therefore conservation encompasses preservation, maintenance, sustainable utilisation, restoration enhancement (Redford & Richter, 1999).

The failure of the 'fence and fine' approach of protected areas' led to the adoption of community based natural resources management (CBNRM) or integrated development and conservation programmes (IDCP) as new biodiversity conservation strategies. The linkage between development and conservation still remains obscure (Haung *et al.*, 2002). These approaches have been adopted as a way of providing local people with environmentally sound and economically sustainable alternatives to destructive land use (Kremen *et al.*, 1994). The main argument for CBNRM is that provision of benefits derived from conservation increases local support for both environment and local people.

Understanding sustainable exploitation of NTFPs, as a means of achieving the complementary objectives of natural forest conservation and income generation for rural dwellers, has been the topic of substantial debate (Mahapatra & Mitchell, 1997; Olsson & Folke, 2001). It has been suggested that forest conservation can no longer be dealt with in isolation but needs to be an integral component of the socio-economic development process (Den Hertog & Wiersum, 2000). However, while this view may seem sensible, the integration of ecosystem conservation and community development is currently being viewed with increasing scepticism, and its effectiveness is being questioned (Salafsy & Wollenberg, 2000; Haung *et al.*, 2002). Some view protection of natural ecosystem as the primary goal, and development as a means to achieve this (the 'biocentric' view), while others view the viability of local communities (community well being) as being the primary goal with conservation being the means to achieve this end (the 'anthropocentric' view) (Mihaeliu *et al.*, 2002).

Successful commercialisation of NTFPs can be described as one that improves the well-being of the community and enhances or maintains the quality and quantity of the resource. However, this is heavily dependent on the existence and effectiveness of institutions governing the use of the resources as much as the type and status of the resource base. Conservation implies restraint by resource users, and as such biodiversity protection will only take place through institutions such as laws, organisations or cultural practices that control behaviour (Kellert *et al.*, 2000; Brechin *et al.*, 2002).

Harvesting almost inevitably involves disturbance of some kind, and ecologists recognise that disturbance is an important agent shaping ecosystem structure, function and controlling species diversity, and promoting system renewal (McIntyre & Hobbs, 1999; Larsen *et al.*, 2005). If the intensity of disturbance is high or protracted, eventually it leads to habitat destruction. Indeed, it is well known that some human activities result in irreversible loss of species and are the major agents of landscape alteration (McItyre & Hobbs, 1999), but still the effects of environmental changes on species composition, diversity and ecosystem functioning are poorly understood (Larsen *et al.*, 2005).

Managing for ecological integrity has also been described as the protection of total native diversity (species, populations, ecosystems) and their ecological patterns and processes that maintain the biodiversity (Grumbine, 1994). As such ecosystem conservation requires consideration of the three primary attributes of ecosystems: composition (identity and variety), structure (physical organisation or pattern of a system, habitat complexity within communities, pattern of patches at landscape level) and function (ecological and evolutionary processes including gene flow, disturbances and nutrient cycling), these determine and constitute the biodiversity of an area (Noss, 2000). Even though promoting or maintaining a diversity of functionally equivalent species in ecosystems enhances their resilience. The capacity of ecosystems to recover from disturbance in species composition and to maintain the original species function in a functional group is not the same in all respects (Walker, 1995).

This study sought to investigate the contribution made by the commercialisation of NTFPs and local institutional arrangements to the conservation of ecosystems. The work focused on baobab oil, marula oil and makoni tea from *Adansonia digitata*, *Sclerocarya birrea* and *Fadogia ancylantha* respectively. Investigations were made as to whether i) successful commercialisation enhanced conservation of the ecosystem in which the resource was found and ii) institutional arrangements had improved conservation of natural resources.

2. Methodology

2.1 Study sites

The research was conducted in Zimbabwe, specific study sites being five districts from two of the ten provinces. From Manicaland Province was Chimanimani (ward 20), Makoni (ward 10) and Nyanga (ward 23) and from Mashonaland Central Province was Centenary (ward 2) (commonly known as Muzarabani) and Rushinga (ward 2) (Figure1). Wards in Zimbabwe are administrative units containing at least 1000 households from six villages, though resettlement areas have slightly more and smaller villages than communal areas. In each ward, two to seven villages (depending on their size) were selected to participate in the research.

2.2 Site selection

This research was undertaken in several villages which were participating in on-going enterprise development programmes facilitated by a regional non-governmental organisation (NGO), SAFIRE in Zimbabwe. The organisation operates in six of the ten provinces covering more than 30 districts. In all these areas the major focus is the enhancement of livelihoods and empowerment of local people to use natural resources sustainably. One of the strategies used by this organisation was to facilitate the development of small scale enterprises with a conscious strategic focus on non timber forest products, but also including agricultural commodities, minerals and water. In three of these five study areas the regional NGO had facilitated the establishment of small scale enterprises through skills development, technology transfer, marketing, product development and micro financing.

2.3 Study site description

2.3.1 Biophysical characteristics

Zimbabwe has been classified into six ecoregions (Central, Eastern Highlands, Kalahari, Open Water, Save-Limpopo, Zambezi) using the ecosystem land classification scheme adapted from the North America approach. This scheme considers a wide range of factors including, soils, vegetation, geology, and altitude rainfall and many other factors (Marshall *et al.*, 1996). The study sites were found in three of these ecoregions.

Chimanimani district is in the Eastern highlands and the Save-Limpopo ecoregions. This study was undertaken in the Save-Limpopo ecoregion which covers 20% of the country and is characterized by low rainfall and high temperatures. Vegetation varies from tree savannah on deep fertile soils to shrub savannah on shallower soils. The most predominant vegetation are *Colophospermum mopane, Adansonia digitata* and several *Combretum* and *Acacia* species (Chenje *et al.*, 1998).

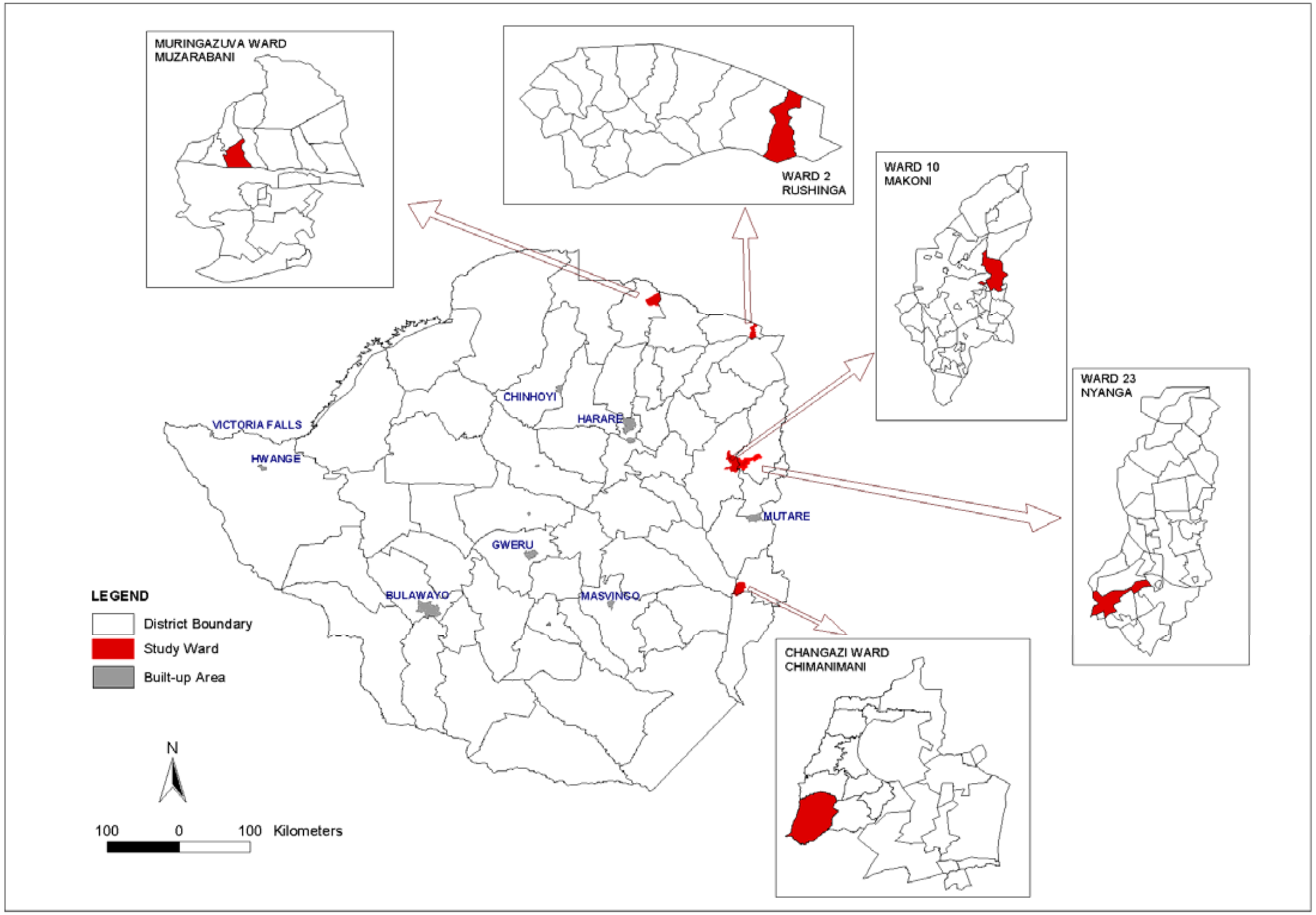

Figure 1. Location of study sites in Zimbabwe.

Muzarabani and Rushinga are located in the Zambezi ecoregion which covers 16% of the country. Vegetation in this ecoregion is xerophytic tree and shrub savannah dominated by *Colophospermum mopane,* and species of *Combretum, Sterculia* and *Acacia* genus (Chenje *et al.*, 1998). This is one area with the most diverse wildlife and for a long time acted as a natural wildlife corridor owing to low human densities and many perennial rivers that empty into the Zambezi.

Makoni and Nyanga districts are located in the Central ecoregion which covers 50% of the country comprising of the main watershed and covering all the major cities. However part of Nyanga district is in the Eastern Highlands ecoregion but this study was conducted in a ward falling in the former. The dominant vegetation in the Central ecoregion is the dry Zambezian miombo woodland with *Brachystegia spiciformis* and *Julbernardia globiflora* as the dominant species. As the rainfall declines in the southerly and northerly directions the woodlands becomes predominantly savannah dominated by several *Combretum* and *Acacia* species. The ecoregion is the agriculturally most productive part of Zimbabwe and besides gazetted protected areas there is limited habitat for wildlife (Chenje *et al*., 1998).

2.3.2 Livelihood activities

Zimbabwe is an agriculturally based economy and livelihood strategies are greatly influenced by rainfall patterns. In the Muzarabani and Rushinga the major crop grown was cotton and to a lesser extent maize (Chenje *et al*. 1998). Many people in these districts were engaged in selling indigenous fruits especially *Ziziphus mauritiana*.

Makoni and Nyanga are located in markedly cooler areas of high rainfall. Major livelihood activities in these areas were the production of horticultural crops, fruits, maize and tobacco (Chenje *et al*. 1998). In addition, some of these people were involved in the collection and selling of forest products, and they were the first in Zimbabwe to produce a herbal tea on a commercial basis from the annual herb, *Fadogia ancylantha.*

Chimanimani further down in the southern lowveld is inherently hot and dry and the only suitable grain crops are small grains, millet and sorghum (Chenje *et al*., 1998). This is one of the areas that suffer from crop failures most years. The people of lowveld Chimanimani depend mainly on irrigated crop production, and the sale of fruit and crafts from the baobab tree.

2.3.3 Commercialisation of NTFPs

Based on a study conducted by the author (Sola, 2005), the study sites were classified according to the level of commercialisation in that area. In this study it was shown that enterprises based on the exploitation of NTFPs were operating along a continuum of commercial activities which vary according to degree of processing, profitability and organisational complexity (level of commercialisation). The less developed commercial ventures are likely to have different outcomes for livelihoods and ecosystems from the more developed ventures. These outcomes may vary not only in type and form but in magnitude and sphere of influence (individual, household and community) (Sola, 2005). Key issues assesed in this study were the business organisation, business operations, raw material supply and business returns. The level of commercialisation for each of the five sites is detailed in Table 1.

2.3.4 Institutional arrangements

A study by the author (Sola, 2005) agued that much discussion has been undertaken about the status of institutions in southern Africa, and the whole world over, but very few rigorous studies have been documented which begin to make comparisons between their structure and function (Barret *et al.*, 2005). In this study a critical analysis of literature suggested four key determinants of viability of institutional arrangements:

i) **Existence of a natural resource management unit** with authority and the ability to restrict access and use (Bromley, 1994; Kremen *et al.*, 1994; Gibson & Koontz, 1998; Ostrom, 1999; Barret *et al*., 2001).
ii) **Existence of institutions** which were defined as taboos, local norms, provisions of local and central government instruments (North, 1990; Ostrom, 1990; Becker & Ostrom, 1995; Leach *et al.*, 1999; Metha *et al.*, 2001; Olsson & Folke, 2001)
ii) **Management of human behaviour** focusing on enforcement and conflict management (North 1990; Ostrom, 1990; Arrow *et al.*, 1995; Becker & Ostrom, 1995)
iv) **Natural resource management strategies** which encompasses incentives for sustainable use and strategies for resource enhancement (North, 1990; Bromley, 1994)

Table 1. Status of commercialization and institutional arrangements in the study sites

Site	Commercialisation of NTFPs					Status of institutional arrangements
	Product	Level of organisation	Level of processing	Period of operation (years)	Level of commercialisation	
Chimanimani	Baobab fruit	Individual	Collection and selling	>50	Low	Medium traditional and medium RDC (medium)
Makoni	Makoni tea	Individual	Collection, fermentation and selling	2	Low	No traditional and strong RDC (high)
Muzarabani	Marula oil	Wadzanai SSE	Buying of kernels, expressing oil and selling	4	Medium	Medium traditional and weak RDC (medium)
Nyanga	Makoni tea	ITPA SSE	Collection, fermentation, crushing and selling	4	High	No traditional and strong RDC (medium)
Rushinga	Marula oil	Kubatana SSE	Buying of kernels, expressing oil and selling	3	Medium	Strong traditional weak RDC (low)

Based on these four determinants or characteristics, levels of successes and strength of institutions were assessed in the five sites/institutions and the status is presented in Table 1.

2.4 Materials and methods

2.4.1 Evaluation of changes in ecosystem composition and structure

Data on ecosystem structure and composition were collected during two visits to each site between March – May 2004 and January 2005. In order to provide a sampling framework for study sites, the main road (road connecting village to growth point or major business centre) was used as the sampling frame. The distance covered by the road cutting through each site was used to evenly locate line transects placed perpendicular to the road at every one or two (depending on distance) kilometre point alternately in opposite directions. Ecological surveys using the line transects were then conducted in each study site to determine species diversity and composition as well assess the extent of anthropogenic disturbance. Transects were between two and five kilometres long and traversed the major land uses in the area which typically comprised settlements close to the road, followed at increasing distances from the road by crop fields and eventually woodlands.

Along each transect sample plots were systematically sampled at intervals of 500m and 250m in the first and second sampling period respectively. Sample plots were $100m^2$ circular plots marked using a 5.64m string. In total 39 transects, with 211 plots covering 0.211ha were surveyed (Table 2). In each plot woody plants were assessed for species occurrence and diameter at breast height (DBH) i.e. diameter at 1.3m from the ground (for trees >2m height). All measurements were captured in a record sheet. Fruit trees (*Adansonia digitata* and *Sclerocarya birrea*) were assessed in larger plots of 50m radius marked using a Range Finder. For *Fadogia ancylantha* data captured included, occurrence, height, number of stems and leaves.

Taxonomic identification was based on publications by Van Wyk and Van Wyk (1997) and Carruthers (1997). Transects and sampled plots were tracked and marked by a Global Positioning System (GPS). The gradient of land use from settlement to forest was not continuous with distance from the road, but patchy. Because of this, each sampled plot had to be independently evaluated for anthropogenic disturbance. This evaluation was based on a visual assessment and recorded as follows:

Low level of anthropogenic disturbance	-woodland with more trees than shrubs -few to no trees cut or lopped
Medium level of anthropogenic disturbance	-mixed woodland of trees and shrubs -visible evidence of deforestation and tree lopping
High level of anthropogenic disturbance	-shrubland with few to no trees -many access routes, -evidence of overgrazing and deforestation
Crop field	-land cleared for crop production -cultivated within the last three years

Table 2. Sampling intensity for each study site

Site	Grid Reference		Number of transects	Number of plots	Total sampled area (ha)
	West to East	North to South			
Chimanimani	$32^{o}23^{l}$ to $32^{o}27^{l}$	$19^{o}49^{l}$ to $19^{o}53^{l}$	7	44	0.44
Makoni	$32^{o}23^{l}$ to $32^{o}25^{l}$	$18^{o}10^{l}$ to $18^{o}13^{l}$	8	42	0.42
Muzarabani	$31^{o}00^{l}$ to $31^{o}04^{l}$	$16^{o}18^{l}$ to $16^{o}23^{l}$	6	52	0.52
Nyanga	$32^{o}31^{l}$ to $32^{o}34^{l}$	$18^{o}15^{l}$ to $18^{o}17^{l}$	11	46	0.46
Rushinga*	$32^{o}34^{l}$ to $32^{o}38^{l}$	$16^{o}37^{l}$ to $16^{o}41^{l}$	7	27	0.27
Total			39	211	2.11

*Field work had to be abandoned due to circumstances beyond our control

2.4.2 Ecosystem structure

The landscape assessment was restricted to the level of anthropogenic disturbance in each area. Data on the number of plots in different anthropogenic categories were pooled and summarised for each site along side the different levels of commercialisation and likelihood of institutional success. A Kruskal Wallis test was used to test the differences in levels of perturbation between the sites.

Tree density, mean DBH and woodland structure were used to assess contributions made by NTFP commercialisation and successful institutions in reducing the impact of anthropogenic disturbance on ecosystem structure. One-way analysis of variance (ANOVA) and post analysis pair wise comparison using least significant differences (LSD) were used to test the differences in tree density between areas of different anthropogenic disturbance within each specific site.

Tree community structure in all the areas with different levels of anthropogenic disturbance (pooled data from relevant plots) in each study site was assessed for deviations from the ideal reverse J shape by presenting proportions of trees in consecutive DBH categories on a bar chart. Results of the three ecosystem structure variables were then used to test the null hypotheses on commercialisation and institutional arrangements by evaluating whether the result supported or rejected the null hypothesis.

2.4.3 Ecosystem composition

To characterise ecosystem structure and composition, species richness and the Shannon-Wiener diversity index ($H=-\sum (p_i \ln p_i)$) (Begon *et al.*, 1990) were computed. These were than plotted against levels of disturbance to evaluate changes in the ecosystem composition. Spearman's rank correlation coefficient was computed to assess associations between disturbance, species richness and diversity. In addition, the coefficient of Jaccard, a binary similarity coefficient was used to quantify the overlap in species composition (Krebs, 1999; Boubli *et al.*, 2005) between the three levels of anthropogenic disturbance for each site.

Another characteristic of ecosystem composition is species dominance. An enumeration of changes in the number and names of species that were the most dominant in each level of disturbance was undertaken using pooled data for all the relevant samples. Species taken as dominant in anthropogenic disturbance category were those that had a frequency of more than 5%. This was done to determine which species had survived the perturbation process from a low to high level.

To determine the number of dominant species in each, disturbance category species frequencies were summed (descending order i.e. starting with the highest) to 25%, 50% and 75% and then enumerating how many species contributed to those frequencies for each level of anthropogenic disturbance. Results of the three ecosystem composition variables were then used to test the null hypotheses on commercialisation and institutional arrangements by evaluating whether the result supported or rejected the null hypotheses.

3. Results

3.1 Ecosystem structure

3.1.1 Landscape patterns

Levels of ecosystem degradation varied among the five sites with Chimanimani, Muzarabani and Rushinga having the lowest proportion of plots in the low disturbance category. Nyanga was the least degraded area overall. Levels of disturbance were significantly different between the sites (Kruskal Wallis, X^2 =90.11, df=4, p<0.001) and the impact of anthropogenic disturbance decreased with increasing strength of institutional arrangements. Study sites with a low likelihood of institutional success had most of the sampled plots located in the areas of high disturbance (>40%) and the converse was true for those with a high likelihood of institutional success, where most of the plots were in low and medium disturbance levels. No similar influence was evident from commercialisation for instance one of the low commercialisation sites (Makoni) had the lowest proportion of plots in the high disturbance levels, while the second (Chimanimani) had the highest with some plots being in crop fields (Table 3).

A Spearman's Rank correlation confirmed these observations as there was a negative association between institutional strength and disturbance (r= -0.25, p<0.001) whilst a low though significant relation existed between levels of commercialisation and the latter (r= 0.07 p= 0.02). This suggests then that stronger institutions reduced levels of ecosystem perturbation such that increases in institutional strength resulted in decreases in anthropogenic disturbance.

Table 3. Proportion of sample plots located in areas of different levels of anthropogenic disturbances in the five sites

Study site	Likelihood of institutional success	Level of commercialisation	Number of plots sampled	Level of anthropogenic disturbance			
				Low	Medium	High	Fields
Chimanimani	Low	Low	44	11.36	6.82	43.18	38.64
Makoni	High	Low	42	23.81	40.48	21.43	14.29
Muzarabani	Medium	Medium	52	10.00	16.00	22.00	52.00
Nyanga	Medium	High	46	33.93	25.00	19.64	21.43
Rushinga	Low	Medium	27	11.11	18.52	40.74	29.63

3.1.2 Community structure

In all sites the deterioration of the ecosystem from low to high levels of disturbance resulted in sharp decreases in tree density, from 980 to 526 trees per hectare in Chimanimani, and 2850 to 1556 and 2400 to 1545 in Makoni and Rushinga respectively. Although in some sites there was the intermediate response of increasing tree density with disturbance, ultimately tree density decreased to about 50% of the original figures in most sites. High tree densities were associated with younger trees or trees of small diameters. As disturbance increased tree density tended to decrease whilst DBH increased (Figure 2). This could be explained by the observation that in highly disturbed areas there were few scattered large trees with no undergrowth. Mean tree densities were significantly different between areas of different anthropogenic disturbances in all sites except for Nyanga (Table 4). The few trees that existed were those mostly selected for their utilitarian value which resulted in the creation of parklands of monocultures (Figure 3).

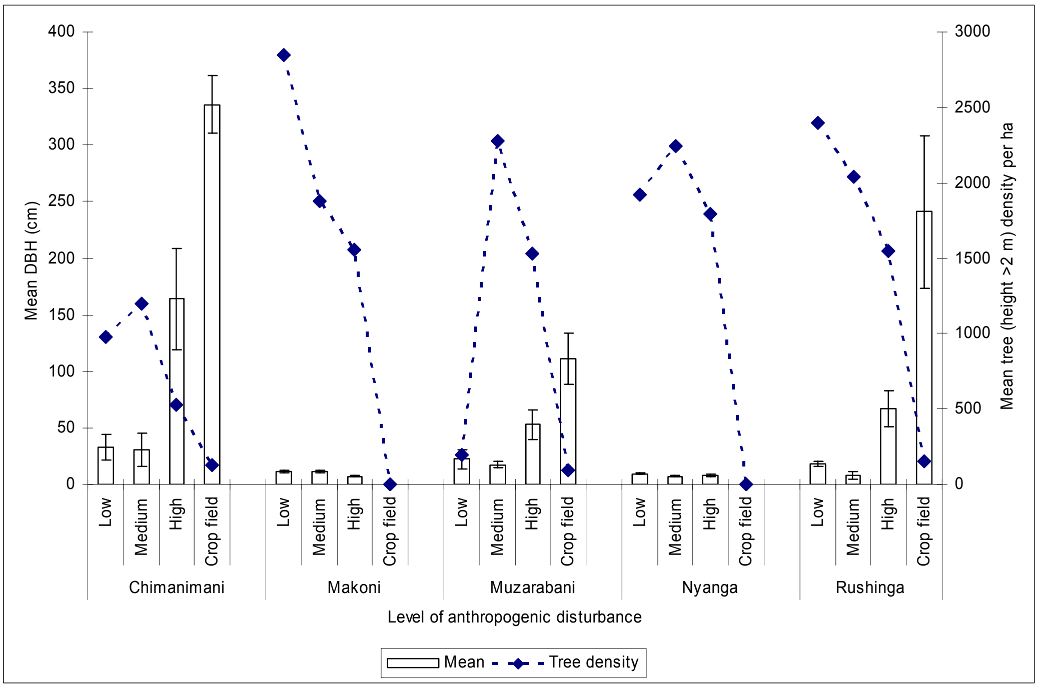

Figure 2. Tree abundance (density) and size (DBH) along the disturbance scale for each study site.

In Chimanimani, Muzarabani and Rushinga the ecosystem structure changed across the disturbance gradient as there were increasingly more trees in the higher DBH size classes, while, in Makoni, and Nyanga the structure remained more or less unchanged. In Chimanimani the trees of DBH size >60 cm constituted 23 % in the low and 71% in high disturbance areas, whilst the same categories had 1% and 3% respectively in Nyanga. However, tree community structure in the least disturbed areas at all sites apart from Nyanga and Rushinga had an inverted J-shape typical of healthy and growing populations. In Nyanga and Rushinga woodlands were dominated by the second DBH size class (11-20 cm), 34% and 50% respectively.

Table 4. Summary of One-way ANOVA for density of trees per ha for the five sites and pair wise comparison (LSD) for the four levels of anthropogenic disturbances

Statistical variables	Study site Chimanimani	Makoni	Muzarabani	Nyanga	Rushinga
		ANOVA			
Df	3	2	3	2	3
F	42.54	12.18	11.54	1.78	19.78
P	<0.001	<0.001	<0.001	0.17*	<0.001
		Post analysis: Pair wise comparison (LSD, p-values)			
Low and medium	0.93	<0.001	0.76	0.06	0.64
Low and high	<0.001	0.002	0.058	0.35	0.008
Low and crop field	<0.001	nd	<0.001	nd	<0.001
Medium and high	<0.001	0.43	0.013	0.69	0.009
Medium and crop field	<0.001	nd	<0.001	nd	<0.001
High and crop field	<0.001		<0.001		<0.001

nd = one of the anthropogenic levels not recorded in the site

Figure 3. *Adansonia digitata* parklands in Chimanimani, Photograph by P. Sola, August, 2004.

In Nyanga and Makoni which have miombo woodlands, changes in tree community structure among areas with the four anthropogenic disturbance levels were not significantly different whilst significant changes were recorded in the other three sites on dry savannas of the lowveld (Table 5). Relating the magnitude of changes in tree community structure to levels of institutional success and commercialisation presented no clear overall trends. In Makoni, although there was low commercialisation, the ecosystem structure was not significantly affected by anthropogenic disturbance.

3.2 Ecosystem composition

3.2.1 Tree species richness

A total of 907 trees (height > 2m) were recorded from 131 species. The number of trees was highest in Makoni (300), and least in Chimanimani (113). Species richness followed the same trend with high values of 65 and 52 in Makoni and Muzarabani and lower values of 44, 43 and 30 in Rushinga, Nyanga and Chimanimani respectively. Species richness changed with changes in the level of disturbance but the direction of change varied among the five sites. In Makoni, Muzarabani and Nyanga species richness was highest at intermediate disturbance while in Chimanimani and Rushinga species richness was lowest at this level of disturbance (Figure 4). However, a high negative association was found between species richness and anthropogenic disturbance Chimanimani ($r= -0.87$, $p<0.001$), Makoni ($r= -0.33$, $p=0.03$), Muzarabani, ($r= -0.79$, $p<0.001$), Nyanga ($r= -0.41$, $p=0.008$) and Rushinga ($r= -0.47$, $p=0.023$). These results could not be explained by changes in level of commercialisation, but one evident trend was that species richness increased with increasing institutional success (Spearman's Rank Correlation, $r=0.3$, $p<0.001$).

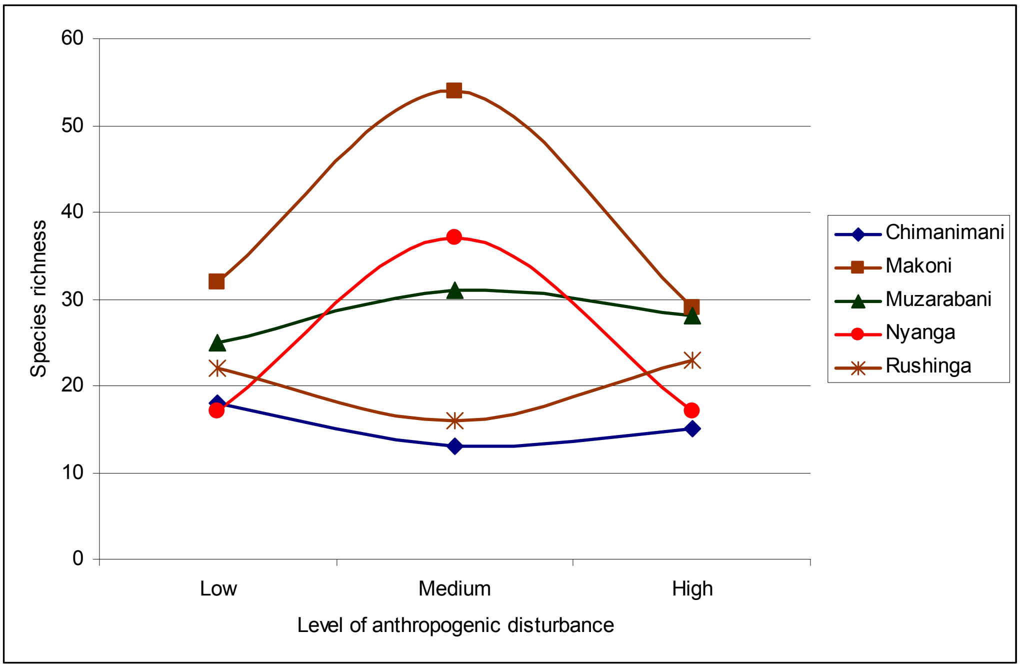

Figure 4. Species richness along the anthropogenic disturbance scale for each study site.

A pair wise comparison (Jaccard coefficient of similarity) of tree species composition between anthropogenic disturbance levels in each site revealed that there was about 60% overlap in species found in areas of different anthropogenic disturbance (Table 5). This means that along the gradient of disturbance about three in every five species persisted in the new tree community and the rest would be new species. What this result cannot show is just which species persisted.

Table 5: Jaccard similarity coefficient for pair wise comparison of tree species composition between anthropogenic levels in each site

Study site	Level of anthropogenic disturbance		
	Low and Medium	Medium and high	Low and High
Chimanimani	0.60	0.58	0.63
Makoni	0.66	0.63	0.67
Muzarabani	0.59	0.64	0.62
Nyanga	0.59	0.68	0.64
Rushinga	0.61	0.61	0.6

Table 6. Occurrence of species with more than 5% frequency in the disturbance area in the five study sites; in bold are species that have persisted from the 'original' woodland (areas of low disturbance)

Study site	Level of anthropogenic disturbance				
	Low	**Medium**	**High**	**Field**	**Overall**
Chimanimani	*Diospyros quiloensis* *Acacia karroo* *Combretum apiculatum* *Colophospermum mopane* *Adansonia digitata*	***Diospyros quiloensis*** ***Colophospermum mopane*** ***Adansonia digitata*** *Bridelia mollis* ***Combretum apiculatum*** *Dichrostachys cinerea*	***Acacia karroo*** ***Adansonia digitata*** *Acacia nilotica*	***Adansonia digitata***	*Acacia karroo* *Adansonia digitata* *Diospyros quiloensis* *Colophospermum mopane*
Makoni	*Julbernardia globiflora,* *Dichrostachys cinerea,* *Brachystegia spiciformis*	***Dichrostachys cinerea*** *Bauhinia galpinii* ***Brachystegia spiciformis*** *Terminalia stenostachya* *Lannea discolor*	***Julbernardia globiflora****,* *Terminalia stenostachya* *Monotes glaber* *Faurea saligna* *Pterocarpus rotundifolius* ***Brachystegia spiciformis***		*Julbernardia globiflora,* *Brachystegia spiciformis* *Dichrostachys cinerea*
Muzarabani	*Sclerocarya birrea,* *Combretum apiculatum* *Bauhinia galpinii* *Combretum collinum*	***Sclerocarya birrea,*** *Colophospermum mopane* ***Combretum apiculatum***	***Combretum collinum*** *Colophospermum mopane* ***Sclerocarya birrea****,* *Friesodielsia obovata*	***Sclerocarya birrea*** *Adansonia digitata*	*Sclerocarya birrea* *Colophospermum mopane* *Combretum collinum* *Combretum apiculatum*
Nyanga	*Julbernardia globiflora,* *Brachystegia spiciformis* *Monotes glaber*	***Julbernardia globiflora*** ***Brachystegia spiciformis***	***Julbernardia globiflora,*** ***Brachystegia spiciformis***		*Julbernardia globiflora,* *Brachystegia spiciformis*
Rushinga	*Sclerocarya birrea* *Combretum collinum* *Dichrostachys cinerea,* *Terminalia sericea*	***Combretum collinum*** *Acacia nigrescens* *Markhamia zambesiaca* *Acacia nilotica*	***Combretum collinum*** ***Sclerocarya birrea*** *Combretum apiculatum*	***Sclerocarya birrea*** *Adansonia digitata*	*Combretum collinum* *Sclerocarya birrea* *Combretum apiculatum* *Acacia nilotica* *Acacia nigrescens*

Another interesting result was that, as the anthropogenic disturbance increased, species dominance changed, though areas with low and high disturbance had similar species (Table 6). Only Nyanga had the same species being dominant in all the disturbance levels, in the other site dominance switched between species. In addition, disturbance changed the number of dominant species (Table 7). Dominant species decreased along the gradient of perturbation in Chimanimani, increased in Makoni and Rushinga and remained more or less constant in Muzarabani and Nyanga. These results are in concurrence with the diversity-disturbance relationship.

Table 7. Number of dominant species based on % contribution of species richness (S), starting with highest contributors (most abundant)

		Level of anthropogenic disturbance		
Site	**Total % contribution of species richness**	**Low**	**Medium**	**High**
		Number of species		
Chimanimani	<25	1	1	1
	26-50	4	2	1
	51-75	8	6	2
	75-100	10	7	13
	S	**18**	**13**	**15**
Makoni	<25	1	3	2
	26-50	2	7	5
	51-75	4	17	16
	75+	28	37	13
	S	**32**	**54**	**29**
Muzarabani	<25	2	1	2
	26-50	4	4	3
	51-75	9	11	8
	75+	16	20	20
	S	**25**	**31**	**28**
Nyanga	<25	1	1	1
	26-50	2	1	1
	51-75	3	5	2
	75+	14	32	15
	S	**17**	**37**	**17**
Rushinga	<25	1	1	1
	26-50	1	2	3
	51-75	2	5	9
	75+	20	11	14
	S	**22**	**16**	**23**

3.2.2 Species diversity

Calculation of the Shannon-Wiener diversity index showed that Chimanimani and Makoni had the most diverse woodlands with indices of 5.0 and 5.5 respectively. Nyanga was the least diverse with an index of 1.8. A plot of the Shannon-Wiener index along the disturbance scale revealed that, diversity remained almost constant in Makoni (from 4.2 to 5) and Nyanga (from 1.7 to 1.2) sites, whilst in Muzarabani and Rushinga diversity increased and in Chimanimani diversity decreased as disturbance increased (Figure 5). This was further supported by the Spearman's rank correlation coefficient between the two variables such that in Chimanimani ($r = -1.0$, $p<0.001$), Makoni ($r=0.33$, $p=0.03$), Muzarabani ($r=0.75$, $p<0.001$), Nyanga ($r = -0.48$, $p<0.001$) and in Rushinga ($r=1.0$, $p<0.001$). The increase could be attributed to a prolific regeneration of new species (succession) while in Chimanimani some species were being lost.

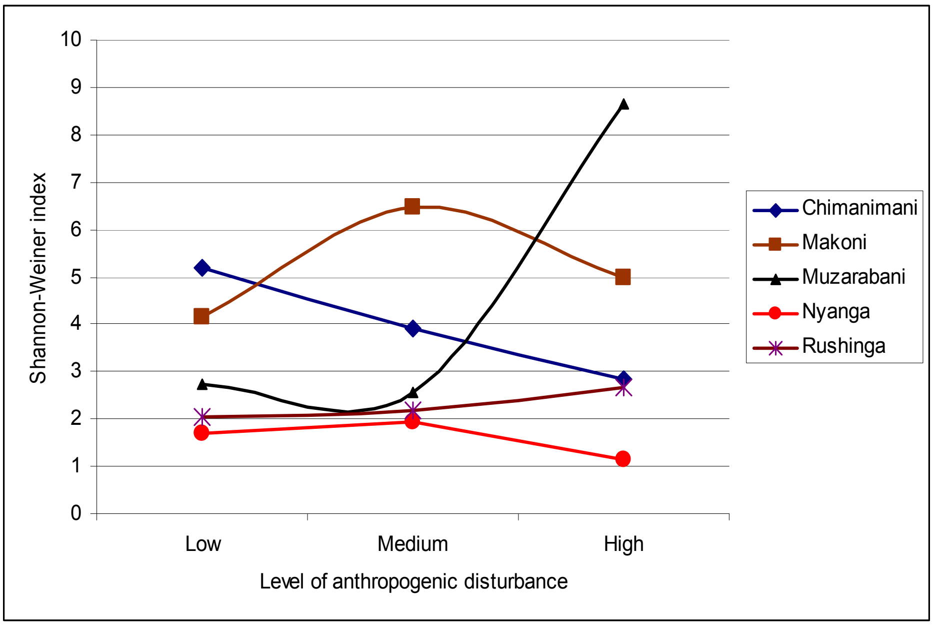

Figure 5. Shannon –Wiener diversity index along the anthropogenic disturbance scale for each study site.

4. Discussion

4.1 CBNRM and ecosystem structure

Extraction of products and use of ecosystem services by people is changing the structure of the ecosystems. In this research it was found that tree density and sizes of trees (DBH) decreased with increasing levels of anthropogenic disturbance. The relevant question arising from this is to what extent were CBNRM strategies reducing the decrease. From this research, indications are that commercialisation has had no impact on the magnitude of anthropogenic disturbance on ecosystems structure as there was no clear trend of decrease with increasing levels of commercialisation. In fact, some areas with low commercialisation had the least disturbed areas. This could be attributed to that, the supposedly lucrative NTFP industry with high potential of sustaining livelihoods of millions living in the agriculturally marginal areas of the savannah has remained very elusive to the rural farmers. Commercialisation of NTFPs has moved from developing markets for local products to developing products for existing markets as well as from low potential (crafts) to high potential (fruit and leaf) products, but still entrepreneur incomes have not increased (Sola, 2005). As such investment in ecosystem conservation is very minimal to effect any changes in the rate of anthropogenic disturbance.

Increased strength of institutional arrangements reduced the scale of anthropogenic disturbance since less land was in the areas of high perturbation for sites with high likelihood of institutional success than in those with low and medium likelihood of success. In addition, the site with high levels of both commercialisation and strength of institutional arrangements had the best conserved ecosystem, suggesting that there could be an optimal combination of the two socio-economic factors for successful conservation.

4.2 CBNRM and ecosystem composition

This research suggests that anthropogenic disturbance has altered ecosystems by changing species composition or forcing them into an alternative successional state regardless of levels of commercialisation. In fact species composition was changed by 40 % at every level of anthropogenic disturbance for all the study sites. In three sites species richness response to disturbance was similar to that of natural populations which exhibit increases at intermediate disturbance. This supports the intermediate response hypothesis which predicts that between species extinction and competitive equilibrium where species of low competitive ability are lost is a level of disturbance that maximises biological diversity suggesting that species richness is enhanced by reduced competition (Connell, 1978; Huston, 1994, Wilson & Tilman, 2002).

However, not all tree communities comply with this hypothesis, for instance in this study, some sites had decreased species richness at intermediate disturbance. These results could not be explained by influences of NTFP commercialisation as at low levels of commercialisation the impact of disturbance in one site (Makoni) was not adverse thus ecosystems were better managed yet in the other (Chimanimani) which was in the same commercialisation category there were species losses as evidenced by drastic changes in species composition. It means then, that in the latter (Chimanimani) there was not just reduced competition but high degradation as predicted by this research.

Species diversity decreased with increased strength of institutional arrangements, but then more conserved areas were found in miombo woodlands which have inherently low diversity making it difficult to sustain this claim. However, to support this claim, species diversity in one site (Chimanimani) decreased due to species loss which is similar to a result that Behera *et al.* (2005) found working in a Himalayan forest. They concluded that decrease in the Shanonn-Wiener index along a disturbance gradient was due to high species richness in the natural forests and species loss in the degraded areas (Behera *et al.*, 2005). Such decreases in species diversity have been said to be linked to limitations of dominant species and emergence of unfavourable habitat conditions (Solon, 1995). Increases in species diversity with increases in anthropogenic disturbances in some of the sites could be attributed to these ecosystems responding by shrubland formation. The driving force behind maintenance of species composition to a near natural state was the strength of institutions.

Changes in species composition were coupled with changes in dominant species, which decreased with increasing disturbance though there was some constancy in areas. This trend was not influenced by commercialisation but institutional success, as less change was recorded in areas of high institutional success, which implies they were conserved at a near natural state (Nyanga and Muzarabani). In some areas anthropogenic disturbance has resulted in the formation of parklands of monocultures as only the trees most valued by the community are left standing (Schreckenberg, 1999; Crook & Lapp, 1998). However, it has been said that species composition resulting from deforestation does not return to an original state as re-establishment of former dominants is very unlikely (McGregor *et al.*, 1999); therefore some allowances have to be made in drawing these conclusions.

5. Conclusion

Community based natural resources management has failed to offer incentives to local people to use natural resources sustainably. The current benefit driven approach of NTFP commercialisation has had no influence or impact on the rate, scale and magnitude of ecosystem simplification, fragmentation and destruction. There are many reasons for this lack of success. Firstly, NTFP commercialisation has not become widespread in Zimbabwe. Currently very few people are involved in formal trade of NTFPs, making the benefits concentrated whilst the costs of extraction are borne by a wider community. Even for those few who are involved the incomes generated are too low to justify any investment in managing natural resources, let alone justifying the existence of these resources to a rural farmer struggling for day to day survival.

Potentially, commercialisation of NTFPs could lead to ecosystem degradation as only species of value will be conserved while all else is removed. This means therefore that successful NTFP commercialisation would have to be supported by strong institutional arrangements. From this study I can conclude that indeed institutional arrangements do improve ecosystem management by reducing and or managing the rate, scale and magnitude of anthropogenic disturbance on ecosystems.

The ecosystem approach to natural resource management has not been adopted as only the species of value are conserved. Resultant ecosystems have not only lost resilience and stability but the potential value for more products and services. Parklands formed as a result of selecting valued species are of reduced value compared to the total as they reduce current and future livelihood options. As a negative feed back such ecosystems become an increasing liability to conserve and land use conversion continues.

However, not all is lost. Based on this study the hypothesis that NTFP commercialisation improves ecosystem conservation by increasing value of forests and incentives for management and stewardship is still largely untested. It still remains an undisputed claim that conservationist and development practitioners working with resource users are yet to test and qualify. Differences in responses of ecosystems to perturbation bring an additional dimension to this debate that is essential to investigate when conservation strategies are being developed.

It is important to highlight that conclusions being made here are based on a simplistic view (unidirectional and non-interactive relationships between commercialisation, livelihoods, ecosystems and institutional arrangements). In this study the changes in ecosystem health was investigated in relation to NTFP commercialisation and institutional success. No attempt was made to assess how the two drivers of change interacted to change ecosystems because such an interaction does exist. It could be said that, i) in some cases successful commercialisation leads to a breakdown in local institutions presumably due to shift in power, and ii) some institutional arrangements constrain while others facilitate the success of commercialisation. This then suggests there are optimal commercialisation and institutional arrangements that would be ideal for ecosystem conservation. This aspect remains a subject for further research.

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