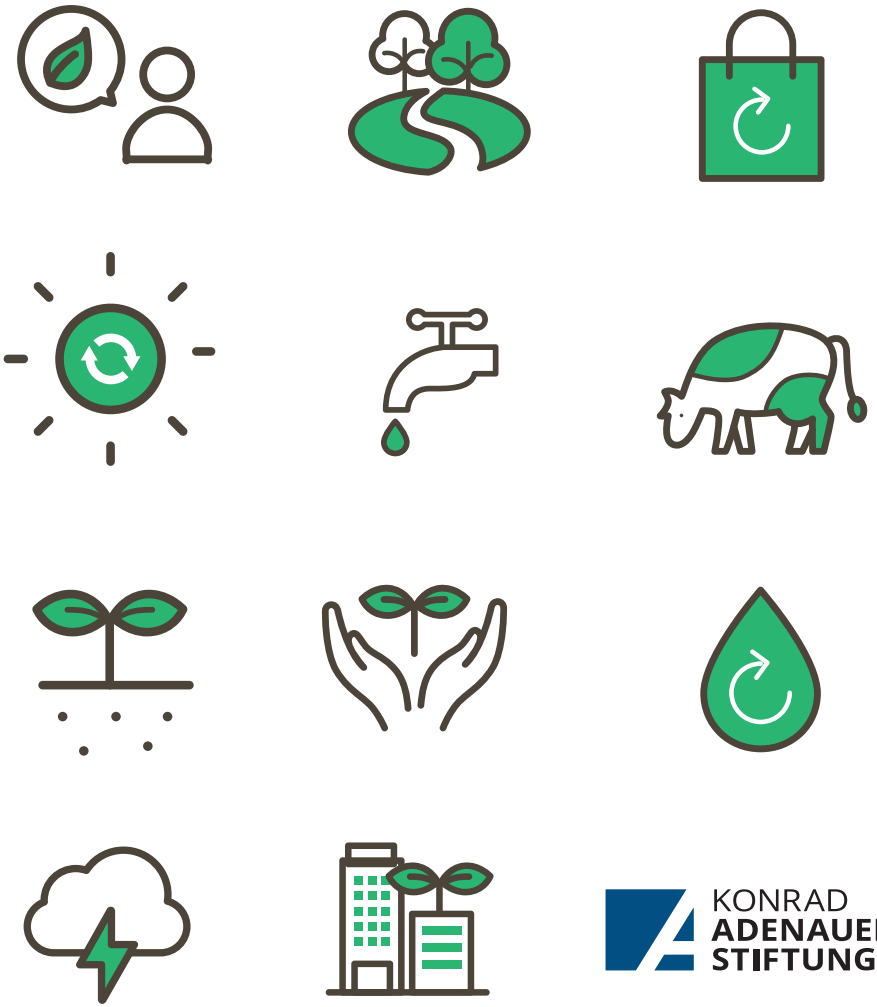
CLIMATE CHANGE IMPACT, ADAPTATION AND MITIGATION IN ZIMBABWE

CASE STUDIES FROM ZIMBABWE'S URBAN AND RURAL AREAS



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Climate Change Impact, Adaptation and Mitigation in Zimbabwe

Case Studies From Zimbabwe's Urban **and Rural Areas**

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Chapter **03**

Social-ecologically Driven Threats to the Climate Mitigation Potential of Forests: A Case of Murehwa District

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Introduction

Climate change is a reality (Ontl et al., 2020; Pacoma, 2019; Kerr & Wilson, 2018) which is posing great challenges to human life and therefore requires urgent attention (Nunes et al., 2020; Tomaselli et al., 2017). According to Nunes et al. (2020), the widely accepted cause of climate change is the increase in carbon dioxide concentration in the atmosphere, which is mainly a result of anthropogenic activities such as burning of fossil fuels. Efforts to mitigate the effects of climate change have been directed towards sustainable ways of reducing atmospheric carbon concentration (Nunes et al., 2020). Forest ecosystems act as a possible solution for mitigating against climate change (Hamilton & Friess, 2018; Shahbazi & Nasab, 2016) because of their carbon sequestration potential (Patil & Kumar, 2017).

Background

Healthy forests are an important component of the terrestrial carbon cycle that captures and stores large percentages of atmospheric carbon in the form of organic carbon in vegetation, forest biomass and soil (Hui et al., 2017; Liverman, 2009; IPCC, 2007). Natural forests fix carbon in their biomass, an environmental service for which forests are now recognised (Yan et al., 2018; Giri & Madla, 2017; Patil & Kumar, 2017). At the global scale, the total amount of carbon that forest ecosystems store exceeds the amount of carbon in the atmosphere (Seidl et al., 2018; Hui et al., 2017; Federici et al., 2017; Lal, 2005). Thus, forest vegetation has the capacity to reduce the increase of atmospheric carbon concentrations (Lawson, 2020; Mahmoud & Gan, 2018; Ward et al., 2018).

Mature and intact forests are the most dense carbon stocks and the most biodiverse natural ecosystems that offer other benefits to the society and the economy (Mackey et al., 2020; Moomaw et al., 2019). Terrestrial sequestration of carbon is accomplished through forest practices that enhance the storage of carbon, and these practices include conservation, restoration and the establishment of new forests (Ontl et al., 2020; Kumar et al., 2017; Schahczenski & Hill, 2009). It is more ideal to conserve existing forests for carbon sequestration owing to the fact that young trees and newly planted forests need many years before they sequester carbon dioxide in substantial amounts (Moomaw et al., 2019). Zimbabwe is a member of the Reducing Emissions from Deforestation and Forest Degradation and Enhancement of Carbon Stocks through Forest Conservation and Management (REDD +) international initiative (Ribeiro et al., 2020; Bond et al., 2010). The REDD+ programme aims to maintain existing forests through strategies such as continued sustainable management and local stewardship of forests, enhancing the sequestration of carbon through afforestation, reforestation and restoration of degraded forest land (vonHedemann et al., 2020).

Forest loss or degradation does not only cause increased carbon concentration in the atmosphere, but also results in loss of ecosystem services that are offered by forests to the environment and people (Blaser, 2010). Deforestation contributes to climate change because it reduces the net flow of carbon from the atmosphere into forests, both in the present and future (Nunes et al., 2020; Curtis et al., 2018). Any change in the carbon balance of forest ecosystems has a strong impact on the atmospheric carbon concentration (Bradshaw & Warkentin, 2015).

The role of local communities is central to the success of maintaining healthy forest ecosystems which, according to Jenkins and Schaap (2018), are free from invasive species, and also provide several services that include climate regulation, productive soils and many of society's needs, such as economic processes and cultural values.

Protection of healthy forest ecosystems is now considered as increasingly important as an approach to mitigate against the negative effects of climate change (Wood et al., 2019). Conservation of forests is vital to the quality of the environment and society, since they provide many services to humans (Stocker et al., 2014). Forests are part of the social-ecological systems in the sense that they exhibit strong intricate interactions between social, economic, ecological, cultural and political components, which underpins the exchanges between nature and human society (Petrosillo et al., 2015). These exchanges in the social-ecological systems have an influence on the well-being of the environment. The purpose of this study was to determine the drivers and restraining forces in the social-ecological system and their influence on the status of forest ecosystems.

Conceptual Framework for Understanding the Relationship between Contextual Factors which Determine the Well-being of Forests

Figure 3.1 is a modified framework adapted from Oakerson (1990). The framework provides the basis for analysing contextual factors that determine the status of common-pool resources which include forests in the communal areas of Zimbabwe.

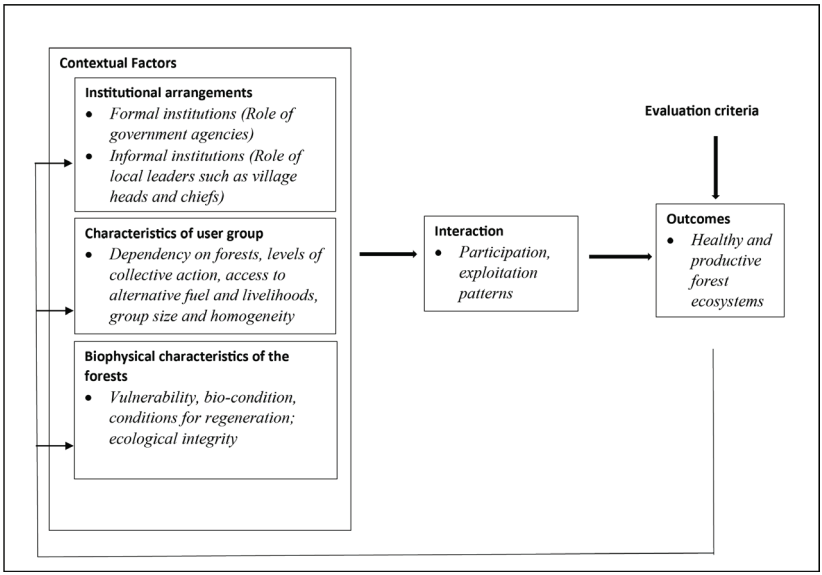

Figure 3.1: Framework for Understanding the Relationship between Contextual Factors which Determine the Well-being of Forests (Adapted from Oakerson, 1990)

Institutional Arrangements

Hardin's tragedy of the commons argues that unless common-pool resources are transferred to government control, overexploitation is inevitable (Frischmann, Marciano & Ramello, 2019; Al-Fattal, 2009; Hardin, 1968). The theory by Hardin (1968) suggests that where there is no state intervention in management, natural resources are accessed freely and selfishly by everyone, and 'ruin' is the ultimate result. However, Ostrom (2005) and Murphree (1991) critique Hardin, arguing that sustainable utilisation of forests can be achieved when local communities are involved in the management of resources available to them. For instance, Ostrom (2009) observes that communities that are involved in designing rules of managing the commons have high chances of success in achieving sustainable use. Nyikahadzoi and Zamasiya (2012) argue that local communities can only sanction violators who would have violated rules that they participated in formulating. Roka (2019) and Chingaipe et al. (2016) emphasise the importance of allowing an adaptive evolution of rules and self-regulatory mechanisms within the community as pre-requisites for sustainable utilisation of natural resources such as forests. However, local institutional initiatives alone failed in natural resource conservation in many countries, including Zimbabwe (Milupi, Somers & Ferguson, 2017).

The failure of centralised mechanisms in the management of natural resources led to the search for a viable and sustainable approach (Nabane & Matzke, 1997). Other scholars have suggested that adaptive co-management, where both government and local communities are engaged in the management of forests, is a sensible endeavour that has the potential to achieve more sustainable forest utilisation (Islam, Ruhanen & Ritchie, 2017; Diver, 2016; Cinner et al., 2012; Ostrom, 1990). Mbuvi and Kungu (2019) and Oosterveer and Vliet (2010) highlight that the principle of subsidiarity (that is, major decisions should be made within the community that would be affected by the decisions) must be upheld.

Characteristics of Resource Users

Sustainable management of forests depends upon the characteristics of resource users. One of the characteristics of resource users, which determine their ability to maintain healthy forest ecosystems, is group size (Cox, Arnold & Tom's, 2009). For users to sustainably exploit forests and work together to achieve common good, their group size should be relatively small in order to increase the levels of interaction (Olson, 1965). Homogeneous resource user groups that share important social, cultural, or economic characteristics have high chances of sharing common interests, and this increases chances of cooperation towards sustainable natural resource management (Fearon & Laitin, 1996). Agrawal and Angelsen (2009) argue that communities that are well-off may not be highly forest-dependent since they can access alternative sources of fuel and livelihood strategies. Therefore, relatively small, well-off communities with shared norms, trust, past successful experiences of cooperation, and interdependence among group members, have better chances of sustainably managing forests available to them (Agrawal, 2007; Larson, 2003; Agrawal, 2001).

Biophysical Characteristics of Resources

Forests that can be sustainably managed are those that exist in a properly functioning ecosystem with necessary conditions for regeneration (Angermeier & Karr, 1994; Oakerson, 1990). Factors such as optimum temperatures and adequate precipitation affect the extent, structure, species composition within forests, and regeneration capacity (Kleinschmit et al., 2015). In a study by Tucker, Randolph and Castellanos (2007), it was found that forests that could regenerate naturally, as well as biodiverse and productive forests, were associated with higher annual rainfall. Thus, sustainable management of forests occurring in areas where there is adequate rainfall, moisture and optimum temperatures is likely to be high with the possibility of high levels of plant biodiversity (Lonn et al., 2018; Agrawal & Chhatre, 2006). Forests that are biodiverse have high chances of resisting the adverse effects of climate change and, as a result, they have a greater chance of

being maintained as healthy forests (Jactel et al., 2017; Agrawal & Angelsen, 2009). Therefore, forests that can be sustainably managed are those that are biodiverse, can also occur in areas with high rainfall, and have predictable regeneration capacity, since such forests constitute an incentive for effective management and sustainable exploitation.

Socio-ecological systems are able to maintain an equilibrium when the off-take is equal to the forest growth. Forests are under threat from climate change, which is resulting in the drying up of large trees in miombo woodlands at an alarming rate. The increasing demand for forest products is also posing serious threats to forest ecosystems. It is important, therefore, to establish the current drivers and threats to maintaining a healthy forest ecosystem both as a carbon sink and also to meet the increasing demand for forest products by marginalised rural communities. The research reported in this chapter used Geographical Information System (GIS) to track changes in forest cover and land use over time. The Force Field Analysis was used to establish the points of view of local actors on the emerging drivers and restraining forces that support or threaten the health status of the forests. Murehwa's wards 26, 27, 28 were used as a case study to assess land use and land cover changes and threats to the well-being of forests.

Description of the study area and methodology

Study Area

The study was carried out in wards 26, 27 and 28 in Murehwa District (Figure 3.2). The District is located in Mashonaland East Province in Zimbabwe at 17.65°S; 31.78°E. The altitude is 1300 metres above sea level. The main vegetation type in the area is miombo woodlands. The area has been experiencing climatic variability.

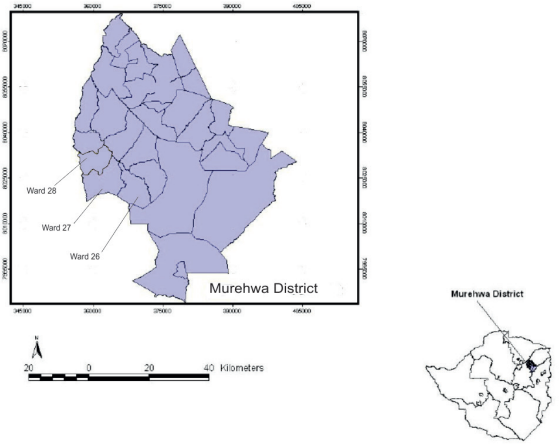

Figure 3.2: Location of Study Sites in Murehwa District

Research Methods

Study Site Selection and Sampling Methods

The study was carried out in Murehwa's wards 26, 27 and 28. Four villages were purposively selected for focus group discussions due to their closeness to forested landscapes. One village was selected in each of the wards 28 and 27, and two villages were selected in Ward 26 owing to the fact that it has more forests than the other two wards. Purposive sampling was also used to identify focus group participants. Participants were mainly farmers relying on rain-fed agriculture, gardening and other livelihood strategies that depend on forest resources. The ages of participants ranged between 35 years and 65 years. Targeted participants were those who had lived in the study area for more than 25 years such that they had historical knowledge of developments within the forests. These participants were identified with the help of village heads. A total of four focus group discussions were conducted. Each focus group discussion was made up of eight participants to ensure effective participation.

Data Sources, Collection Methods and Analysis Procedures

The study adopted a qualitative methodology. In order to map changes in forest cover over time in the areas under study, the researchers used Land Use Land Cover change maps (LULC) spanning from 1990 to 2020. Geographical Information System (GIS) and remote sensing were used. Administrative shape-file boundaries were digitised in a GIS environment. Satellite images from Landsat series of Landsat 5 were used for 1990 and 2005. Landsat 8 images were used for 2020 images because Landsat 8 images for 1990 and 2005 could not be found. Landsat images which were used were captured in June for easy identification of forests and cropland owing to the fact that farmers would have harvested their crops. The classification was done using random forest classifier in Google Earth Engine. For GIS maps to be produced, Landsat image series of Landsat 5 and 8 were processed using Aeronautical Reconnaissance Coverage Geographic Information System (ARCGIS) to come up with LULC map layouts. Estimations of crop land and forest land were calculated using the total number of pixels in the study area layout. Each pixel represented 900 m2.

The Force Field Analysis was used to establish enhancers and threats on forests. Figure 3.3 shows the driving forces which push towards maintaining a healthy forest ecosystem, as well as restraining forces which push against maintaining a healthy forest ecosystem. This approach assumes that in every situation there are driving and restraining forces and, in this case, these forces determine the ultimate status of the forest ecosystem.

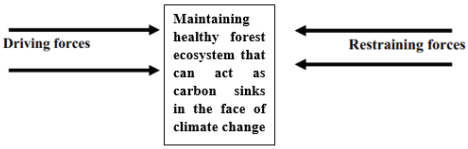

Figure 3.3: Force Field Analysis

Focus group discussions were conducted at village level where participants listed driving and restraining forces for maintaining healthy forests. The purpose of the discussions was explained to all participants in each focus group using the local Shona language. Subsequently, a brainstorming process was carried out to determine the driving forces that would result in healthy forests that can act as effective carbon sinks. Each participant was given an opportunity to speak. All the driving forces were read aloud to ascertain what the respondents had said. Each driving force was given a score according to the participants' perceptions, from 1 (weak) to 3 (strong). Afterwards, another brainstorming process was carried out to determine the restraining forces that threaten the existence of healthy forests that can act as effective carbon sinks. Restraining forces were read aloud to ascertain what the respondents had said. Each restraining force was scored according to the participants' perceptions, from 1 (weak) to 3 (strong). The time taken during each focus group discussion ranged between one hour and, one and half hours.

Data collected from focus groups was tabulated and translated, and the calculation of average scores for the mentioned forces was done by adding different values which were given to the forces by focus group participants, and then divided by the number of instances the statement was mentioned. Reasons which were given by the respondents for scores which they assigned to different forces were audio-recorded and these audios provided explanations for the origin and the severity of the forces.

Results

Temporal Forest Cover Change in Ward 26, 27 and 28 in Murehwa District (1990 -2020)

The changes in land use cover in Murehwa's wards 26, 27 and 28 from 1990 to 2020 are shown in figures 3.4 to 3.6.

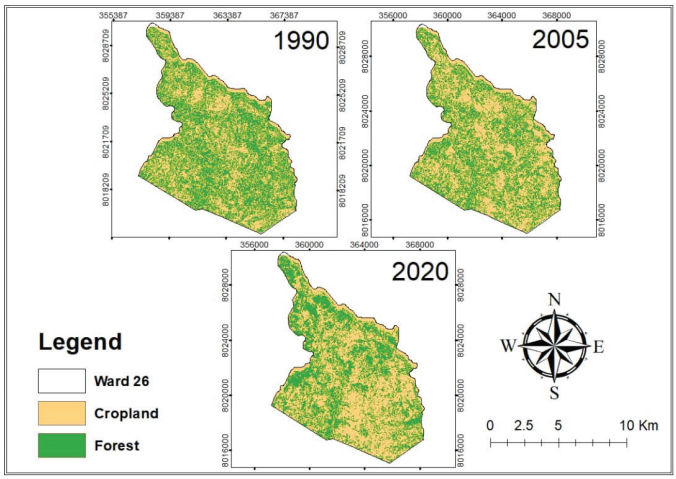

Figure 3.4: Land Use Land Cover Change in Ward 26 of Murehwa District (1990-2020)

Ward 26 experienced forest cover loss, but the major decline occurred between 2005 and 2020 (Figure 3.4). The south-eastern part of the ward was the most affected as it showed greater forest cover loss and a greater increase in crop land than the other parts of the ward.

Forest cover and land use changes in Ward 27 showed that forests occur mainly to the west of the ward (Figure 3.5). The loss of forest cover in the ward was minimal.

Figure 3.6 shows decrease in forest cover and land use changes in Ward 28. Although forests are disappearing in the whole ward, the 2020 map is showing some regeneration of forests, especially on areas that were completely bare on the central part of the map.

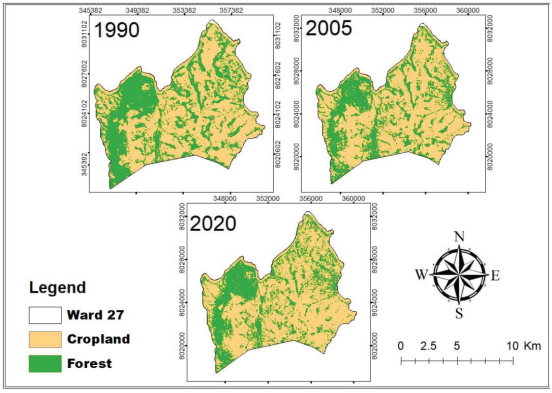

Figure 3.5: Land Use Land Cover change in Ward 27 of Murehwa District (1990-2020)

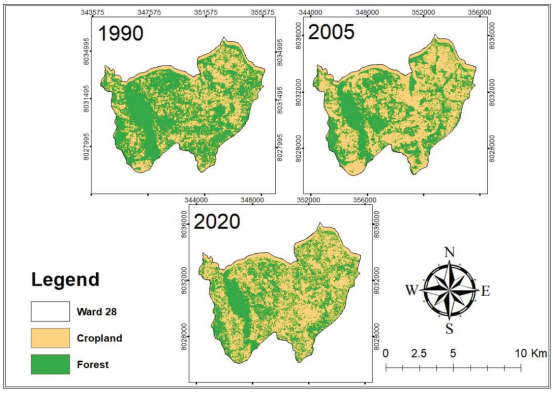

Figure 3.6: Land Use Land Cover Change in Ward 28 of Murehwa District (1990-2020)

Table 3.1 summarises changes in land use in the three wards between 1990 and 2020. Forest cover has been decreasing in all the three wards over a period of 30 years. The highest rate of forest cover loss of 27% occurred in Ward 28, followed by Ward 26, with a forest cover loss rate of 19% and, lastly, Ward 27 had the least rate of forest cover loss of 14%. As forest cover decreased, crop land or agricultural land increased in all the three wards. The highest rate of crop land increase of 43% occurred in Ward 28, followed by Ward 26 with a 20% increase, and the least being Ward 27 with a 9% increase. Results from Table 1 show that forests are under threat. Therefore, the key question is: What is causing the forest cover to decrease from 1990 to 2020?

Table 3.1: Summary of Forest Cover and Crop Land Changes in Three Wards in Murehwa District (1990-2020)

WARD	Forest Cover (ha)				Crop Land (ha)			
	1990	2005	2020	% Change 1990-2020	1990	2005	2020	%Change 1990-2020
Ward 26	4951.17	4096.62	4021.83	-19%	4690.89	5545.44	5620.23	+20%
Ward 27	4813.65	4161.6	4138.56	-14%	7245.9	7897.96	7920.99	+9%
Ward 28	4328.1	3182	3156	-27%	2712.9	3858	3885	+43%

(-) Decrease (+) Increase

Driving and Restraining Forces for Maintaining a Healthy Forest Ecosystem

The results of the Force Field Analysis which was used during focus group discussions to establish local people's understanding of enhancers and threats to the existence of a healthy forest are shown in Table 3.2.

The forces that were considered to be strong in driving towards a healthy forest ecosystem are effective co-management, active local leadership and community involvement in maintaining healthy forest ecosystems (Table 3.2). The mean scores show that the driving force that had the highest strength was active local leadership. The forces that were considered to be strong in restraining towards a healthy forest ecosystem are community level poaching, population increase, climate change driven low rainfall, and the growth of invasive species (Table 3.2). The mean scores show that the restraining forces that had the highest strength were community level poaching and population increase.

Table 3.2: Driving and Restraining Forces for Maintaining a Healthy Forest Ecosystem in Wards 26, 27 and 28 of Murehwa District

Driving Forces	**Mean Score**	**Objective:** **Maintaining a Healthy Forest Ecosystem**	**Restraining Forces**	**Mean Score**
1.Effective co-management arrangements between Environmental Management Agency and local institutional arrangements	2.7± 0.6	**Maintaining a healthy forest ecosystem**	1. Community level dependency on forests as people cut down trees for firewood to use at home, to burn bricks and cure tobacco	3 ±0
2. Active local leaders who are teaching community members the importance of conserving forests	2.75 ±0.4		2. People from other villages poach forest resources in other people's forests	3 ±0
3. Community involvement and participation in forest management	2.7 ±0.6		3. The population is increasing and people are clearing forests land for settling and agricultural activities	3 ±0
			4. Climate change driven invasive species and low rainfall which is preventing the regeneration of forests	2.75 ± 0.4
Total	**8.15**			**11.75**

(1=weak 2=medium 3=strong)

Driving Forces

Co-management is one of the key drivers that can be instituted in order to maintain healthy and productive forests. Co-management arrangements can be put in place to improve the enforcement of management regulations governing forest use (Driving Force 1). According to focus group participants, the Environmental Management Agency (EMA) has formed a co-management arrangement with local communities. Participants indicated that the co-management arrangement had the potential to reduce poaching of timber from the forest since communities report violators to EMA. Poachers are then arrested by EMA. However, some participants alleged that EMA will not always come to apprehend timber poachers due to lack of human and financial resources necessary for putting up an effective enforcement and surveillance system. Nevertheless, participants in one of the focus groups acknowledged that the few arrests by EMA in the past instilled a sense of fear of apprehension in the community. The group participants agreed that the apprehension of those who violate forest management regulations is very infrequent because EMA relies on whistle-blowers for information. However, participants argued that the fear of losing important social relations makes it impossible to self-regulate and report violators to responsible authorities.

Local institutional arrangements are perceived as playing a significant part in maintaining healthy forests (Table 3.2). A traditional leader who was part of one of the focus groups pointed out that as local leaders in Zimbabwe they are empowered through the Traditional Leaders' Act Chapter (29:17), to be the custodians of natural resources, including forests. The duties of local leaders include ensuring that natural resources, including forests, are exploited sustainably through teaching, and controlling and preventing the degradation, abuse or misuse of natural resources within their jurisdictions (Driving Force 2). Participants said that their local leaders were organising days on which community members would go into the forest to remove invasive species in order to create space for the growth of new miombo trees. A ward councillor who had attended one of the focus group discussions also said that ward councillors are working with traditional leaders to remind their subjects on the importance of conserving forests during community meetings.

There is evidence of collective action to maintain the integrity of the forests (Driving Force 3). Participants indicated that they are working together towards the maintenance of healthy forests. The communities are removing Lantana camara, an invasive species that disturbs the regeneration of forests. Participants from one focus group discussion reported that there were days in which village members would go into the forests to remove invasive vegetative species. Participants were of the view that community efforts presented an opportunity for maintaining healthy forests. Participants also affirmed that communities were actively involved in the maintenance of healthy forests through self-policing against overexploitation and illegal extraction of forest resources.

Restraining Forces

The restraining forces that are working against the maintenance of a healthy forest ecosystem are listed in Table 3.2. Difficult conditions have forced villagers to disregard EMA and local leaders' forest management rules and regulations designed to maintain a healthy forest ecosystem. The main restraining forces include pressure on forests as a result of poverty, population growth and the need to meet household food and income security.

Smallholder tobacco farmers utilise firewood harvested from the forests to cure tobacco. They have no alternative source of fuel. Participants in one of the focus groups indicated that for farmers to break the vicious cycle of poverty, they have resorted to tobacco farming which has resulted in excessive cutting down of trees for firewood to cure tobacco. Other participants observed that due to the lack of other income-generating strategies, farmers were mainly engaging in growing tobacco in order to raise income for household expenses. Tobacco curing consumes a lot of firewood, resulting in the loss of many trees. Participants also stressed that the majority of farmers engaged in tobacco farming illegally extract large amounts of wood from forests.

Participants also highlighted that people overexploit forests in order to supplement household income. Trees are harvested to burn bricks. Small businesses for moulding and selling bricks are rampant. Focus group participants indicated that brick moulding has grown into a popular income-generating strategy among most rural able-bodied men, particularly the youth. It was reported that brick moulders were causing forest degradation in two ways, namely, (i) clearing land on which they would carry out brick moulding activities and (ii) cutting down trees for firewood to burn their bricks. The burning of bricks required large amounts of wet firewood resulting in large miombo trees being selectively removed.

Communities are also highly dependent on forests as a source of firewood for household use (Table 3.2, Restraining Force 1). Participants were aware that to keep a stable forest, there should be a balance between off-take and the forest's ability to regenerate. Participants affirmed their desire to conserve forests for the future generation, in spite of the fact that they do not have viable alternative sources of fuel. The majority of them cannot afford alternative fuels such as liquefied petroleum gas. They have also not been introduced to other efficient cooking stoves.

According to focus group discussion participants, the very few households that could afford alternative fuel could not readily access it since the providers are only found in urban areas and at a few growth points. The challenge, according to participants, is accentuated by the Forestry Commission's failure to supply local communities with trees for planting to restore degraded forests through afforestation and reforestation. Participants argued that plantations which were started by communities from trees

they got from the Forestry Commission used to reduce pressure on indigenous forests since communities got alternative sources of firewood. One focus group participant emphasised that the involvement of the Forestry Commission in supporting reforestation was essential in maintaining the balance between extraction of firewood and regeneration of forests.

During the focus group discussion, participants pointed out that there is massive land clearing in the area to support increasing agricultural activities. This is supported by figures 4, 5 and 6 that show an increase in crop land by 43%, 20% and 9% over a period of 30 years in wards 28, 26 and 27, respectively. One of the major reasons for the expanding of agricultural land was that farmers are practising extensive agriculture and need more land in order to increase production so as to self-insure against food insecurity. Participants stated that smallholder farmers were no longer getting good yields because their soils were exhausted. Poor yields were also exacerbated by the adverse effects of climate change which include poor rainfall and high temperature. This has caused smallholder farmers to clear more forests to create virgin land that is naturally fertile. Farmers also expected their yields to increase with the increase in the land under cultivation.

The expansion of agricultural land is also on the rise especially in wards 26 and 28 owing to the increase in population. The rapid increase in the population is causing farmers to encroach into forest land. The large number of people who settled in forest land were those who had left their parents' household to start their own families. These need land to settle and for farming purposes. Participants also stated that pressure on forests emanated from urban to rural migration since people were moving back from towns as a result of unemployment. It was also expressed by one village head who was part of the focus group that as the pressure increases, local leaders are forced to allocate people land in the forests. Efforts by local leaders and government agencies to manage forests sustainably are weakened by the pressure emanating from natural population increase and urban to rural migration.

During the focus group discussions, participants explained that devastating and persistent droughts are now forcing the smallholder farmers to cultivate in the few wetlands that exist in the area, in order to escape hunger. The wetlands gardens are fenced by poles and branches extracted from forests in order to protect crops and vegetables from livestock. The smallholder farmers cut a large number of trees for poles and branches to fence their gardens. Having a garden in wetlands ensures better yields and provides household income after selling the produce both during the dry and wet seasons. The demand for poles and branches for fencing is being accentuated by the fact that most smallholder farmers are poor and cannot afford to buy barbed wire and fence.

Maintaining healthy forest ecosystems was hindered by the encroachment of Lantana camara in miombo woodland (Restraining Force 4). According to participants from one focus group discussion, Lantana camara suffocates native miombo trees and impedes the regeneration of seedlings, which leads to a decrease in the population of miombo. Although community members were trying to control the invasive species, it grew faster than the rate at which it was being removed.

Climate change and climate unpredictability have also resulted in rainfall variability, which is one of the major restraining forces which threatens the existence of healthy forests. Participants highlighted that recurrent droughts have negatively affected the health of their forests. Focus group participants said that persistent and extended droughts have resulted in the reduction in soil moisture, which has resulted in the drying up of large trees at an alarming rate. Participants also confirmed that tree seeds were germinating after a rain event, but they were not growing into mature trees because the young trees would not have long taproots to access the water table which would be very low

Discussion

One would expect forest ecosystems to be healthy in the three wards due to the availability of local institutional arrangements since local leaders encourage people to conserve forests. Local communities have the ability to self-regulate when they realise that their resources are in danger of depletion (Yuliani et al., 2018), the assumption being that resource users recognise the intrinsic value that is in natural resources such as forests. However, forests in the area are under threat due to community overdependence on them for firewood, crop land and fencing materials. The overdependence on forests renders formal and informal institutional arrangements incapable of conserving forests and managing utilisation patterns. As such, forests are failing to regenerate.

The need for survival, coupled with desperation, poverty and lack of alternative sources of fuel, is putting forests under threat of degradation. Efforts from EMA to limit illegal extraction of forest resources are hindered by the lack of human and financial resources. As such, co-management mechanisms are ineffective. Even in the presence of co-management arrangements between local communities, local leaders and government agencies, forests remain under the risk of further degradation due to the fact that what drives people to overexploit forests is stronger than the need to conserve them. The findings are supported by Oyanedel, Gelcich and Milner-Gulland (2020), who argue that individuals have a tendency of disregarding sustainable exploitation of resources when opportunities presented by legitimate activities are inadequate and incapable of sustaining them. Resource users may be well aware of both short- and long-term impacts of overexploitation; but they may not have an incentive to think of

other resource users (Colin-Castillo & Woodward, 2015). Human dependence on forests is a multifaceted phenomenon because forests provide a diverse stream of benefits to humans, a fact which puts forests at a vulnerable position (Garekae, Thakadu & Lepetu, 2017). It is consequently difficult to maintain healthy forests in areas where people overly depend on forests for their survival. Thus, forests remain in danger due to individual choices and the need to earn a living which is a strong restraining force to the maintenance of healthy forest ecosystems.

Natural resources can be managed sustainably through community involvement, collective action and cooperation (Flanery et al., 2020). The results show that communities can work together to achieve a common good such as controlling an invasive species and forcing compliance to forest management regulations. The results from focus group discussions and LULC change analysis show that the efforts by communities were not enough since forests are disappearing. The rate at which invasive species are growing and disturbing the regeneration of native *miombo* woodlands exceeds community efforts to control the invasive species. Compliance to regulations was not universal since only those who had forests complied. Forests belonging to villages that comply were threatened by external poachers who disregarded forest management regulations. Compliance or non-compliance is an instrumental decision that is made by individuals after calculating gains when rules are complied with, and the costs of not complying, given the probability of being apprehended (Acheampong & Maryudi, 2020). Poachers seem to be gaining more from their illegal activities since chances of being apprehended are very low.

Ecological integrity and the ability of forests to regenerate are key parameters that determine the maintenance of healthy forests (Ordóñez & Duinker, 2012; Wurtzebach & Schultz, 2016). Adequate rainfall is one of the factors that ensure natural regeneration of forests (Khaine et al., 2018). The results show that shortage of rainfall is perceived as impeding the capacity of forests to regenerate naturally. There is an imbalance between the regeneration capacity of forests and exploitation patterns. The findings do not support the view by Garver (2017) that humans reduce exploitation when they realise that their natural resources are ecologically vulnerable. Human exploitation patterns were not being determined by the fact that forests are not regenerating optimally. Instead, the major influence was the people's need to earn a living from forest products. The vulnerability of forests in the area is worsened by the failure of forests to regenerate, which is coupled with high exploitation rates due to community overdependence on forests for livelihoods.

Conclusion

Despite the presence of forest co-management arrangements and community involvement in the conservation of healthy forest ecosystems, forests are threatened

by the need to meet food and income security from forest resources, poverty prevalence which emerges in the form of lack of alternative fuel, and overdependence on forests. Climate change is also increasing the vulnerability of forests. Drivers of forest conservation are outweighed by restraining forces. The social-ecological systems which threaten the existence of forests should be addressed in order to improve the health status of the forest ecosystems.

Recommendations

Communities in the three wards in Murehwa District over depend on forests for firewood to burn bricks and cure tobacco. They, however, also have a desire to maintain healthy forests. The Forestry Commission can assist by providing saplings to develop community plantations that will be used as alternative sources of fuelwood and poles. This will alleviate pressure on natural forests. The government and development partners should introduce other ways of cooking that save firewood, such as the use of tsotso stove or jengeta huni/ quedidubo stove. This will ease pressure on forests and increase efficiency. Gardens can be fenced using live fences instead of poles and branches of trees. Agricultural extension officers should teach farmers sustainable agricultural intensification pathways such as improving the fertility of soils already under cultivation by using green manure from forests. Community members will be motivated to conserve forests as a source of manure to improve their soils.

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