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A study of the roles, opportunities and challenges of environmental sub-committees (ESCs): A case of Masvingo district, Zimbabwe.

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Abstract

Zimbabwe is committed to the implementation of environmental management strategies that promote the conservation of biological diversity while supporting sustainable utilisation of natural resources. As part of this strategy, Environmental Sub-Committees have been established throughout the country in order to support the work of Environmental Committees. This study was conducted in Masvingo District to determine the role of Environmental Sub-Committees in Natural Resources Management and the challenges they face. Purposive sampling was used to select the respondents in the Wards which had functional committees. Questionnaires were used in interviews with 38 Environmental Sub-Committee members from 12 wards as well as representatives from 8 organisations that interface with Environmental Sub-Committees. The results showed that the major roles of Environmental Sub-Committees were related to promoting environmental awareness and in the enforcement of environmental laws. Major challenges faced by Environmental Sub-Committees were resistance from the communities, absence of an Environmental sub-Committee identification system and inadequate transport. The majority of the respondents highlighted that there was a need to amend several by-laws in order to enhance environmental protection within the District. The most common offences are related to deforestation (41%), veld fires (27%) and gold panning (12%). There was a high incidence of repeat offenders and this was attributed to the non-deterrent fines currently in place. It was therefore recommended that Environmental Sub-Committees should strengthen efforts to create awareness of their activities among those stakeholders who are also involved in natural resources management. Environmental Sub-Committees can play a pivotal role in Natural Resources Management if the challenges that they face are fully addressed.

Key words: Environmental Sub-Committees, Masvingo District, Natural Resources Management, Environmental protection, Sustainable Utilisation, Zimbabwe

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1. Introduction

Zimbabwe is committed to environmental management and the conservation of biological diversity. Consequently, at the international level, the country is a signatory to several Multilateral Environmental Agreements (MEAs). These include the Convention on Biological Diversity (CBD), (Convention on Biological Diversity, 1992), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1973 as amended), Convention on Wetlands of International Importance, especially as waterfowl habitat (Ramsar, 1971), United Nations Framework Convention on Climate Change (1992) (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD).

At the national level, Zimbabwe's Constitution implicitly recognises the importance of these MEAs. Section 34 of Chapter 2 of the constitution states that "The state must ensure that all international conventions, treaties and agreements to which Zimbabwe is a party are incorporated into domestic law," (Constitution of Zimbabwe, 2013). In line with this Constitutional provision, several Acts of Parliament on the environment have been enacted. The Act that deals with environmental issues is the Environmental Management Act (Chapter 20:27 of 2003). The Act provides for the establishment of an Environmental Management Agency (EMA). This Agency is mandated to implement the provisions of the Act. One of the major objectives of the Act is to provide for the sustainable management of natural resources and the protection of the environment (Environmental Management Act, 2003). Other Acts that support the Environmental Management Act include the Parks and Wildlife Act, Chapter 20:14 (Parks and Wildlife Act, 1996 as amended), Forest Act, Chapter 19:05 which was amended in 2002 (Forest Act, 2002), Rural District Council Act, Chapter 29:13 (Rural District Council Act, 1993) and the Traditional Leaders Act, Chapter 29:17 (Traditional Leaders Act, 2000).

In Zimbabwe, state land that is communally owned, (Communal Lands), is under the jurisdiction of the local authorities (Rural District Councils). The traditional leaders also have some responsibilities over this land in terms of the Traditional Leaders Act. The Environmental Management Act has provision for the delegation of responsibilities related to environmental issues, to the Rural District Councils (RDCs). Consequently, in communal lands, the Environmental Management Agency works closely with the both the Rural District Councils and the community structures including the Traditional leaders.

In Masvingo District, most of the land is communal land. The problem with communally owned resources is of shared responsibilities which result in lack of accountability. This leads to the reckless and unsustainable exploitation of natural resources (Masiiwa, 2004). To protect the environment from the '*tragedy of the commons'* (Murphree, 1997), mechanisms must be put in place for communities to participate in the management of natural resources. In order to assist in the dissemination of environmental information, the Environmental Management Agency has established Environmental Committees (ECs) and Environmental Sub-Committees (ESCs), (www.ema.co.zw).

In terms of the Traditional Leaders Act (2000), the duties of the chief include, *inter alia*, "ensuring that the land and its natural resources are used and exploited in terms of the law, and in particular, controlling over-cultivation, over-grazing, indiscriminate destruction of flora and fauna, and illegal settlement, and generally preventing the

degradation, abuse and misuse of land and natural resources in his area." (Traditional Leaders Act, 2000).

In order to ensure that the Chief's duties with respect to natural resources and the environment are incorporated in the activities of the ESCs, the composition of the ESCs includes one Chief or his/her representative. Thus, the composition of an ESCs should adhere to the following guidelines; (a) The Committee shall have not less than 5 and not more than 14 members appointed by the local authority (the Rural District Council), (b) A Chairperson who shall be the Councillor for the Ward, (c) One Chief or his representative and, (d) Any co-opted member who shall be a local resident and should have a proven track record of sustainable management of natural resources. Thus, the establishment of ESCs is meant to enhance a participatory approach to natural resources management. The objective of this study was to assess the roles of ESCs as well as the opportunities and challenges faced by these ESCs in promoting sound natural resource management in Communal Lands. A Case Study approach was used.

2. Materials and Methods

2.1 Study Area

The study was conducted in Masvingo District in Masvingo Province (Figure 1). The Province is located in Southern Zimbabwe (Figure 1). Masvingo District has 35 administrative wards and wards, 29 out of 35 wards have Environmental Sub-Committees. The study covered wards 1, 2, 5, 6, 7, 8, 14, 23, 24, 26, 31 and 32 (Figure 1).

2.2 Data collection

Purposive systematic sampling was used to select the respondents in the study from wards with functioning ESCs. Ward numbers were written on small pieces of paper and the first 12 selected ward numbers were to be sampled. The 12 sampled ESCs had a total of 38 respondents. The research included 8 different organisations which are involved directly or have some activities involving natural resources management within the District. These organisations were Environmental Management Agency, SAFIRE (Southern Alliance for Indigenous Resources), Forestry Commission, Ministry of Agriculture, Mechanisation and Irrigation Development, Masvingo Rural District Council, Care International, Zimbabwe Republic Police and Madzivanyika High School. The committees were chosen based on various activities carried out in a particular ward which include type of vegetation, land tenure system, economic activities (agriculture, mining), wards which are affected by non-residents of the wards and their activities such as industrialisation resulting in pollution for example wards surrounding Masvingo City. From each committee four respondents who included the chairman (ward councillor), secretary, monitor and any other committee member were selected.

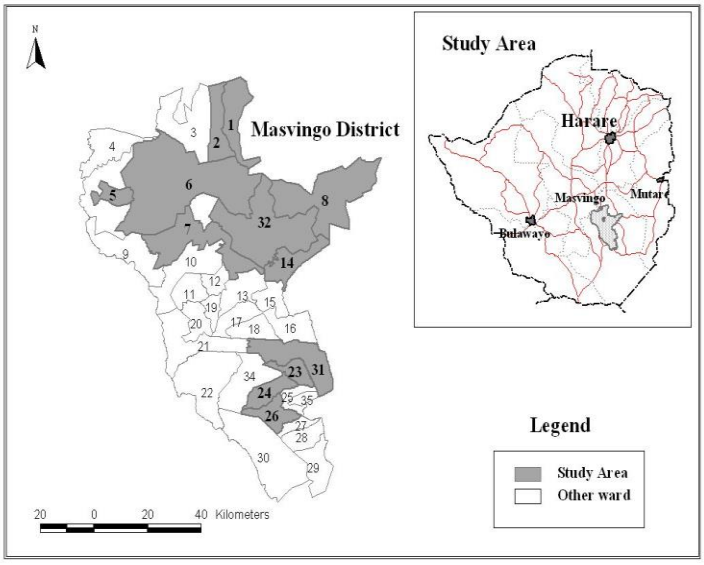

Figure 1: Map showing the study area.

2.3 Data Analysis

The data were analysed using Statistical Package for the Social Sciences (SPSS v.17) software. Data were analysed using descriptive statistics to produce tables and graphs.

Results

A total of 48 questionnaires were administered to the 12 selected ESCs and the response rate was 79%. For organisations, the response rate was 73%. The average response rate for this research was therefore 76%.

There were 63% male respondents and 37% female respondents. On average, 29% of the respondents were aged between 20 to 40 years, 55% were aged between 41 and 60 years, while 16% were aged 61 years and above.

Table 1: Major roles of ESCs as reported by respondents

Role	Frequency of response
Promoting environmental awareness among the public	25
Enforcing environmental laws	12
Protecting natural resources	9
Advising stakeholders on environmental issues	2
Educating local leaders on environmental issues	1
Reporting offenders to relevant authorities	1
Resolving conflicts	1

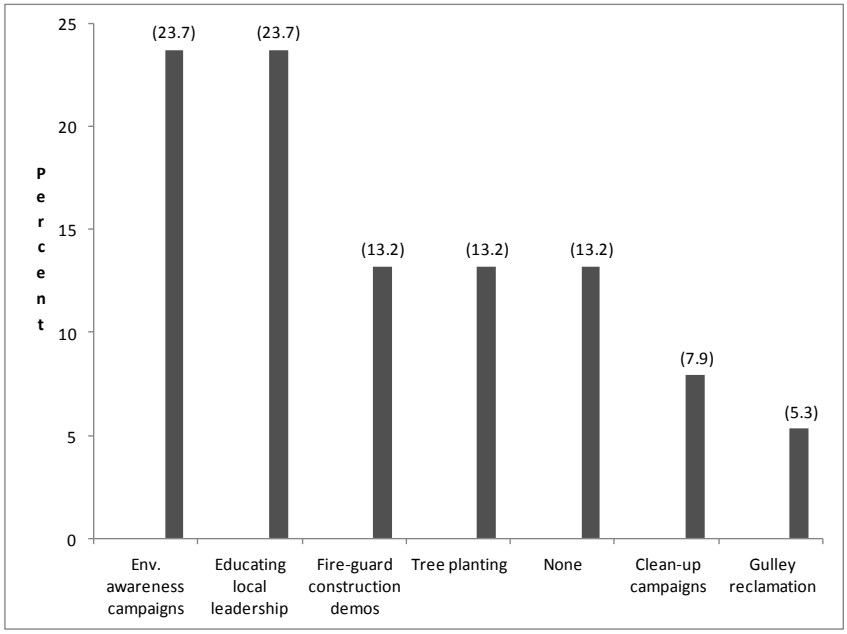

Figure 2: Major activities that are promoted by ESCs

Table 2: Major challenges faced by ESCs

Challenge faced	Frequency of response
Resistance from the community	18
Lack of ESC Identification systems	12
Inadequate ESC transport	7
Conflict with local leadership	4
Lack of regular funding for ESC activities	4
Ignorance among stakeholders	3
Lack of arresting/enforcement powers for ESCs	2
Politicising of ESC role	2
Inadequate (soft) penalties for offenders	1
Lack of ESC meetings	1

The ESC members promote sustainable natural resources management through various activities that include environmental awareness/education programmes, advisory services as well as enforcing environmental regulations. The ESC members carry out several activities that include tree planting, gulley reclamation carried out by ESCs programmes as well as demonstrating the correct way of constructing fire-guards. All these activities promote environmental protection and sustainable

natural resource utilisation. The ESCs face several challenges. The major challenges relate to resistance by the community, the lack of an identification system and inadequate transport. Other challenges are related to the lack of arresting powers, and in some cases, the ESC role is politicised where some local leaders may want to bring politics into ESC activities. With respect to the local communities' appreciation of the role of ESCs in natural resources conservation, 55% of the respondents agreed that the community appreciated the ESC role, 37% indicated that the communities did not appreciate the ESC role, while 8% were not sure.

On the issue of the importance of ESCs to improved natural resources management, in their localities, 76% of the respondents felt that the ESCs were important, while 24% felt that the ESCs were not important. The majority of the respondents (63%) concurred that traditional leaders promoted sustainable natural resources management, while 32% disagreed and 5% were not sure. Figure 3 shows the authorities and organisations where the ESC members report offences. The majority of the ESC members report offenders either to the local leaders, or to the Zimbabwe Republic Police (ZRP). A few of the ESC members report offences either to the local offices of EMA (Environmental Management Agency) or to the RDC (Rural District Council).The occurrence of repeat offenders was reported to be high as 71% of the respondents indicated that they had handled cases of repeat offenders while 29% of the respondents reported that they had not had such incidences. Deforestation, veld fires and gold panning are the more prevalent offences, while fishing with nets, stream-bank cultivation, use of wooden sledges and tree ring-barking are less prevalent. Most of the ESC members who were interviewed (87%) noted that there was a need to amend the Rural District Council by-laws that are focused on environmental management, 10% of the members stated that there was no need to amend the by-laws, while 3% were not sure.

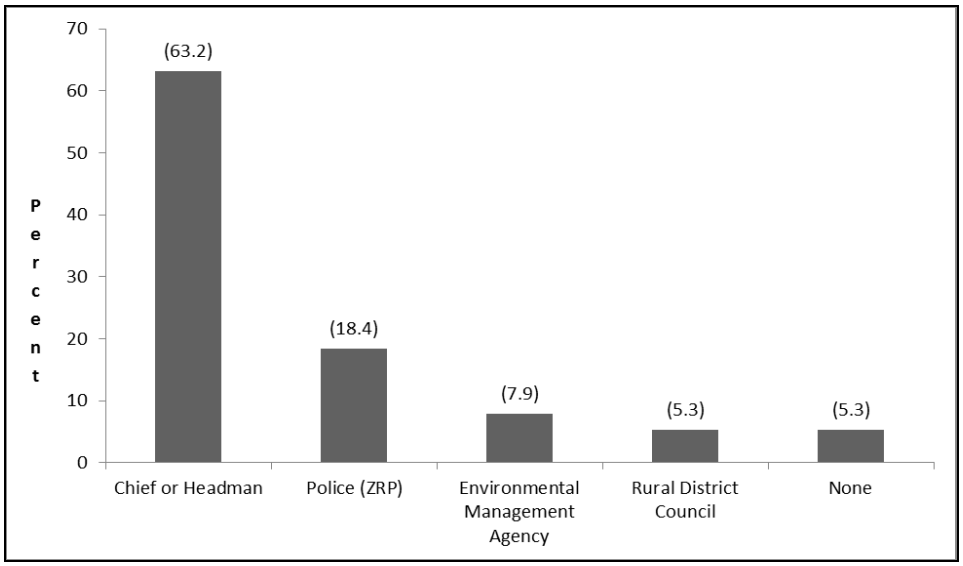

Figure 3. Authorities and organisations where ESCs members can report environmental offences.

Table 3: Common offences reported by ESCs

Offence	%
Deforestation	41
Veld Fires	27
Gold panning	12
Fishing with nets	7
Stream-bank cultivation	5
Use of wooden sledges	5
Tree ring-barking	2

Table 4: Recommended amendments to by-laws, as suggested by respondents

Recommendation	Frequency
Fine should be raised	10
Punishment/Fines for local leadership should be raised	5
Veld fires	3
Gold panning	2
Mine collapsing	2
Deforestation	1
Fines should be specific	1
Number of stock (livestock) kept by each household	1
Pollution	1
Sand extraction.	1

The amendments to the by-laws were to include the increasing of the fines in terms of the penalty fee. It was also recommended that the fines that relate to the local leadership had to be increased as well. More detailed by-laws relating to veld fires, gold panning, mine collapses and deforestation had to be formulated. There was need to formulate by-laws to regulate the number of livestock kept by each household in order to curb overgrazing. By-laws relating to sand extraction and pollution, especially aquatic pollution also had to be revised to make them more stringent. Most of the organisations that were interviewed (87%) were aware of the ESCs' activities, and only 13% were not aware of the activities carried out by the ESCs. Only 63% of the organisations that were interviewed confirmed that they received reports from the ESCs, while 37% did not receive any reports.

Discussion

The results of the study showed that there were more male committee members (63%) than female members (37%) who responded to the questionnaires. The sampling approach was random in terms of gender and hence the differences in the percentages of males and females who responded could be as a result of that there are more males than females in the ESCs. It is worth noting that at least 16% of the respondents were above 60 years of age. This is important because these individuals have been resident in the area for a long time and they had a lot of institutional memory, especially with respect to environmental issues. The major roles of ESC members' are highlighted in Table 1. The members indicated that their major roles included promoting environmental awareness among the public, enforcing environmental laws and protecting natural resources. The indicated roles were in line with their mandate as ESC members. As part of their mandate, the ESC members carry out a number of activities which are shown in Figure 2 to promote sound environmental protection and environmental management.

Several challenges are faced by the ESC members. These challenges included resistance by the communities, lack of identification systems, inadequate transport, lack of funding and conflict with the local leadership (traditional leaders). These challenges limit the effectiveness of the ESCs. However, these challenges were not unique to Masvingo District alone as similar problems have been reported by Agrawal and Gibson (1999), Armitage (2005), Pagdee et al. (2006) and Gruber, (2010), With respect to lack of an identification system, some of the ESC members recommended that this could be addressed by either issuing them with identification cards related to their work or providing them with specific clothing (e.g. reflective vests, or uniforms with a specific logo), or both.

The majority of the ESC members felt that local communities appreciated their role in natural resources conservation (Table 6), while 33% of the members () felt that their role was not appreciated, with only a few 8% who were not sure. The percentage of members who felt that their role was not appreciated highlights the need to conduct further studies to establish the community members' perceptions of the ESC. Gandiwa et al. (2015) noted that the absence of grassroots institutions and structures for enforcement and management can be a constraint to the enforcement of rules. In the current study, while the devolved structures are in place, in the form of the ESCs, they still lack the legal backing to enforce the rules. Most ESC members (76%) were of the view that they played an important role in improving natural resources management in their locality. However, 24% of the respondents felt that the ESCs were not important in improved natural resources management. This negative perception could have been due partly to factors such as lack of powers to arrest /enforce laws and conflicts with local leaders (Table 2). This has been a challenge, especially in the smallholder farming areas where the ESC, together with local leadership were rendered powerless in governing natural resources under their governance by the centralised government system. The same observation was also reported by Chinamatira et. al. (2014).

While 63% of the ESC members felt that traditional leaders promoted sustainable natural resources management, about one-third (32%) had a contrary view, while a few (5%) were not sure. Conflict with traditional leaders was highlighted as

one of the challenges (Table 2) and this conflict may have contributed to the perception that traditional leaders did not promote natural resources management. Muchapondwa and Stage (2015) also reported that conflicts may occur between traditional and modern/political structures. They concluded that the disharmony between these structures can reduce the effectiveness of conservation at the local level. Given that almost a third of the ESC members felt that traditional leaders did not promote natural resources management, this lack of implementation has to be explored further through a study that will ascertain in detail the relations and interactions between the Environmental Monitors and the Chiefs and Headmen, especially with respect to natural resources management.

Since the ESC members do not have powers to arrest, they have to report offences to different authorities. Most of the ESC members reported either to the Chief or Headman (63%). Other members reported to the Police (18%), the Environmental Management Agency (EMA) staff and the Rural District Council (5%). Those who did not make any reports may have been frustrated as a result of the non-deterrent fines which some of the ESC members felt were too lenient (Table 2). The ability to enforce regulations is an important factor in successful Community Based Natural Resources Management (Armitage, 2005; Barrett et al, 2005; Pagdee et al, 2006)

There was a high incidence (71%) of repeat offenders. The "soft" (lenient) penalties may be a contributory factor as well as the needs of the communities. The common offences are shown in Table 3. The three common offences were deforestation/tree-cutting, veld fires and gold panning. While tree-cutting and gold panning are related directly to meeting livelihood/household needs, the issue of a high incidence of intentional veld fires requires further investigation since this has become a national problem. It is also worth noting that wooden sledges are still in use despite their having been banned. These sledges increase the increase the risk of soil erosion and contribute to deforestation as they are made from trees.

There was concurrence among the majority of ESC members (87%) for the need to amend some of the RDC by-laws in order to enhance environmental protection. Details of the proposed amendments are shown in Table 4. There was a strong consensus for increasing the fines so as to make them enough of a deterrent. Other recommendations were also related to strengthening the by-laws so as to enhance environmental protection and improve natural resources management.

The majority of the organisations that were interviewed (87%) were aware of the ESCs and their activities. Only 13% were unaware of the ESC activities. The ESC members should make every effort to increase the awareness of their activities among stakeholder organisations through various methods such as visits to the various organisations or through the print media.

The majority of stakeholder organisations (63%) indicated that they did not receive reports from the ESC. Only a few (37%) of the stakeholder organisations indicated that they received reports from the ESC. Notwithstanding the financial constraints that the ESCs face, the ESC members should endeavour to inform their major stakeholders using various channels of communication. These can include the traditional reports as well as social media platforms.

4. Conclusion

The findings of this study show that the Environmental Sub-Committees play an important role in environmental protection and natural resources management. However, their effectiveness is hampered by several challenges. Efforts should be made by the relevant stakeholders, to address these challenges so that the ESCs' contribution to the management of the nation's environmental resources is enhanced. These include provision of financial resources to the ESCs as well as facilitating the participation of ESC members whenever these organisations are carrying out activities related to environmental management. Berkes (2004) noted that in community-based conservation initiatives, equity and empowerment are often more important than monetary incentives.

Acknowledgements

The co-operation of all the ESC members who participated in this study is gratefully acknowledged. The representatives of Environmental Management Agency, SAFIRE (Southern Alliance for Indigenous Resources), Forestry Commission, Ministry of Agriculture, Mechanisation and Irrigation Development, Masvingo Rural District Council, Care International, Zimbabwe Republic Police and Madzivanyika High School who accepted to be interviewed during this study are also acknowledged.

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The dynamics of land use-land cover changes for the years 1984, 1992, 2001 and 2014 in Mutasa district, Zimbabwe.

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Abstract

Tropical woodlands in southern Africa are a primary focus of conservation efforts because they are currently under threat from rapid clearing for agriculture and human settlements. A study was carried out in Mutasa district (18°35′0″S and 32°45′0″E) in northern Eastern Zimbabwe using data that spanned the period 1984 to 2014 in order to quantify the spatial and following the conversion to agricultural lands. The land cover changes analysis for the district showed a marked decline in land areas under woodland and considerable increase in area devoted to cultivation. Temporal land-use and land cover changes in Mutasa district on the woodland and plantation forests cover. The annual rate of net cover change from natural woodland to cropland in the district was 0.8% and this was generally higher than the annual rate of net cover changes in tropical Africa which averages 0.36%. The period from 1992 to witnessed the highest daily conversion rate of commercial farm land under woodland (miombo) and forest plantations to cropland of about 3 ha per day and this also coincided with the Fast Track Land Reform Programme which started in 2000.

Keywords: land cover change; deforestation; environment; resettlement.

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1. Introduction

Land use and land cover changes are a global concern because of the negative impacts that they have on the environment (Ademiluyi, 2008; Getahun and Van Lanen, 2015). Land cover is generally described as the observed bio-physical cover of the Earth's surface that includes vegetation, inland water surfaces, bare soil, bare rock as well as man-made features (Awotwi, 2009; Mwangi et al., 2016b). On a fundamental level, land cover is the most important element for description of the study of the environment (Malmer et al., 2010; Bodart et al., 2013). Land use, by contrast, describes activities that take place

on the land and represent the current use of the land resource (Fonji and Taff, 2014). Land use and land cover (LULC) change has been recognized as an important driver of global environmental change at spatial and temporal scales (Varkonyi-Koczy, 2010; Zewdie and Csaplovies, 2015). Land use and land cover changes are intertwined in many ways with other environmental issues, such as climate change, carbon cycle, loss of biodiversity, sustainability of agriculture and provision of safe drinking water (Ademiluyi, 2008; Lambin and Meyfroidt, 2011). The recently adopted implementation plan of the Group on Earth Observation (Craglia et al., 2017) highlights the importance of land cover for all areas of societal benefits. In this context, the United Nation's Conference on Environment and Development's Agenda 21, the World Summit on Sustainable Development (WCCD) in Johannesburg 2002, and previous UN conventions, most prominently the United Nations Framework Convention on Climate Change (UNFCCC), have further emphasised the importance of LULC and change dynamics as key variables in global change phenomenon (Guo et al., 2010; Vittek et al., 2014).

Land cover changes rapidly over time and is a good proxy for dynamics of Earth surface resulting from the variety of drivers and factors (Kashaigili and Majaliwa, 2010; Malmer et al., 2010). Land cover change is the most obvious and detectable indicator of human interventions on the environment (Ademiluyi, 2008; Getahun and Van Lanen, 2015). Land cover change can either be in form of substitution of, for example, forest land by agriculture or in other cases land cover changes involve small changes of land cover type while retaining the primary status, such as bush land to exotic forest (Zewdie and Csaplovies, 2015). Land use land cover changes in forest biomes are known to negatively impact on species diversity as well as leading to forest degradation and deforestation (Malmer et al., 2010; Salemi et al., 2013; Zewdie and Csaplovies, 2015). Empirical studies have established the positive relationship that often exists between habitat area and species richness (Salami et al., 2013; Pimm et al., 2014). A commonly accepted definition of forest is the one from the United Nations Food and Agriculture Organization (FAO), which includes natural forests and forest plantations (FAO, 2010; O'Connor et al., 2013). According to the FAO (2010) deforestation occurs when forest is converted to another land cover or when the tree canopy cover falls below a minimum percentage threshold of 10%. Forest degradation is defined as a process leading to a temporary or permanent deterioration in the density or structure of vegetation cover or its species composition (Salemi et al., 2013; O'Connor et al., 2014), and thus lowering the productive capacity of the forest (Gibbs et al., 2007; Bodart et al., 2013).

In Zimbabwe it is estimated that about 30 000 hectares of forest land is converted to agriculture every year (FAO, 2010). The root causes behind land use land cover changes in various countries differ, although their impacts on forest cover and species diversity are almost similar (Pimm et al., 2014). The main causes of forest loss include demographic and institutional changes, adopted development policies, political and social-cultural forces, war and development of infrastructure (Martson, 2010; Getahun and Lanen, 2015). Rapid depletion of forests in the country has been associated with increase in population, intensification of agricultural activities and increased demand for forests products (Malmer et al., 2010; Mwangi et al., 2016b).

In situations of rapid land cover land use change, earth observations provide objective information of human utilization of the landscape (Vittek et al., 2014). Remote

sensing is a useful tool for monitoring the environment and has had an important contribution in documenting land cover change on regional and global spatial scales since the early 70's when the Landsat Multi-Spectral Scanner (MSS) provided the first commercial satellite images (Lambin and Meyfroidt, 2011; Redo et al., 2011; Getahun et al., 2015). Viewing the Earth from space is crucial in understanding of the influence of human activities on forest resources over time (Lambin and Meyfroidt, 2011; Zewdie and Csaplovies, 2015). Data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructure, managing natural resources and studying environmental change (Awotwi, 2009; FAO, 2010; Lambin and Meyfroidt, 2011; Gessner et al., 2013).

In the past three decades, the satellite earth observation has witnessed remarkable improvements in satellite image quality in terms of spectral and spatial resolution (Whiteside et al., 2011; Zewdie and Csaplovies, 2015) as well as in digital data processing algorithms, analyses and interpretation (Kashaigili and Majaliwa, 2010). The improvements in satellite images, along with the progress in the integration of Earth observation and geographical information systems (GIS), has vastly increased opportunities for environmental quantitative analysis (Zewdie and Csaplovies, 2015). The collection of remotely sensed data facilitates the synoptic analyses of Earth-system function, partitioning, and change at local, regional and global scales over time (Ademiluyi, 2008). Such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Awotwi, 2009; Pimm et al., 2014; Zewdie and Csaplovies, 2015).

Despite the growth in earth observation and GIS technologies, spatially explicit information on forest cover conversion throughout the sub-tropics has not previously been available to identify locations of most rapid change and in Mutasa district this information is not available. This study, therefore sought to examine the spatial and temporal land use land cover changes in Mutasa district in Zimbabwe over three decades from 1984 to 2014. The study also evaluated the effects of the government initiated resettlement exercises in Mutasa district on land use and land cover changes over the 30-year period.

2. Materials and methods

2.1 Description of study area

The study was conducted in Mutasa district (18°35′0″S and 32°45′0″E), in the eastern highlands of Zimbabwe (Figure 1). The district lies in Agro-Ecological Region II of the country which experiences an annual total rainfall that ranges between 800 to 1000 mm (Mugandani et al., 2012). Most of the rainfall is received in the summer season which is from November to March. The mean annual temperature is around 20°C although high temperatures of up to 35°C can be recorded during the hot months of October to December. Winter seasons can be extreme in some years recording temperatures as low as –3°C between May and July (Mugandani et al., 2012).

The economy of Mutasa district is mainly dependent on large scale commercial plantations and farms that produce timber, coffee and tea. Since the early 1980s,

Mutasa district has been characterised by a shift in land use systems as a result of the land resettlement programmes initiated by the Government of Zimbabwe aimed at decongesting communal areas and redistributing land to landless natives. The resettlement programmes

saw some commercial farming areas being converted to resettlement areas. Commercial farming areas in Zimbabwe at independence in 1980 were generally natural woodlands and forest areas of the commercial farmland. The district has also experienced a significant increase in population from the early 1980s. In 1982 the district had a total population of 118 002 which significantly grew to 168 747 by 2012 (ZimStats, 2012) (Table 1).

2.2. Establishment of land use/land cover changes between 1984 and 2014. Four Landsat images acquired during the month of August in 1984; 1992; 2001 and 2014 were used in the study. Satellite images during the dry season month of August for each year were used in order to avoid the negative influence of cloud cover on image clarity. The four satellite images were used to produce land use land cover classification maps of Mutasa district. The Landsat satellite images were downloaded from Global Land Cover Facility of the University of Maryland, USA (http://glcf.umd.edu/data/landsat/). Table 2 shows the actual dates, the spatial resolution and the path and row of the Landsat images used in the study. The Landsat image for 1984 was chosen as the starting point because it marked the beginning of the resettlement programme by the Government of Zimbabwe. The 1992 Landsat image was selected for land cover and land use changes analysis in Mutasa district because it marked the onset of Phase 1 and II of the resettlement program which was operational until 1999. In a bid to speed up the process of land acquisition and resettlement, the government passed the Land Acquisition Act of 1992, following the introduction in 1990 of Constitutional Amendment Number 11.

characterised by well vegetated farmlands. The onset of the resettlement exercises marked the beginning of a rapid encroachment of crop cultivation activities into the

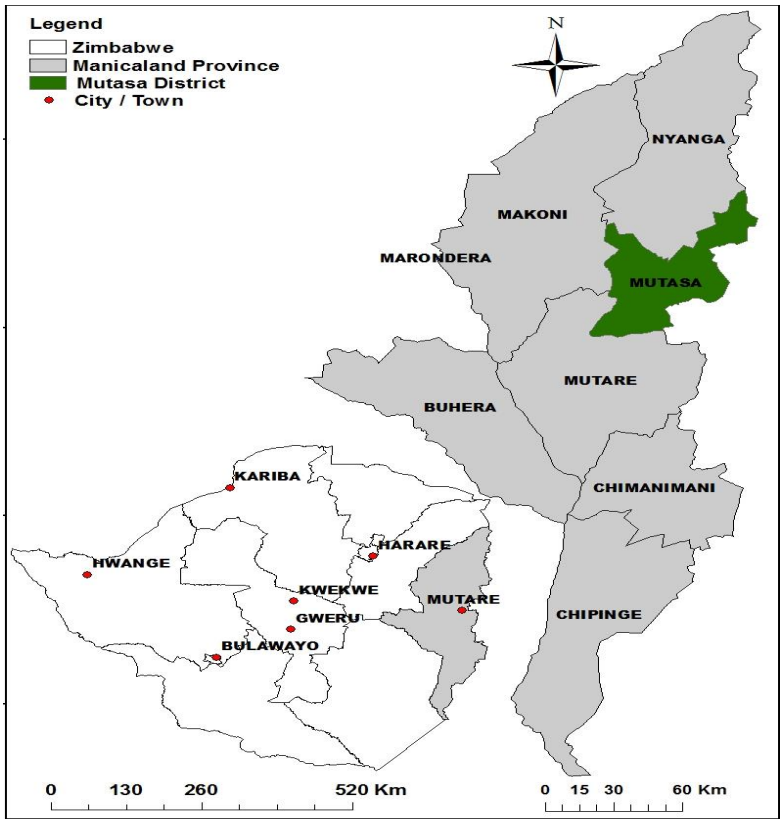

Figure 1: Location map of Mutasa district

Table 1: Population figures for Mutasa district (1982, 2002 and 2012).

Year	Male	Female	Total Population
1982	54 546	63 456	118 002
2002	78 470	88 176	166 646
2012	79 548	89 199	168 747

Source: ZimStas, 2012

This period witnessed a further conversion of the generally well vegetated commercial farmland into resettlement areas in which the smallholder farmers are more inclined to dry land cultivation of the staple maize crop after clearing the land. A further decline in the area under natural woodlands in response to the increase in the land under resettlement was anticipated during this period. This1992 period is also of particular importance for the fact that it witnessed the completion of the Osborne dam that flooded an area of 2600 ha under smallholder farming. This necessitated an involuntary relocation of smallholder communities to commercial farming areas of the district. During the period from 2000 to 2003 the government of Zimbabwe again initiated the Fast Track Land Redistribution Programme (FTLRP) in response to the slow pace of land redistribution under

Phase 1 and Phase II of the resettlement program. The program was characterized by massive land occupations of commercial farming areas as well as in previously ecologically preserved areas. The program saw large tracts of land being converted to communal settlements and small farming plots under the A1 and A2 models. It has been reported that the fast track land reform program has left most of the country's forests facing a serious threat of deforestation, increasing from 1.41% (1990–2000) to 16.4% (2000–2005) (Dalu et al., 2013).

2.3 Image Pre-processing

Remotely sensed raw images from satellites are full of geometric and radiometric flaws caused commonly by the curved shape of the earth, the imperfectly transparent atmosphere, daily and seasonal variations in the amount of solar radiation received at the surface, and imperfections in scanning instruments, among other things. While the 1984, 1992, 2001 and 2014, Landsat images were initially corrected by USGS Earth Resource Observation Systems Data Centre to a quality level of 1G (Jolla, 2010), the images were further radiometrically and geometrically corrected to enhance comparability of images from different years at pixel level. Digital numbers in individual bands were converted to radiance using the Gain and Bias method in ENVI. The Gain and Bias method uses the following formula:

$$L = gain * DN + bias \qquad (1)$$

Where **L** is the cell value as radiance; **DN** is the cell value digital number; **gain** is the gain value for a specific band; **bias** is the bias value for a specific band. After converting the digital numbers to radiance, the bands were atmospherically corrected using Quick Atmospheric Correction (QUAC) procedure in ENVI 4.7. The three bands were then combined to create colour composite images through layer staking. A 1:25000 vector layer with administrative boundaries was used to geo-reference and subset the images. Geo-referencing was done using the nearest neighbour re-sampling method employing at least 15 ground control points for each image. Geo-referencing was based on the Universal Transverse Mercator zone 36 south projection and the WGS84 datum. A root mean square error of less than 0.2 pixels was achieved for all the images. *After geo-referencing, the administrative boundaries layer was used to subset the images corresponding to the extent of Mutasa district using masking in ENVI (Jolla, 2010).*

Table 2: Satellite images used in the study

Sensor type	Date	Path – Row	Spatial resolution
Landsat TM	27 August1984	168-073	30m
Landsat ETM +	25 August 1992	168-073	30m
Landsat ETM+	17August 2001	168-073	30m
Landsat ETM+	06 August 2014	168-073	30m

2.4 Image classification

Landsat bands 3, 4 and 5 representing visible red, near infrared, mid infrared respectively were used for LULC classification in this study. These bands have been shown to provide good results in many land cover investigations as they provide the most relevant and contrasting information for land cover discrimination (Whiteside et al., 2011; Zewdie and Csaplovies, 2015). Maximum likelihood supervised image classification in ENVI 4.7 software was used to determine the LULC classes for the different years. A false colour composite with band

combination (Awotwi, 2009; Guo et al., 2010; Varkonyi-Koczy, 2010) in the Red; Green; Blue format was used for the classification. Accuracy assessment of the classified maps was evaluated using at least 100 sample points randomly spread around the study area for each image by computing an Error Matrix. Error matrix compares, on a pixel-by-pixel basis, the relationship between known referenced data and the corresponding results of an automated classification. Such matrices are square; with the number of rows and columns equal to the number of land cover classes obtained in the classification. Overall accuracy assessment of at least 82% was achieved for the classified images.

After classification, change detection analysis in ENVI 4.7 was applied to determine the spatial and temporal changes in land use and land cover between 1984 and 2014 in the study area. Overlay analysis of land use/ land cover maps with population data for 2001 and 2007 was carried out in Arc GIS 10.1.

3. Results

3.1 Land use land cover changes

The broad geographic patterns of land cover changes in Mutasa district were inferred from the 1984; 1992; 2001 and 2014 Landsat images. Natural forest cover changes were much more frequent and pronounced in the study area than the other forms of land cover change. Seven land cover categories were identified in this study (Table 3). The land cover classification (Table 3) for 1984 from the Landsat TM satellite image showed that the area under cultivation accounted for the largest part (98350.78 ha or 38.79%) of the study area. Smaller areas were occupied by grassland (2213.67 ha or 0.87%) and water body (146.8 ha or 0.06%). The area under woodland accounted for 64675.76 ha (25.51%), bush land 51324.67 ha (20.24%) and rock outcrop and mine dumps occupied 8608.36 ha, (3.40%). The land cover classification on satellite images for 1992 showed that comparatively larger portions were occupied by opened up arable lands (105909.61 ha, ~41.77% of land area) and woodland which occupied 64010.39 ha, (~25.25%). Smaller areas were covered by the grasslands which occupied 2246.96 ha, (~0.89%) as well as rock outcrop and mine dumps which occupied 8192.72 ha (~3.23%).

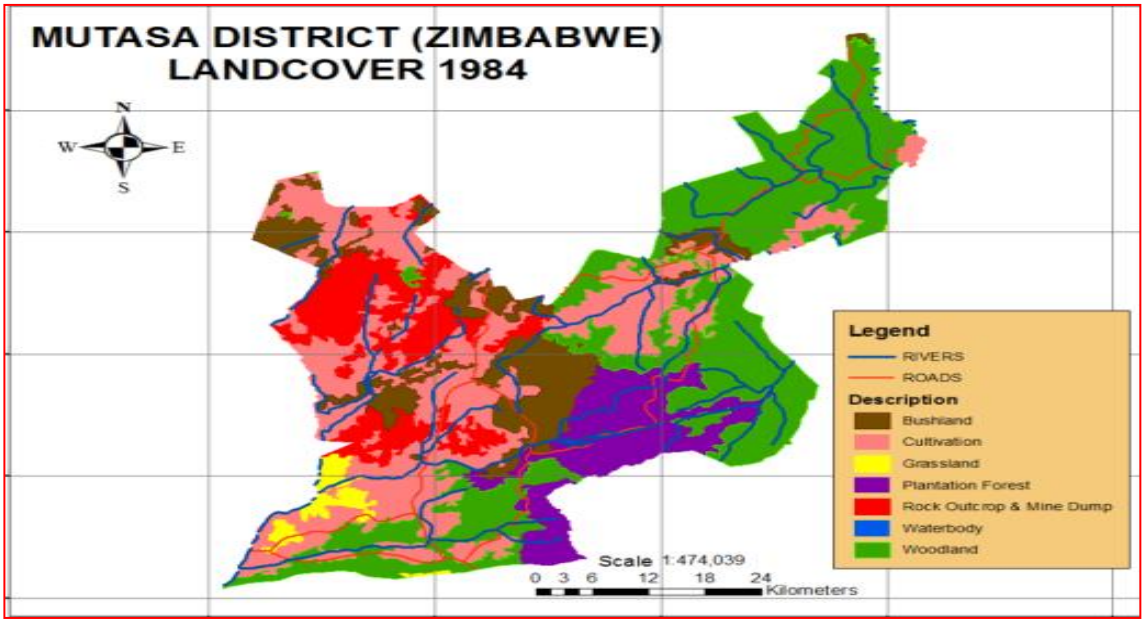

Figure 2: Land cover map for Mutasa district for 1984

Table 3: Land Cover classes and their corresponding areas for 1984 – 2014

	Bush lan	Cultivation	Forest plantations	Water boc	Woodland (Miombo)	Grassland	Rock outcrop a mine dum	Wooded grassland	Total area, ha
1984 area, l	51324.6	98350.78	28234.01	146.80	64675.76	2213.67	8608.36	-	**253554.05**
% land co 1984	20.24	38.79	11.14	0.06	25.51	0.87	3.40	-	**100**
1992 area, l	49125.7(	103662.70	26168.80	146.80	64010.39	2246.96	8192.72	-	**253554.05**
%land co 1992	19.37	40.88	10.32	0.06	25.25	0.89	3.23	-	**100**
2001 area, l	4221.40	113626.20	24325.60	1876.0	63278.90	6033.60	2201.30	-	**25355.0**
%land co 2001	16.65	44.81	9.59	0.74	24.96	2.38	0.87	-	**100**
2014 area, l	39675.3	12121.33	22975.56	1967.0	56234.45	7763.11	2156.45	1564.78	**253554.02**
%land co 2014	**15.65**	**47.81**	**9.06**	**0.78**	**22.19**	**3.06**	**0.85**	**0.62**	**100**

A comparative analysis of the 1984 and 1992 Landsat satellite imagery (Figure 2 and Table 3) has shown definitively that the area under bush land, woodland and forest plantations decreased by 0.87%, 0.26% and 0.82%, respectively. In contrast, the area under cultivation increased by 2.09% in response to conversion of land under natural vegetation and plantations to agricultural activities. Generally, the areas devoted to water bodies remained constant, while areas under grassland increased marginally by 0.02% in response to a reduction in forest land. Results of the study have demonstrated that the area under cultivation increased by 5311.9 ha over a period of eight years. This increase in the area devoted to cultivation resulted in-a decrease of 2730.6 ha of the area under forest plantations and natural woodland over the same period. On average, about 664 ha of woodland,

forest plantations and grassland were converted to cultivated land annually between 1984 and 1992 in the district. This period represented an era before the Government of Zimbabwe passed the Land Acquisition Act of 1992. When the 1992 and the 2001 Landsat images were compared in terms of the total area of each land cover category, substantial quantitative spatial changes were established. As shown in Table 3 and Figure 3, the land cover class that increased considerably in area is that under cultivation, while areas under grassland and water bodies expanded marginally. The area covered by forest plantations and woodland declined as a consequence of an expansion in areas under cropland over the same period. The construction of Osborne dam from 1992 to 1994 contributed to an increase in the area under water bodies in the district for the period under consideration. About 9964 ha under forest plantations and natural woodland were converted into cultivated land between 1992 and 2001 with an annual increase in cropland extent of 1107 ha and corresponding decline in the area under natural woodland, forest plantations and grassland of 2620 ha for the same period. This period coincided with the introduction of the Fast Track Land Reform Program by the Government of Zimbabwe. The 1992 to 2001 period exceeded the 1984 to 1992 period in the conversion of area under natural vegetation and forest plantations into cropland by 4653 ha. The trends in land cover changes identified in the period 1984 to 1992 and 1992 to 2001 were generally maintained in the period between 2001 and 2014 (Table 3, Figure 4). Areas under woodland, bush land and forest plantations decreased considerably while the areas under cultivation, water bodies and rock outcrops and mine dumps recorded increased for the 2001 to 2014 period. The increase in the extent of cropland occurred concurrently with the largest reduction in the area covered by woodland and forest plantations for the same period. Land cover data presented in Table 3 show that the cropland extent increased by 7591 ha between 2001 and 2014. On average, the land cover under cropland increased by 584 ha annually from the conversion of woodland and forest plantations into cropland after the resettlement of smallholder farmers in the formerly commercial farm land. The annual rate of conversion of forest land into cropland-was highest during the period 1992 to 2001 (1107 ha $year^{-1}$). The periods 1984 to 1992 (664 ha $year^{-1}$) and 2001 to 2014 (584 ha $year^{-1}$) had comparatively similar annual rates of conversion of woodland into cropland.

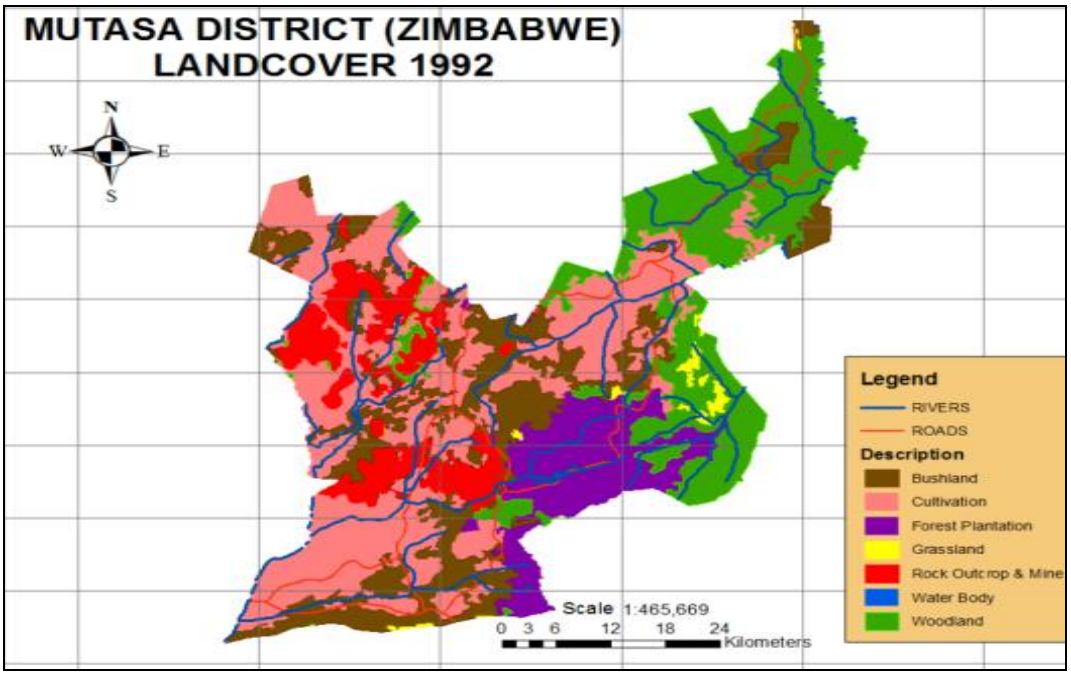

Figure 3: Land cover map for Mutasa district for 1992

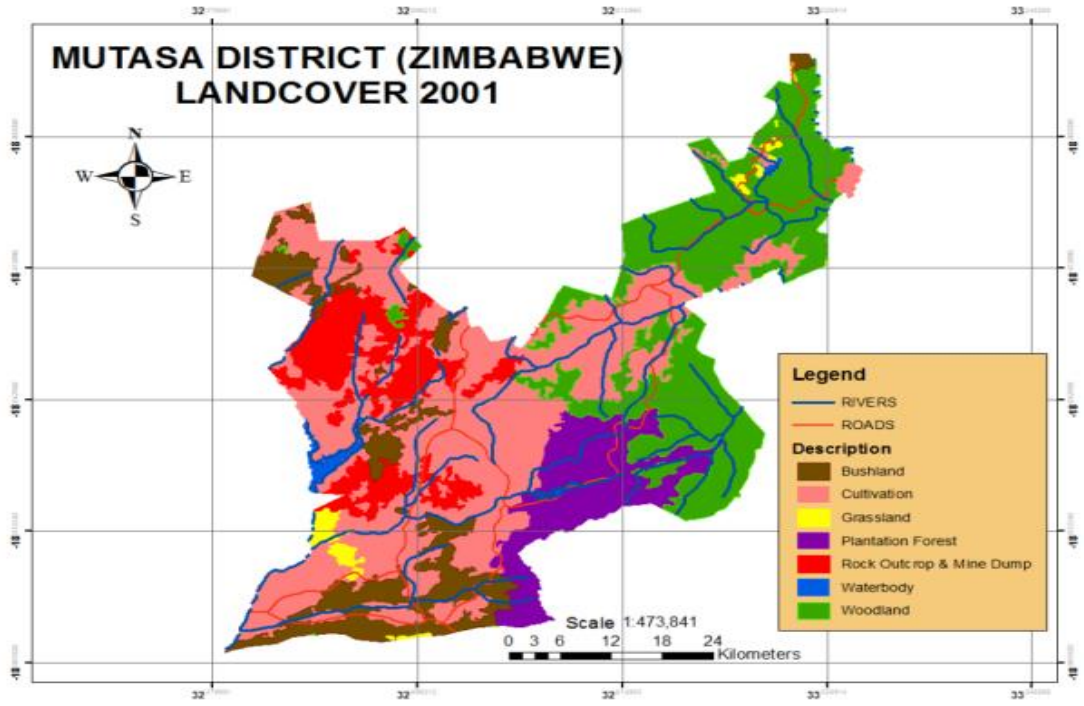

Figure 4: Land cover map for Mutasa district for 2001

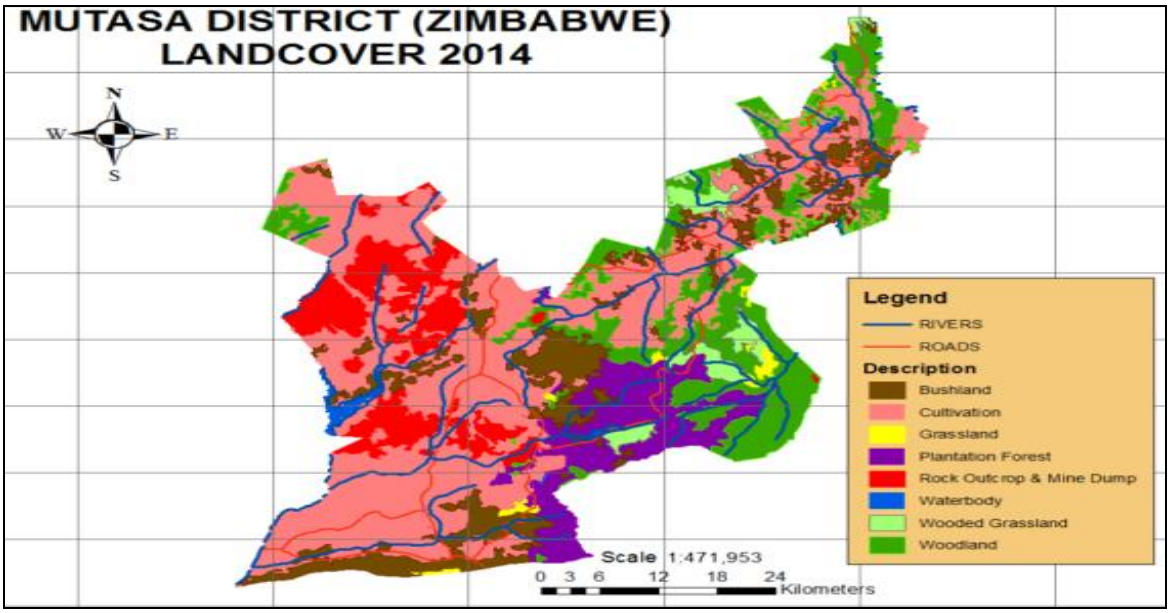

Figure 5: Land cover map for Mutasa district for 2014

In Figure 5, shows a substantial decline in forest and woodland areas over the 1984 to 2014 period while areas under cropland increased considerably in the district. Specifically, the woodland and forested areas converted into cultivation were increased by 22866 ha. The area under wood land, bush land and forest decreased by 8441; 11650 and 5259 ha, respectively, over a period of 30 years (1984 to 2014) in the district. Trends depicted in Figure 5 indicate that the area devoted to cultivation in the district increased annually by 762 ha with a corresponding annual decline of 388 ha of areas under bushland; 281 ha of woodland and 175 ha of forest plantations. This translates to a net cover change of 0.8% for the conversion of woodland area into cropland in the district.

3.2 Land cover and Population

Figure 6 shows an overlay of population data for the year 2012 (CSO, 2012) with woody species land cover map (woodland and plantation forests) extracted from the 2014 classification map. The population map is based on ward boundaries. The ward with the highest population has 16518 people while the least populated had 958 people. The densely populated wards are mainly on the north eastern side of the district in Honde communal lands (Figure 6). The western and central parts of the district are also highly populated with the highest ward having a population of 10 596. The areas which are densely populated have less vegetation cover as compared to those with smaller populations. This demographic change, particularly population growth, may form the basis for explaining the land use changes observed in the study area and the resultant negative changes in forest cover.

4. Discussion

4.1 Land use/ land cover changes and deforestation

Deforestation is the most measured process of land-cover change at a regional and local scale (Lambin and Meyfroidt, 2011). Deforestation as a result of resettlement of smallholder communities in Mutasa district was recognized as the most important driver of land cover

changes for the thirty-year period under consideration (1984 to 2014).

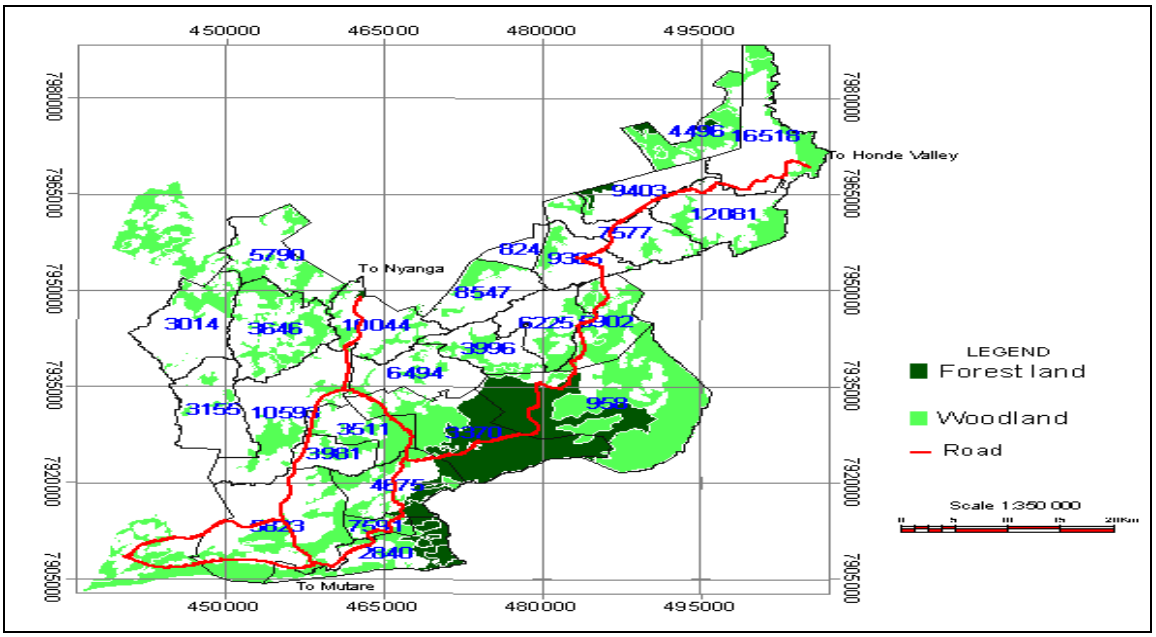

Figure 6: Overlay of land cover and population data

Deforestation occurred in the district when natural woodland and forest plantation were converted to cropland. It has been established that the annual rate of conversion of woodland into arable crop land in Mutasa district was highest during the period 1992 to 2001 (1107 ha year^{-1}).

Knowledge about the causes of land-use change in sub-tropical Africa has moved from simplistic representations of two or three driving forces to a much more profound understanding that involves situation-specific interactions among a large number of factors at different spatial and temporal scales (Porter-Bolland et al., 2012; Fonji and Taff, 2014; Mwangi et al., 2016b). Specifically, the trends in deforestation processes identified in this study were mostly related to decreasing opportunities for non-farm employment over the years for farmers in marginal lands and the redistribution of commercial farm land and previously protected areas to the smallholder farmers. Zimbabwe inherited a racially skewed system of ownership of agricultural land at independence in 1980 in which indigenous populations were located in marginal lands in the predominantly low-potential agricultural zones (United Nations Environment Program, 2002). Coupled with the rising population growth rates (until recently above 3 percent per annum (Zimstats, 2012), rural communities were thrown into increasing poverty due to the inadequate and poor-quality land for subsistence farming hence the farmers depended heavily on forest resources. In an effort to decongest densely populated rural areas, the Government-led resettlement programmes relocated smallholder farmers on commercial farms and some protected areas leading to extensive land clearing exercises in order to create arable land for cropping. Inevitably, the dry sub-tropical natural forest (miombo) and commercial forest plantations in the

affected commercial farms suffered extensive and permanent deforestation recorded by the Landsat images for the periods 1984 to 1992; 1992 to 2001 and 2001 to 2014 in this study. The forest areas converted to cropland reached 22866 ha over a period of 30 years (1984 to 2014) in the district. In a related study on African forests by Malhi et al. (2013) a similar trend was reported. It was established that tropical regions lost 15.2 million ha of forests per year during the 1990s. Generally, the annual rate of net cover change from woodland and forest plantations into cropland for the period 1984 to 2014 in the district was 0.8%. In a related study, Bodart et al. (2013) reported an annual net cover change in Africa of 0.36%, which is much lower than the annual net cover change in Mutasa district and most probably in many other districts of Zimbabwe. This high land cover change was attributed to the resettlement programs by the government of Zimbabwe and the increase in population.

Land use land cover changes and the resettlement programs

The results of images classification of the three periods under consideration in the study show that the annual rate of conversion of forest land into cropland in Mutasa district was highest during the period 1992 to 2001 (1107 ha year^{-1}). Comparatively similar annual rates of conversion of woodland into dry land cropping were recorded for the periods 1984 to 1992 (664 ha year^{-1}) and 2001 to 2014 (584 ha year^{-1}). The period 1992 to 2001 coincided with time when the Government of Zimbabwe, resolved to implement "Fast Track" resettlement program. The objective was to accelerate the process of land acquisition of 5 million ha from the commercial farming sector for resettlement purposes by December 2001 (United Nations Environment Programme, 2002).

The government-initiated resettlement exercise, the construction and subsequent completion of the Osborne dam in the 1990s was followed by a massive relocation of smallholder households in the dam basin to the commercial farming areas. The commercial farming areas, which had greater ecological integrity covered by natural woodland and forest plantations of the district, were not spared from this concerted government drive to resettle smallholder communities from densely populated areas The period from 1992 witnessed the highest daily conversion rate of commercial farm land under woodland (miombo) and forest plantations to cropland of about 3 ha per day and this also coincided with the Fast Track Land Reform Program which started in 2000.

The resettlement of poor rural communities from densely populated smallholder areas of the district to ecologically more secure large scale commercial areas between 1984 and 2014 may have had immediate positive impacts on reducing population densities, but in the long term the program had deleterious impacts on the global atmospheric environment if it is adopted as a solution to reducing the effects of increased population densities in rural communities at regional and continental levels. The conversion of wooded land into cultivated areas reduces the capacity of the woodland areas to sequestrate carbon dioxide from the atmosphere in photosynthesis.

4.2 Environmental implications of land use land cover changes

Terrestrial ecosystems of the sub-tropical regions have been recognized as important sources and sinks of carbon and this has underscored the impact of land use/ land cover change on the global climate via the carbon cycle. The uncertainty of these terrestrial sources and sinks of carbon remains a serious challenge today not only at sub-

continental level but globally (Guo et al., 2010; Bodart et al., 2013). The impact of cropping on soil organic carbon has been extensively investigated, with long-term cultivation trials indicating a steady loss of soil carbon with cultivation (Malmer et al., 2010). In a related study on soil carbon stocks and land use change, Malmer et al. (2010) concluded that changes in land use can cause significant changes to soil organic carbon (SOC) stocks. Specifically, the change from natural vegetation to cultivation in the converted may have caused significant disturbances to the soil, leading to a higher outflow of carbon without sufficient inflow to counter-balance soil carbon losses (Reitjes et al., 2011a) due to the low efficiency of smallholder farming activities in Zimbabwe generally. In this respect, the land cover changes from woodland to cropland had negative consequences as it reduced the carbon sequestration capacity of the land and increases the possibility of soil organic carbon losses to the atmosphere.

5 Conclusions

The Land cover changes analysis for Mutasa district for the periods1984 to 1992, 1992 to 2001 and 2001 to 2014 has shown significant decline in land areas under woody species (woodland and plantation forests) and considerable increase in area devoted to cultivation. The annual rate of net cover change from woodland and forest plantations into cropland in the district (0.8%) was higher than the average annual net cover changes for tropical Africa (0.36%). The Land Reform Program coincided with the highest daily conversion rate of commercial farm land under woodland (miombo) and forest plantations to cropland of about 3 hectares per day by the resettled farmers for a period of nine years (1992 to 2001). While the redistribution of land to the landless was effective in settling a political disparity on the land question, the exercise became a source of environmental degradation through deforestation and cultivation of virgin arable land.

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Conflict of interest

The authors confirm that they have read and understood the contents of the section on compliance with the statement of disclosure of the journal. In the disclosure of potential conflicts of interest, we can confirm that the authors have no conflicts of interest (either real or perceived) in the processes of data collection and analysis that led to the compilation of the results and the conclusions derived from these results. The authors unreservedly acknowledge the assistance from the Midlands State University grants and have disclosed all relationships or interests that could have direct or potential influence or impart bias on the work.

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Causes of wildland fires and factors that influence knowledge of fire management at Crofton village, Makoni District, Zimbabwe

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Abstract

Wildland fires are a threat to the conservation of biodiversity and human life. In Zimbabwe, the newly re-settled smallholder farmers are perceived as the major drivers of wildland fires. A survey was conducted in Crofton Village Ward 38 of Makoni District in Zimbabwe to determine farmers' knowledge on the causes of wildland fires and factors that influence their knowledge on the management of wildland fires. Randomised purposive multistage sampling was used to select 60% of the total population in the study area. Data processing and analysis was done using the Statistical Package for the Social Sciences (SPSS) version 21.0 of 2012 to analyse the relationship between the dependent variable (farmers' knowledge of wildland fire management) and independent variables (sex, age, level of education and period of stay in the village. Farmers revealed that land clearing, poor disposal of ashes, brick moulding and arson were the chief causes of wildland fires. There was a significant ($p<0.05$) relationship between period of stay in the village with farmer's knowledge of management of wildland fires. Farmers' knowledge on wildland fire management was influenced by period of stay and exposure to wildland fires in the village. Farmers with a longer period of stay in the study area were more knowledgeable than those with a shorter period. Gender and age had an effect on farmer's knowledge about causes of wildland fires and men apparently had more knowledge and experience with wildland fire management. Human activities were responsible for most of the wildland fires. Resettled farmers, farmers with primary level and those with no formal education had limited knowledge on wildland fire management. It was recommended that effective wildland fire awareness programmes be put in place to improve farmer knowledge and wildland fire management skills.

Keywords: Wildland fires, anthropogenic activities, resettled smallholder, management.

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1.0 INTRODUCTION

Wildland fires are a major problem in the savanna region because they occur too frequently thereby causing land degradation, loss of biodiversity, food insecurity, loss of life, destruction of property and

emission of greenhouse gases which cause global warming and climate change (Svotwa et al., 2007; Amissah et al., 2010; Nyamadzawo et al., 2013). According to the EMA (2014) between 2010 and 2014 Crofton village lost approximately 3 000 ha to wildland fires on an annual basis. Forests are under the highest threat from wildland fires though they play an important role in the economy, social well-being of people and the environment. In Zimbabwe, forests contribute 3% to Gross Domestic Product (GDP) (Forestry Commission of Zimbabwe, 2011).

Several reasons have been cited as causes of wildland fires. Human beings were reported to cause 95% of wildland fires in Southern Africa, while natural fires have become rare (Nkomo et al., 2009). However, farmers in Cashel Valley cited agricultural activities as the major factor for wildland fires (Nkomo, 2009). In Zimbabwe farmers use fires to burn plant residues and clear virgin land during land preparation (Svotwa et al., 2007). They also burn plant residues to kill pests especially in grazing lands (Nkomo et al., 2009). In the Chegutu area, farmers perceived hunting as the major cause of wildland fires (Svotwa et al., 2007). Hunting and burning by hunters who want to flash out wild animals are activities that also cause wildland fires, in addition to bee smoking, throwing of burning cigarette stubs, lighting of fires by resting motorists on the roadside, poor disposal of ashes and arson which have also been reported to be among major causes of wildland fires (Svotwa et al., 2007; Nkomo et al., 2009; EMA, 2011).

Korem, (1985), assumed that farmers have limited knowledge in fire management and do not make any effort to curb the incidence of wildland fires, while Amissah et al. (2010) suggested that farmers have limited knowledge on fire management and this resulted in fires getting out of control. Amissah et al., (2003) argues that, since farming is dynamic and is constantly fed by farmers' knowledge and perceptions, farmers should have an appreciation of fire-related causes to enable them cope with increasing incidences of wildfires in the agricultural landscapes. Farmers have knowledge on the ways of managing wildland fires but their ideas need to be supported (Amissah et al., 2003). A study conducted by Absher et al., (2009) on who is responsible for fire management found that the responsibility is shared between farmers and environmental managers.

Documented information on factors influencing the farmers' knowledge levels in wildland fire management in Zimbabwe is currently scanty. For example Amissah et al., (2010) researched on the perspectives of farmers on the management of wildland fires but did not look into factors that influence their knowledge. Such factors form the basis for successful wildland fire management and if not considered during awareness campaigns, meetings and workshops the goal of reducing wildland fires will not be achieved. There is therefore need to assess and understand the causes of wildland fires and the factors that influence farmers' knowledge on wildland fire management.

Knowledge of farmers can be influenced by several factors such as age, gender, level of education and period of stay in an area or exposure to wildland fires. Land owner's knowledge towards prescribed burning and suppression of wildland fires is associated with previous experiences (McCaffrey, 2008; Toledo et al., 2013). Those with more years of stay in an area have more experience and skills to manage wildland fires than those with a shorter period of stay. Morris (1991) cited gender as a

factor that can influence people's knowledge and adoption of new technology. Mostly women are forgotten in technology adoption and transfer. Cultural systems reinforced this by insisting on women to remain at home while husbands attend meetings, workshops and seminars, however they do not teach women what they have learnt (Mazvimavi et al., 2009). Education is a major factor that can influence the level of knowledge of fire management. The farmer's level of education determines ones' appreciation for managing natural resources (Norman, 2005). The farmer's education background is an important factor that determines the readiness to accept and properly apply technologies (Swamson et al., 1984).

Wildland fires continue to be a menace in Makoni District just like in most parts of the country. The relevant environmental authorities such as EMA and the Forestry Commission of Zimbabwe have been making relentless efforts to minimise the occurrences of wildland fires but without much success. There is need for a paradigm shift in wildland fire management strategies in Zimbabwe, which should encompass the level of understanding that farmers on causes of wildland fires in their localities, and to assess how much knowledge they have in practical wildland fire management. This study therefore examined farmers' knowledge on the causes of wildland fires and factors that influence their knowledge on the management of wildland fires in Crofton village.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted at Crofton Village in Ward 38 (18.47295° S, 32.12705°E and altitude 1 468 m above sea level) in Makoni District, Zimbabwe. Makoni district is in Natural Region (II) with annual rainfall between 750 mm to 1 000 mm. The soils is the study are were grey paraferallitic soils (Vincent and Thomas, 1960). The mean annual temperature of 24^0C to 30^0C (Goudie, 1984). It is characterised by hot wet summers and cool dry winters. Wet periods are experienced from November to March and cool dry periods are from April to July, the period when trees in the area lose their leaves in response to winter. These weather conditions especially between July and October are conducive for wildland fire outbreaks.

The main crops grown in the village are maize (*Zea mays* L.), ground nuts (*Arachis hypogaea* L.) and tobacco (*Nicotiana tabacum* L) (Mtambanengwe et al., 2012). The area is characterised by common thatching grass *Hyparrhenia hirta* (L.) growing to a height of about 2.5 m. It is characterised by Miombo woodland dominated by tree species such as *Brachystegia spiciformis* (Benth), *Brachystegia boehmii* (Taubert) and *Julbernardia globiflora* (Benth) (Mtambanengwe et al., 2012). *Lantana camara* an alien species is also found in the study area. There are 63 resettled farmers who moved into the area during the Fast Track Land reform programme in 2002.

2.2 Data collection

Purposive sampling was used to select the study area. It was based on selecting the district with the highest percentage of wildland fires in Manicaland Province. This district recorded 19 673.3 ha (46.6%) out of 42 203.7 ha which was destroyed by wildland fires (EMA, 2014). Purposive sampling was also used to select Ward 38 which had the highest frequency of wildland fires. Households surveyed were randomly selected until a sampling of 60% was reached. A questionnaire with both semi-structured and open ended questions was

administered to the selected farmers and focus group discussions were also held. In addition, other methods such as direct observation and key informant interviews were also used during data collection. A total of 10 key informants from EMA, Forestry Commission, Makoni Rural District Council, Agritex, village Committees and District Administrator (DA) were interviewed.

2.3 Data analysis

Data were analysed using SPSS version 21.0 (2012) to categorise farmers' perceptions on the causes of wildland fires. The causes were ranked according to their frequency from most common to the least common. Ordinal regression was used to analyse factors that influence farmers' knowledge on wildland fire management. From the responses knowledge of farmers towards management of wildland fires was considered as the dependent variable and independent variables were level of education, period of stay in the village, gender and age of farmers. A weighted dependent variable was generated using the following equation.

$$Y= a+b1X1+b2X2+b3X3+e$$

Where, Y = dependent variable (knowledge level of farmers on wildland fire management) a = constant, b = regression co-efficient X1 = age, X2 = education level, X3 = period of stay in the village, e = error term.

3.0 RESULTS

3.1 Causes of wildland fires

Approximately 83.8% of the farmers identified poor disposal of ashes from homesteads as the major cause of wildland fires in Crofton village, followed by brick moulding (62.2%), arson (59.5%) and land clearance (52.8%). Bricks were in high demand for construction. Smoking was cited as a major cause of wildland fires by 38% of the respondents, while hunting was cited by 13.5% respondents (Figure 1).

3.2 Factors that influence farmers' knowledge on wildland fire management

There was a significant relationship between period of stay and farmers knowledge of wildland fire management ($p<0.05$). The longer the farmer had resided in the village, and the more exposure they have had to wildland fires, the more knowledgeable they were on wildland fire issues. Farmers who had been in the village for longer (between 11 and 15 years) were more knowledgeable than those who had been in the village for between 6 and 10 years and for less than 5 years.

Gender had an effect on level of knowledge on wildland fires amongst villagers. Men were more knowledge and experienced with wildland fire management compared to women. However, level of education had a significant effect on farmers' knowledge on wildland fire management. Farmers with primary level and those with no formal education had limited knowledge on wildland fire management. Farmers who attended secondary school were better knowledgeable than those who only attended primary school and those who never attended school. There were no significant differences between age categories and knowledge regarding wildland fire management, as all adults interviewed showed significant knowledge about the causes of wildland fires (Table 1).

4.0 DISCUSSION

Most wildland fires in Crofton Village were caused by anthropogenic activities. Anthropogenic activities caused fires due negligence or accident,

for instance, when wind simply carries a fire away from its intended point of origin. In this study

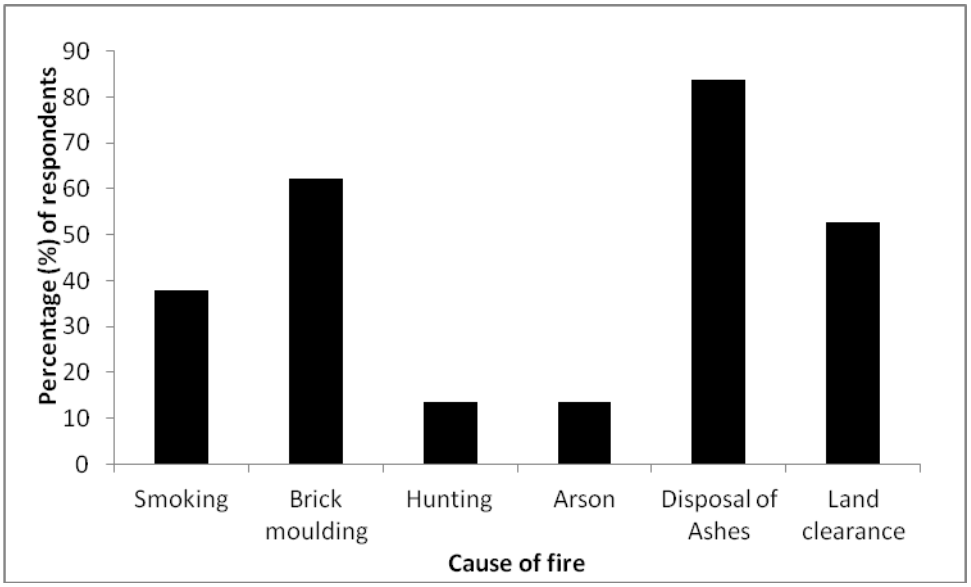

Figure 1. Causes of wildland fires in Crofton Village in Makoni district of Zimbabwe.

Table: 1 Relationship between dependent (knowledge of farmers on wildland fire management) and independent variables (sex, age, level of education and period of stay).

Table 1

Parameter	Category	Standard Error	P Values
Age	16-30 years	1.577	0.96
	31-50 years	1.563	0.47
	51^{+} years	.	.
Gender	Male	1.114	0.79
	Female	.	.
Period of stay	1-5 years	1.670	0.10
	6-10 years	0.000	.
	11-15 years	.	.
Level of education	Non and Primary	0.00	0.42
	Secondary	1.454	.
	Tertiary	.	.

anthropogenic activities such as poor disposal of ashes, clearing land for agriculture, hunting, and arson were the major causes of wildland fires. The issue of poor disposal of ashes as a major cause of wildland fires was only perculiar to Crofton village. Hot ashes disposed in waste dumps accelerated the ignition of fires (Bird, 2009). However, other similar studies, e.g. Nkomo et al. (2009) and Nyamadzawo et al., (2013) land clearance and hunting as top causes of wildland fires.

Key informant interviews revealed similar causes of wildland fires to those highlighted by the farmers. However, the key informants ranked land clearance and hunting of wildlife as the major causes of wildland fires. Environmental Management Agency (EMA) also reported that farmers were reluctant to construct fireguards which resulted in rapid spread of wildland fires. Furthermore, many farmers who constructed fireguards did not make them 9 metres wide as stipulated in the EMA legislation. The main reason

for this was cited as lack of capacity by most smallholder farmers to construct fire guards and lack of enforcement and monitoring by EMA.

In Crofton village, hunting was not the top major cause of wildland fires, and the depletion of wildlife population was cited by respondents as the major reason. Some of the factors that may have pushed wild animals away from Crofton include shortage of forage and habitat which were destroyed by wildland fires and human expansion into grazing and forested areas. This observation was supported by Nkomo et al., (2009) who argued that wildland fires destroy pastures and force animals to migrate. However, in contrast to the above, most of the studies which were conducted in resettlement areas before 2010 singled out hunting as the major cause of wildland fires (Panzer and Schwartz, 2000; Svotwa et al., 2007).

Beekeeping was not common in the study area and the major reason for low bee keeping was cited as frequent destruction of hives by wildland fires. As a result of low numbers of hives and bee keeping activities, bee smoking was not cited as a major cause of wildland fires. These results contradict those by Svotwa et al. (2007) and Nyamadzawo et al., (2013) who argued that honey harvesting was a major cause of wildland fires.

Brick moulding was one of the major causes of wildland fires in Crofton. Brick firing season often coincides with the dry season, when conditions conducive for wildland fire spread are available, such as high fuel load and high wind speed. During the first two days of firing bricks, kiln openings are left open to allow oxygen to enter to support combustion. Due to high wind speed, the openings of kilns allows hot ashes and flames to be blown out which causes fires if they reach nearby grass that subsequently catch fire resulting in wildland fires.

Conflict between land owners and workers is one of the major causes of arson. This is consistent with observations by Nyamadzawo et al., (2013) which articulated that non-payment of farm employees' or low remuneration is contributing to arson. Another cause of arson was claimed to have been jealousy among farmers who want their neighbours to be fined by EMA. The farmers who are charged for failing to construct standard fireguards also tend to start fires outside their farms or in grazing areas as a way of protesting against environmental law enforcement agencies such as EMA. The research findings are similar to those by Bond (2001) who stated that arson burns are common sometimes due to a protest against state authority.

Due to inadequate farming equipment, some farmers are still using the slash and burn technique to clear the land for farming. Land clearing using fire is decreasing due to the fact that most of the arable land is almost taken up and occupied. Nevertheless, this study showed that slash and burn farming is still practiced but at a lower scale. These observations are supported by Nyamadzawo et al. (2013) and FAO (2010) who noted that many smallholder farmers with inadequate resources and equipment to use in land preparation tend to use fire since it is cheap.

Farmers who had stayed in the village for a long period had more knowledge regarding wildland fire management acquired during awareness campaigns, meetings and workshops. Farmers who attend more meetings have more knowledge. In addition, farmers with longer period of stay have witnessed more wildland fire impacts such as loss of life, property, livestock, houses and crops. Consequently, this could have influenced their

eagerness to learn more about wildland fire management methods so that they can mitigate the impacts of wildland fires. This concurs with the research conducted by McCaffrey (2008); Toledo et al., (2013) which showed that knowledge of farmers is influenced by their previous experiences.

Farmers with 1-5 years period of stay have migrated from different areas, 70% came from urban areas, 15% from nearby villages and 15% from rural areas. Therefore there is high probability that farmers with 1-5 years period of stay have come into Crofton village without knowledge about wildland fire management. In addition, the newcomers have attended few or no environmental meetings and workshops. Level of education has an influence on wildland fire management. Attending tertiary education will allow one to know wildland fire management methods while not even going to school or to quit school at primary level will affect their understanding of wildland fire management.

Therefore, it is recommended that the school curricula should incorporate wildland fire issues from primary level. Those who did not go to school and those who quit school at primary level are less likely to read newspapers, fliers and textbooks where information on wildland fire can be disseminated. Similar research conducted by Norman (2005) showed that education level affects knowledge on managing natural resources.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Wildland fires are causing negative impacts to human life, flora and fauna in Crofton village of Makoni District in Zimbabwe has a negative impact on the biodiversity and ecosystem. Human activities are responsible for causing most of the wildland fires in the in Crofton village. Although, the rate of using fire in agricultural activities is decreasing, however, due to poverty and lack of knowledge on managing wildland fires, farmers are still using fire for land preparation. In Crofton village, poor disposal of ashes, brick moulding and arson are chief causes of wildland fires. Knowledge of farmers on wildland fire management was influenced by period of stay in the village. The level of education, had a bearing on wildland fire management. Resettled farmers, farmers with primary level and those with no formal education, as well as women had limited knowledge on wildland fire management. This can be explained by gender inequality enshrined is communities where the girl child is given less access to education compared to the boy child.

It is recommended that more wildland fire awareness programmes be put in place. In addition village wildland fire-fighting committee be put in place in resettlement areas and these should be inclusive to include women.

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Evaluation of Chicken Blood and Maize Stover Compost as a Nitrogen Source for Maize

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ABSTRACT

Organic materials are an important source of nutrients for many smallholder farmers. The use of composted organic amendments is constrained by their variability and maturity. The aim of this study was to evaluate the potential of aerobically composted chicken blood and maize stover mixtures on maize N uptake and to determine the effect on seed emergence in a greenhouse pot experiment. Four composts with proportions of 10%, 30%, 70% and 100% maize stover were used as soil amendments and compared against an unamended soil (control). The greenhouse pot experiment involved planting 10 maize seeds in each pot. Seed emergence percent was determined a week after sowing to ascertain whether the composts had phytotoxic effects. Percent emergence did not differ significantly among treatments (p =0.26). Two plants were allowed to grow in the pots for five weeks after which maize dry matter yield and foliar analysis followed. The foliar samples were analysed for total nitrogen, dry matter yield and cations (Mg, Ca, K and Na). Nitrogen uptake differed significantly among treatments and ranged from 0.27% to 0.75%. Nitrogen uptake was higher in soils amended with 10% and 30% maize stover compost treatments. Dry matter yield also differed significantly ranging from 1.09g to 2.2g per pot). Uptake of all cations did not differ ($p>0.05$) significantly among treatments. The 10% and 30% maize stover composts had greater potential to support maize growth as shown by the dry matter yield and total N concentrations in the plant samples.

Key words: Compost, emergence, maize, nitrogen.

1. INTRODUCTION

Organic materials are an important source of nutrients for many smallholder farmers who lack financial resources to purchase mineral fertilisers (Masunga et al., 2016; Steinfield et al., 2006; Rufino et al., 2007). The use of organic amendments is however constrained by their heterogeneity, variability and benefits are not realized immediately after incorporation hence most organic resources show limited increases in crop growth (Vanlauwe, 2004). Organic materials and compost use in crop production is gaining popularity due to the increased appreciation that conventional and intense tillage cropping systems

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result in soil organic matter loss (Chivenge et al., 2009). Incorporation of compost can result in organic matter build up and an increase in organic matter results in an increase in cation exchange capacity (CEC) of soils and also adsorption of soil contaminates (Mando et al., 2005; Vanlauwe, 2004). Nutrients become available to plant roots at a slower rate with compost compared to inorganic fertilisers thus nutrients are retained for longer in soils. In order to develop efficient systems to improve soil nutrient dynamics a balance must be established between crop demands and nutrient supply from the decomposition of organic materials (Munthali et al., 2015). Organic matter decomposition releases these nutrients and is affected by a wide range of factors including soil nutrient content, moisture content, biological activity and organic residue quality. A good quality compost is one that has the capacity to function within natural or managed ecosystem boundaries by restoring and enhancing the potential of the soil to sustain plant and animal productivity (Brinton 2012; Bera et al., 2013; Pisa and Wuta 2013)

Though compost applications have a number of benefits, there have been cases in which composts have had negative impacts on crop growth. Tiquia (2010) reported delayed seedling emergence and reduced crop growth after the incorporation of some compost products. These negative impacts were attributed to the use of unstable or immature compost. Compost maturity determines whether compost can be used in crop production without negative effects due to N immobilisation, oxygen depletion or the presence of phytotoxic compounds, such as the organic acids; propionic, acetic and butyric acid. Low molecular weight organic acids such as phenolic compounds are responsible for phytotoxic effects of composts on seed germination, emergence and plant growth (Gómez-Brandón et al., 2008). Monspart-S'enyi (2012) demonstrated that volatile low molecular weight organic acids decreased with composting duration and are associated with early stages of decomposition. Various parameters have been used as compost maturity indices (Gómez-Brandón et al., 2008; Mangkoedihardjo, 2006). Carbon to nitrogen ratio and NH_4^+:NO_3^- ratio can be used to determine compost maturity (Chukwujindu et al., 2006; Mangkoedihardjo, 2006). Electrical conductivity of less than 2.0 mmho, pH between 6 and 7.5, absence of phytotoxic substances and an NH_4^+:NO_3^- ratio of less than 1:1 (Pant et al., 2011; Radovich et al., 2011), are indices used to determine compost maturity.

Nitrogen is the most limiting nutrient to crop growth in most Zimbabwean soils (Agren et al., 2012; Mapfumo and Giller, 2001) requiring the use of soil amendments. Nitrogen in organic amendments, such as compost, is in organic form (Bremmer, 1996) therefore the fertilising value of the compost is evaluated on the basis of its ability to release mineral N to meet crop requirements. It is therefore necessary to determine the content as well as the potential of the compost to release mineral N (Pisa and Wuta, 2013). The ability to release N has to be balanced against contribution of the stable soil organic matter pool which contributes more to long-term soil fertility. Handayanto, et al. (1997) explored the possibility of synchronising nutrient release and plant uptake through composting and mixing residues of different quality. The intention is to increase N release from low quality organics by mixing them with high quality organic to meet plant requirements. There is thus a possibility of using mature composts along with mineral fertilisers or mixtures of raw waste in proportions which

moderate the nutrient release pattern of the mixture favourably.

In Zimbabwe, there has been limited research on composting and the ability of the compost products to supply nutrients. Research done include composting of household wastes as soil amendments for peri-urban farming systems (Mhindu et al., 2013) and composting of poultry wastes to produce an organic fertilizer for maize and horticultural crops (Pisa, 2007; Pisa and Wuta, 2013). However, there has been no study that has evaluated the potential of chicken blood and maize stover compost as a nitrogen source in crops. Large quantities of blood are produced in Zimbabwe's small abattoirs and slaughterhouses. The blood is held in lagoons and holding tanks for a long time before disposal (Pisa, 2007; Pisa and Wuta, 2013) as fresh blood cannot be spread over land. Blood is rich in N and other essential plant nutrients (Mittal, 2007) and therefore can be used as a source of plants nutrients. It cannot be however applied directly to land due to associated environmental pollution problems such as the presence of pathogens, eutrophication, groundwater pollution, acid deposition, and high ammonia and nitrate concentration in the soil (Akinro et al., 2009, Singh et al., 2014). To avoid pollution composting a mixture of blood and maize stover was found to produce stable compost with little or no environmental problems. Pisa and Wuta 2013 determined the composting performance of chicken blood and maize stover but the potential of the finished compost to support plant growth was however not done The compost produced was assumed to be stable and environmentally friendly with no pathogens, a C:N ratio less than the critical 20:1 (Marthur et al., 1993, Kokkora et al., 2010) and an NH_4-N:NO_3-N ratio of less than 0.16 (Pant et al., 2011; Radovich et al., 2011). The aim of this study was to evaluate the potential of aerobically composted chicken blood and maize stover mixtures as sources of nitrogen and also determine their effect on maize seed emergence.

2. MATERIALS AND METHODS

Chicken blood and maize stover were aerobically composted (Pisa and Wuta, 2013) and the finished product was used in this study. Chicken blood from slaughter houses was mixed with maize stover at different proportions of 10%, 30%, 70% and 100% maize stover by weight and composted in composting bins measuring 1 m^3 over 72 days (Pisa, 2007; Pisa and Wuta, 2013). The final composts were tested in a greenhouse pot experiment at the University of Zimbabwe using sandy soils from Churu farm (1390 masl; 30^o 55'E & 17^o 56"S) in Harare. The finished composts and the soil were characterised before use.

2.1 Soil sampling and analysis

Soils were collected from Churu farm by randomly taking five representative soil sub samples from a depth of 0 to 20 cm using a soil auger. Bulk soil samples were also collected and mixed to make a total of 50 kg of soil for use in the greenhouse experiment. The composite auger sample was air dried and sieved to pass through a 2 mm sieve. Soils were analysed for texture, pH, organic carbon, available P and N. Soil texture was determined using the hydrometer method after dispersing the soil using sodium hexa-meta-phosphate (Anderson and Ingram, 1993). Soil pH was measured using the $CaCl_2$ method (Okalebo et al., 2002) using a Jenway model 3510 pH meter.

Soil organic carbon was determined using the modified Walkley-Black method (Anderson and Ingram, 1993) with external heating. Total N was

extracted from a soil sample by wet digestion using concentrated sulphuric acid, selenium powder, lithium sulphate and hydrogen peroxide mixture (Anderson and Ingram, 1996). Total soil N was measured colorimetrically at a wavelength of 650 nm (Okalebo et al., 2002).

2.2 Compost sampling and analysis

Composite samples were collected from respective compost bins by pooling 5 sub-samples from random positions of each bin at the end of the composting period. Before collecting samples, compost in each bin was thoroughly mixed. The compost samples were oven dried at 60^{o}C for 48 hours before grinding them to pass through a 2 mm sieve. Composts were analysed for total N, mineral N, total nutrients (Ca Mg Na and K), organic carbon, pH, electrical conductivity and ash after oven drying using standards methods described in Okalebo, et al., 2002).

Mineral N (ammonium-N and nitrate-N) was extracted from compost samples by shaking 10 g of fresh compost in 100 ml of 0.5 M K_2SO_4 on a reciprocal shaker for one hour. The mixture was filtered through a Whatman's No 42 filter paper. Ammonium–N was determined in an aliquot (0.2 ml) of the filtrate after colour development with sodium nitro-prusside and nitrate-N was determined in a separate aliquot (0.5 ml) after colour development with 5% salicylic acid using a spectrophotometer (Okalebo, et al., 2002).

Total N, total nutrients (Ca Mg Na and K), organic carbon, pH, electrical conductivity and ash content were determined on ground oven dried compost samples. Total N was extracted from compost sample by wet digestion using concentrated sulphuric acid, selenium powder, lithium sulphate and hydrogen peroxide mixture (Anderson and Ingram, 1996). The hydrogen peroxide oxidises the organic matter while selenium powder acts as the catalyst for the process. Sulphuric acid completed the oxidation at elevated temperatures. Total N was determined in an aliquot of the digest after colour development with sodium nitroprusside using a spectrophotometer (Okalebo et al., 2002).

Electrical conductivity and pH were determined on water extracts (1:10 air-dried compost raw material: water) as outlined by Smith and Hughes (2002). The ground samples were shaken in distilled water on a reciprocal shaker for 30 minutes and left to stand overnight. pH was measured using a Jenway model 3510 pH meter and EC was read on an EcoScan Con 5 electrical conductivity meter. Ash and organic matter content were determined as residual mass and weight loss respectively on ignition at 550^{0}C for 12 hours in a muffle furnace. Organic carbon was calculated from weight loss on ignition using equation 1:

%C = (weight loss on ignition x 100)/1.8
(Haug, 1980) **Equation 1**

Total cations (Ca, Mg, Na and K) were determined in ash by adding 2 to 3 drops of distilled water. Hydrochloric acid (50%; 2.0 ml) was added to the sample and the sample heated to dryness on a block heater. Nitric acid (25%; 5.0 ml) was added to dissolve the sample. The dissolved sample was transferred to a 50 ml volumetric flask and the volume made to the mark. After settling a clear supernatant (1.0 ml) was pipetted into a 50 ml volumetric flask. Strontium chloride (1%; 25 ml) was added followed by distilled water (24 ml) and the mixture was thoroughly mixed. Calcium and magnesium were read on an atomic absorption spectrophotometer (AAS) at wavelengths of 422.7 nm and 285.2 nm respectively. Sodium and

potassium was determined using flame emission spectrophotometry.

2.3 Green house experiment layout and procedure

A green house pot experiment was established using air dried Churu farm soil to test the maturity of the finished compost derived from chicken blood and maize stover. The compost was used as a soil amendment. Maize variety SC 513, an early maturing variety was grown in pots filled with amended sandy soil. The pots used measured 23 cm in diameter and 23 cm depth. The soil was first sieved to pass through a 2 mm sieve before use. The soil was amended with an equivalent rate of 100kg of N per hectare. Maize N requirement ranges from 90 -120 kg N/Ha (FAO, 2006). Treatments used are shown in Table 1.

Composts were ground to pass through a 2 mm sieve before mixing with 3 kg of soil. The treatments were replicated three times and pots were placed in the greenhouse in a completely randomised design. A total of 15 pots were used. The soil and the composts were thoroughly mixed and ten maize seeds placed into each pot. After determining percent emergence by counting the number of emerged seeds two weeks after sowing, two plants were left in each pot. The remaining plants were allowed to grow for five weeks because at between four and five weeks plant nutrients are well distributed in the plant and this is when optimum nutrient uptake from the soil takes place. Soil moisture was adjusted regularly according to plant requirements to avoid moisture stress and leaching the soils. The above ground plant parts were harvested at five weeks and oven dried at 60oC for 48 hours. Oven-dried maize samples were ground and analysed for total N, Mg, Ca and K using the same methods outlined for the compost samples (Okalebo et al., 2002).

2.4 Statistical analysis

Statistical analysis was done using Genstat 6 package, (Genstat, 2003). Treatment means were calculated and a general ANOVA was used to determine whether there were significant differences among treatments at a confidence interval of 95%. Least significant difference (LSD) was used to determine treatments that were significantly different.

RESULTS

3.1 Characterisation of soil and the final compost

Tables 2 and 3 show the different chemical properties of the composts and the soil used for the greenhouse pot experiment. Total and mineral N content decreased in the order 10% > 30% > 70% > 100% in the maize stover compost treatments. The C:N ratio of the 10% and 30% maize stover compost treatments where below the critical 20:1 ratio while the 70% and 100% where higher.

Percent Seed emergence

Seed emergence percentage did not significantly differ among treatments (P =0.260, Table 4). Most of the planted seeds germinated and emerged well indicating that there were no problems.

Table 1. The treatments used in the greenhouse pot experiment

Treatment	Proportions of chicken blood and maize stover in the finished compost
1	10% maize stover + 90% chicken blood
2	30% maize stover + 70% chicken blood
3	70% maize stover + 30% chicken blood
4	100% maize stover + 0% chicken blood
5	No amendment (control)

Table 2. Chemical properties of soil amendments

Chemical properties	10% stover	30% stover	70% stover	100% stover
Total N (%)	3.75	3.43	2.41	0.98
Ammonium –N ppm	146.9	62.36	55.9	35.4
Nitrate – N ppm	1.52	0.94	0.44	0.37
Total cations (ppm)	43.99	40.78	33.60	30.40
Organic Matter (%)	50.6	47.7	55.0	59.00
pH	6.03	6.52	6.49	7.74
EC ($mScm^{-1}$)	4.05	3.46	2.88	2.14
Ash Content (%)	16.38	14.54	15.04	15.06
C/N ratio	13.52	13.92	22.84	60.20

Table 3. Selected chemical soil properties

Chemical properties	
% Clay	5
% Silt	3
% Sand	92
Texture	Sandy
pH ($CaCl_2$	5.2
OC (%)	1.6
Available P (ppm)	11
Available N (ppm)	23

Table 4. Percent seed emergence for each soil amendment

Percent maize stover in compost amendment	% Seed emergence
10% Maize stover	96.7
30% Maize stover	100
70% Maize stover	93.3
100% Maize stover	86.7
Control	100
Least significance difference	14.09

Maize dry matter yield

Maize dry matter yield differed significantly among treatments ($p<0.05$) and was in the order 10% > 30% >70% > 100% > control (Figure 1). The plants grown in the soil amended with 10% and 30% maize stover final compost had greater biomass. These were significantly different from the 70%, 100% and control treatments.

Foliar analysis

Total Nitrogen

Mean N concentration in plant samples increased with a decrease in the proportion of maize stover in the compost. Nitrogen values were in the order 10% > 30% >70% > 100%> control (Figure 2). There were significant differences ($p<0.001$) among treatments in terms of N concentration with the plants growing in the soil amended with compost derived from 10% maize stover treatment having the greatest N concentration (0.75%) and those in the control the least (0.27%).

However, there was no significant difference in N concentration between the soils amended with the 70% and 100% maize stover compost and the

Nutrient content in maize plant samples

control. Total cation (Mg, Ca, K and Na) uptake did not differ significantly among treatments (p.> 0.05) (Figure 4). The control, however, had the highest total cation content and was significantly different from the soils amended with compost.

4. DISCUSSION

Maize seed emerged well for all the treatment indicating that the amendments did not have phytotoxic organic compounds, such as the propionic, acetic and butyric acid which hinder germination and seed emergence. Baziramakenga and Simard (1998) demonstrated that volatile low molecular weight organic acids decreased with composting duration and are associated with early stages of decomposition.

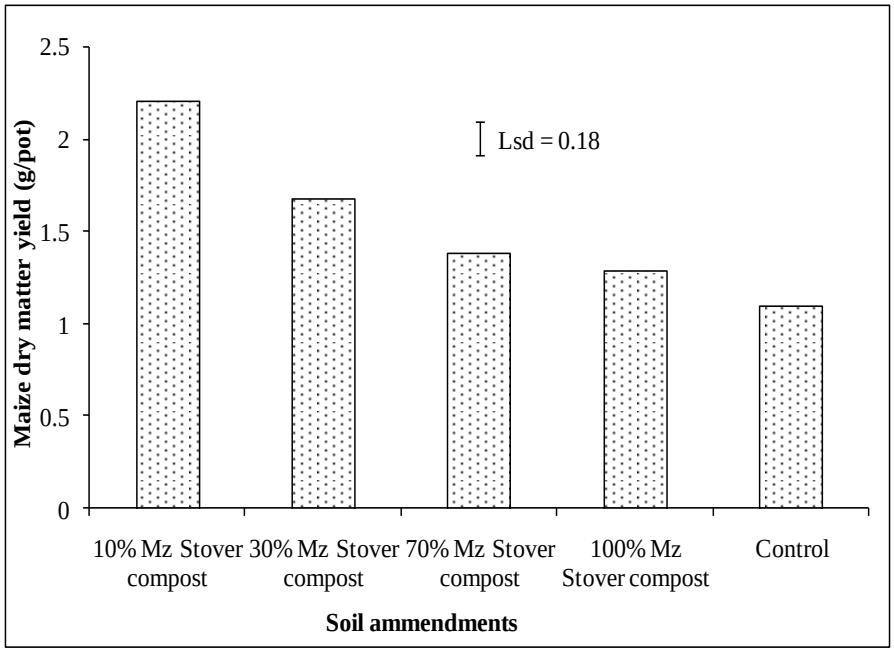

Figure 1: Effects of final composts on maize dry matter yield at five weeks after emergence in the greenhouse pot.

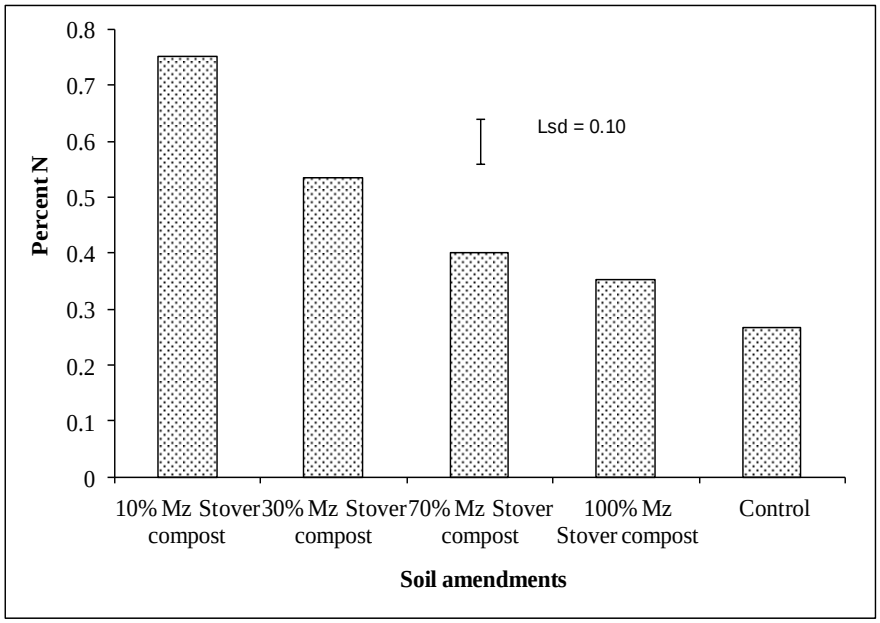

Figure 2: Total nitrogen uptake by plants grown in soils amended with different chicken blood finished compost. (Data points are the mean of the three replicates)

Figure . Total cation uptake by plants grown in soils amended with different chicken blood finished compost. (Data points are the mean of the three replicates)

Tiquia and Tam (1998), Tiquia et al., (1996) and Terman et al., (1973), reported that the application of immature composts inhibited seed germination, emergence and plant growth due to phytotoxic compounds. Nitrogen availability in the soils amended using the 70% and 100% treatments was low compared to the 10% and 30% treatments. This could have been due to differences in N mineralization as C:N ratios differed significantly, $P < 0.05$). Rate of nitrogen mineralization is

affected mainly by the C:N ratio of the organic amendment. Residues with low C:N ratios tend to exhibit net N mineralization, while residues with high C:N ratio exhibit immobilization (Mohanty et al., 2010;). The 10% and 30% treatments had C:N ratios of 13.52 and 13.92 respectively. These were below the critical C:N ratio of 20:1 (Mupondi et al., 2006) and thus mineralised better and faster than the other treatments making more N available for uptake. The initial C:N ratios of the 70% and 100% maize stover treatments were 22.84 and 60.20 respectively. The 10% and 30% composts also had more available NH_4 –N and NO_3-N (Table 2). However, the concentrations of N for all the treatments were lower than the adequate plant N tissue concentration reported by Okalebo et al., (1999). Nitrogen should range from 3.5 to 5% at 5 weeks for maize (Okalebo et al., 1999). in fields after the application of organic amendments. Research has also shown that mineralisation occurs in multiple phases after compost application depending on the decompostibility of the composts (Hargreaves et al., 2008; Kokkora et al., 2010). This means there is a non-steady N release rate even if compost is expected to result in net N mineralisation at C:N ratio below 15. Nyamangara and Giller, (2003), reported N deficiency in maize during early plant growth (6 weeks after planting). For this study the maize crop could have been left to grow over a longer period. Most studies on compost mineralisation have been done over longer periods. Murillo et al., (1995) found 22% mineralisation over a 22 week period of incubation while Iglesias and Alvarez, (1993) found 21% mineralisation over a 6 month pot study.

The low N recoveries suggest slow mineralisation rates. Large compost applications would be required to significantly increase short term soil N supply (Hartz et al., 2000) or combine with Composting reduces N mineralisation rates of organic waste. It stabilises C and N in the organic soil amendment (Nyamangara et al., 1999). Kokkora et al., (2010), Hargreaves et al., (2008ab), and Hartz et al. (2000), however, reported that mineralisation rates of composts vary nearly as widely as those of uncomposted manure. Castellanos and Pratt (1981) found N mineralisation rates ranging from 4 to 35% in a 10 month assay for manure composts, while Douglas and Magdoff (1991) reported that three manure composts had net N immobilization over 67 day incubation period.

The maize plants were stunted and yellow in colour and this could have been due to the inadequate N concentration in the soil. Short term immobilisation could be attributed to the deficiency symptoms observed. This could explain crop N deficiencies inorganic fertiliser (Nyamangara et al., 2003). Compost and manure amendment trials can indicate the value of organic amendments in long term soil building and their limitations in enhancing short term N availability.

5. CONCLUSION

From the study, the composts derived from mixtures of chicken blood and maize stover with initial proportions of 10% and 30% maize stover had greater potential to support maize growth as shown by the dry matter yield and total N concentrations in the plant samples. Total cations (Mg, Ca, K and Na) did not show significant difference among treatments. Further studies where the composts are combined with mineral nitrogen fertilizer to enhance the supply of N are recommended because the N from the composts were inadequate. Maize seed emerged well for all the treatments indicating that the amendments did not have phytotoxic organic compounds.

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Challenges faced in controlling wildland fires in Mazowe A1 resettlement farming areas of Zimbabwe

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Abstract

Wildland fires pose a big threat to both flora and fauna. In Zimbabwe an estimated 1 million hectares (ha) are burnt annually. The present study uses multiple sources of information including review of published literature, reports, field observations, questionnaires and interviews to investigate the challenges faced in controlling wildland fires in A1 resettlement farming areas of Zimbabwe. Two sites, ward 24 and 31 in Mazowe District were used as case studies to compile responses from 400 households. The results of the study indicated that issues of education, experience and lack of information in wildland fire management played a role in wildland fire management. In ward 24.6% never attended school, while 30%, 48% and 8% had reached primary education, secondary education and tertiary education respectively. In ward 31, the highest level of education of the respondents was 8%, 58% and 34% for primary level, secondary level, and tertiary education respectively. The predominant challenge was lack of experience in fire control as 52% of the respondents had never been involved in fire suppression. In addition, lack of information was highlighted as a major cause of wildland fires, as only 35% of respondents had attended fire awareness campaigns. The other challenges included; lack of proper fire fighting equipment, poor volunteerism and poor implementation of policies and regulations. It was concluded that multiple challenges exist in managing wildland fires, and hence more emphasis should be placed in training and equipping communities with fire management skills and provision of fire fighting equipment. A multi-sectoral approach is also recommended for implementation and enforcement of fire management regulations in the resettlement farming areas.

Keywords: Fires, resettlement farming areas, fire management, Mazowe District, sectorial approach.

INTRODUCTION

Wildland fires over the years have continued to ravage ecosystems causing damage to the environment. In most farming areas in Zimbabwe, cropped land, grasslands and pasturelands have been destroyed during the dry season causing

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shortage of herbage material and hence low productivity in livestock production (Svotwa et al., 2007). Wildland fires have destroyed property, caused loss of human life and exerted unquantifiable damage to the ecosystems throughout Zimbabwe (Ndangana, 2006). Since wildland fires continue to play a role in environmental degradation, it is therefore important to improve fire management especially in rural environments where communities live close to bush or forested areas and where livelihoods are hinged on natural resources (Chigurah et al., 2010). There are thought-provoking statistics about wildlands fires and their effects. According to Roberts and Wooster (2008), fires in the African continent were estimated to account for between 30–50% of the total annual biomass burned globally over the past eight years. In spite of efforts by various environmental organizations to curb fire incidences, wildland fires continue to be a major threat to agricultural activities. This is signified by an increase in hectarage lost, for example, in Zimbabwe, the area burnt increased from 713 770 hectares (ha) in 2011 to 1.5 million ha in 2015 (EMA, 2012). These statistics calls for greater attention to deal with wild land fires and also to look at possible mitigating factors in dealing with this menace.

A large percentage of people living in A1 resettlement farming areas and rural communities in Zimbabwe, heavily depend on agriculture and forest products for their livelihoods (Ndangana, 2006). Fire incidences is one of the major challenges that the resettlement farmers in A1 villagised schemes especially when they hunt for small game animals such as pigs and mice. This practice removes vegetation cover and its camouflaging effect and it becomes very easy to catch the wild animals. Resultantly, these wild land fires have destroyed ecosystem goods and services that the rural people derive from forests to sustain their livelihoods (Chigurah et al., 2010).

Several factors have been responsible for the occurrence of the wildland fires. The use of fires for land preparation by resettled farmers has been pointed out as one of the major cause of wildland fires (Svotwa et al., 2007; Phiri et al., 2011). Other causes of wildland fires include smoking out beehives, charcoal preparation, gold panning, and cooking (Chimatira et al., 2016). In the Southern African region some fires are started deliberately during the early winter to promote a green flush for their animals and by hunters clearing vegetation to catch their prey more easily (Nkomo et al., 2009; EMA, 2011), by people creating firebreaks around their homesteads or seeking to improve visibility, or by children playing with fires.

In Zimbabwe, cases of arson where employees are disgruntled over non-payment of salaries or low salaries have been reported in large-scale forested areas (Nyamadzawo et al., 2013). Ownership or land tenure disputes have been reported as the underlying causes of arson fires (FAO, 2007). Wildland fires can also be a result of roadside fires for warming especially during the cold dry winters, and can also start from lit cigarettes thrown out from moving vehicles (EMA, 2011). EMA (2011) reported that 60% of all fires occurred within 500 m from major highways as a result of roadside fires and throwing out of lit cigarettes and road accidents where vehicles catch fire. Some infrequent accidents such as by locomotives derailment and electrical faults from power lines have also been reported to cause wildland fires.

Wildland fires can be controlled through several ways which include education (improved community awareness) and strategies such as fire guard construction. The government of Zimbabwe through the Environmental Management Agency (EMA) has been educating the public on the dangers of uncontrolled wildland fires through printed literature, television and radio programmes. Several Acts of Parliament aimed at preventing fires such as the Environmental Management Agency CAP 20:27 of 2007, Parks and Wildlife Act CAP 20:14 of 1996, Forest Act CAP 19:05 of 1996 and the traditional leaders ACT of 1998 have also been enacted though the problem of wildland fires still exists. In spite of these efforts, both the ecosystem and people's lives and property remain in danger from wildland fires. Fire management remains a major challenge in wards 24 and 31. Therefore, the objective of this study was to investigate the challenges that are faced in controlling wildland fires in A1 resettlement farming areas of Zimbabwe, using two in Mazowe as case studies.

MATERIALS AND METHODS

Study Site

The study was carried out in two wards, wards 24 and 31 of Mazowe district located in Mashonaland Central Province approximately 40 km North of Harare. The study area is characterized by, small and large scale commercial farms under both A1 and A2 land resettlement model. For this study, only A1 households were considered as wild land fire incidences are highly pronounced in the area. Mazowe receives an average of 750-1000 mm of rainfall per year and average daily temperatures of 15oC and 30oC in summer. The dominant soils which are moderately deep to deep reddish brown Ferrallitic soils formed from mafic rocks. The vegetation consists of miombo woodlands and scattered grasses. The dominant grass is mainly *Hyparrhenia filipendula* and forest is dominated with by Brachystegia tree species. Crops grown include maize, tobacco, wheat and soya beans and citrus farming. Figure 1 shows the map of Mazowe district.

Sampling

Two wards were selected namely ward 24 and 31. Theses wards were purposefully chosen as the prevalence of wildland fires has been high, hence there was a need to conduct an in-depth study using two case studies. In ward 24 of Mazowe Rural District, 250 households were randomly selected to whilst in ward 31, 150 households were also randomly selected using computerised random numbers. All in all the total number of households interviewed reached 400. These were further stratified in equal numbers of males and females to avoid bias in the responses.

Data collection

Multiple data sources including review of published literature, reports, field observations, questionnaires and interviews were used to collect data. The questionnaires used had both closed and open format questions. Open format questions were introduced to allow respondents to give their individual opinions. Interviews were conducted with key informants (headmen, AGRITEX and EMA officers, ZRP representatives, elders and teachers). Additional data were also collected from

secondary data such as magazines, publications, bulletins, pamphlets and the internet.

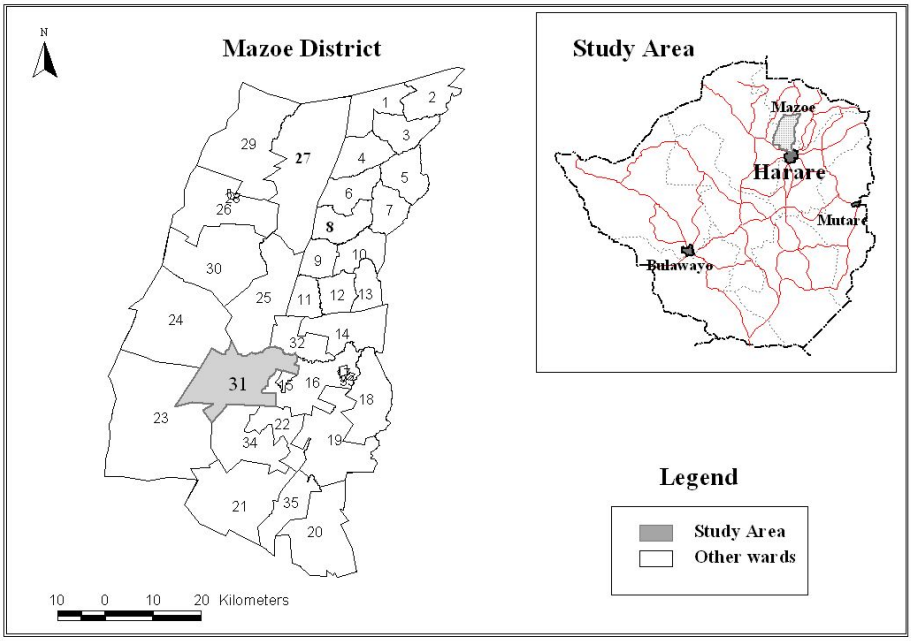

Figure 1. Map of ward 31 and the neibhouring ward 24 of Mazowe District, Zimbabwe.

RESULTS

Education status of respondents

In ward 24.6% never attended school, while 30%, 48% and 8% had reached primary education, secondary education and tertiary education respectively, whereas in ward 31, the highest level of education of the respondents was 8%, 58% and 34% for primary level, secondary level, and tertiary education respectively. The respondents' view on fire suppression depended on the level of education. All the respondents who attained primary level of education said they did not worry about suppression of wildland fires, while 91% and 100% of those who attained secondary and tertiary level all agreed to the need for fire suppression.

Causes of wild land fires

The major causes of wildland fires were identified as of anthropogenic origin in both ward 24 and 31. The major cause of wildland fires was land clearing which accounted for 50% and 35.5% of the fires for ward 24 and 31 respectively. Hunting resulted in the outbreak of about 20% and 8% of the wildland fires in ward 24 and 31 respectively. The deliberate lighting of wildland fires for no apparent reason reported by 18% respondents in ward 24 and 12.5% in ward 31. Other causes of wildland fires were cited as, children playing with fires (10%), smoking (2%), panning (3.3%) and bee smoking (2.6%). There was a great variation of perceptions on major causes of wildland fires in the area and the views depended on whether the person was involved in fire suppression or not, years of

experiencing wildland fires, and whether there was a fire fighting team in the area.

Reasons for fighting wildland fires

Several reasons were given on why wildland fires should be suppressed. Twenty five percent (25%) of the respondents suggested that wildland fires should be suppressed to avoid the destruction of property and livestock, 23% suggested that wildland fires should be suppressed to prevent damage to crops and livestock, and 23% suggested that they should be prevented to avoid the death and injury of people. Thirteen percent of the respondents suggested that fires should be prevented to avoid damage to property while 7% suggested that fires should be prevented to avoid damage to the environment and the ecosystem (Figure 2). A total of 66% of respondents, who never own any livestock agreed that wildlands fire should be suppressed, compared to 100% of livestock owners who agreed to fire suppression.

Gender and fire suppression

The majority (72%) of the women respondents agreed that fire suppression should be carried out, while 28% were indifferent to fire suppression. A total of 92% of men were agreeable to fire suppression. Only 11% of the youth took part in the extinguishing of wildland fires. Most of the youth would light fires and ignore them as they spread.

Challenges in controlling wildland fires

Several reasons were given as challenges faced in controlling wildland fires. The most common was that there was lack of experience in fire control as 52% of the respondents had never been involved in fire suppression, while only 26% had been involved in fire suppression. The majority of those who had not been involved in wildland fire suppression were the youth and women. The results showed that people that had no fire fighting teams in their villages and not been involved in firefighting are 2.6 times more likely to have a low response to a fire incident and to be involved in fire suppression.

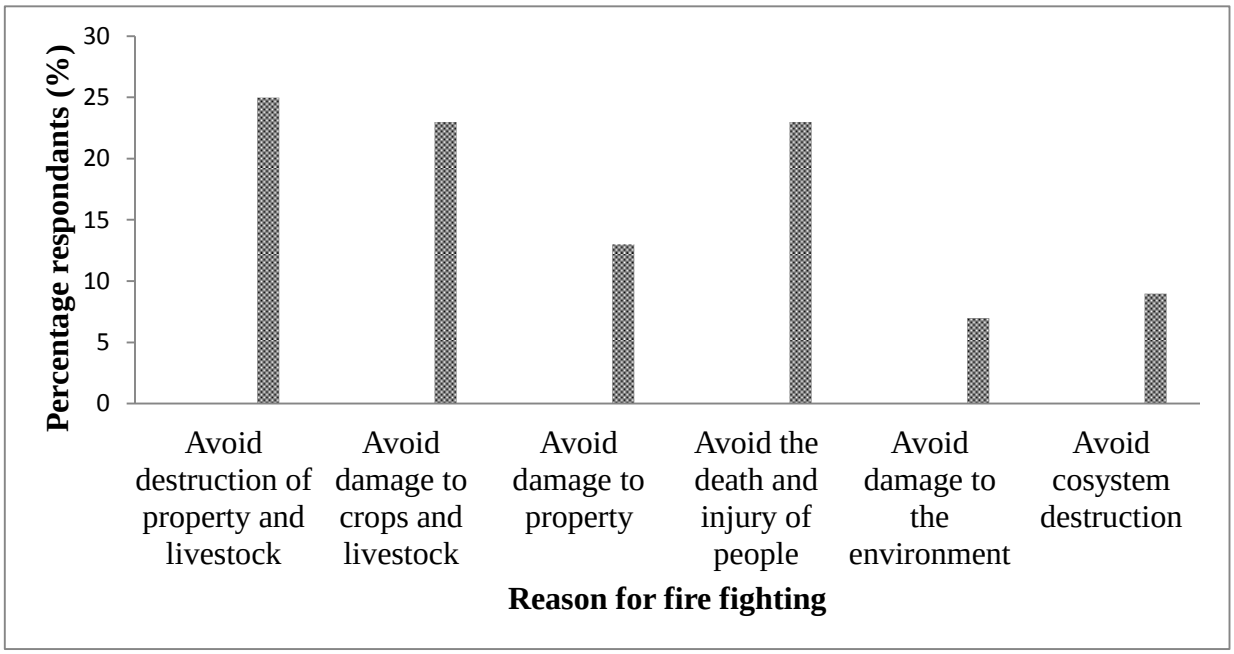

Figure 2. Reasons for fighting wildland fires

The other challenge that was observed was the lack of cooperation among community members. The youth did not put much value in environmental conservation in the area and this had a negative effect on their response to wildland fires. Adults were the ones who tended to respond to fires quickly and showed concern at the destruction caused by the fires. The youth were blamed for igniting most of the fires in the area during hunting expeditions.

The study found out that there were wildland fire awareness campaigns that were conducted in the study area towards the fire season. Only 35% of the respondents stated that they had attended wildland fires campaigns. Education (awareness) received by respondents about wildland fires usually came from EMA, Forestry Commission officers and local leadership towards the fire seasons in addition to programmes on radio and television but these campaigns are few. Most respondents also cited the lack of proper firefighting equipment as another challenge to fighting wildland fires. Some respondents cited the lack of resources to construct fireguards as another challenge. Another challenge was poor fire detection since most fires occurred at night when most of people are asleep.

Lack of knowledge on firefighting legislation was seen as one of the most reported challenges in dealing with wild land fires. Most respondents did not know that there was legislation that was put in place to guard against wildland fires. Approximately 60% of the respondents stated that they did not know about any legislation on wildland fires. One respondent on being asked whether they knew that they were supposed to inform their neighbor before starting a fire on their

premises stated that: “Why is it my neighbors’ business to inform them of what I do in my farm?”

The local leadership play an important role also in dealing with the issues of wildland fires. However, concern was raised on the diminishing role and annexation of the power of the traditional leadership by the government. The role played by indigenous knowledge systems (IKS) has been shown to be important since it encourages a grassroots approach on wildland fire management. The research findings revealed that the headman and chiefs also conducted awareness campaigns and IKS in order to inform people on the dangers of wildland fires.

DISCUSSION

The level of education had a bearing on response to fire fighting in A1 resettlement area of Mazowe district. All the respondents who had not attained primary education level did not attach much importance to controlling wildland fires. Among those who had attained secondary education, some were conversant of the dangers of wildland fires but interestingly, they did not put the knowledge into practice. However, those who had attained tertiary education showed much concern about the wildland fires and did what was in their ability to conserve their environment by adopting fire preventive measures. On the same note, the respondents who attended environmental education and awareness meetings and campaigns had higher levels of responses than those who never attended these meetings. These were found to have better appreciation of environmental issues. It is during these meetings and campaigns that issues to do with veld fires including skills on how to fight veld fires are discussed and also imparted to the community.

The youth did not put much value in fire suppression were blamed for igniting most of the fires in the area during hunting expeditions. This is probably because they are the most active members of the society who normally engage in hunting activities. The spread of the fires would then depend on the success in catching the prey. If the hunted animals encroach onto another forest area then the hunters will light fires in the new area. This explains why fires sometimes jump fire guards erected. Sturtevant and Cleland (2007) revealed that the likelihood of fire to starts is primarily influenced by human activity whereas biophysical factors determine whether those fire starts become large fires.

Women were more concerned and responded by trying to extinguish fires near their homes. Ryan and Wamsley (2008) and Lim et al., (2009) reported that males are less concerned about the risks of fire near homes. This is probably because women are usually at home than man who are normally more mobile in the forest hunting. It is more likely that man who like hunting are the ones who cause much of the fires which then spread from the wild towards homes especially when economic conditions are not very favourable to create employment for them. In Russia, it was discovered that the political and economic crises were the main underlying causes of recent large-scale fires (IUCN/WWF, 2000).

Most of the A1 farms are densely populated as compared to A2 farming areas and land is often underutilised and this causes increased fuel load. Studies around the globe affirms that population

density is positively related to wildfire ignitions (Cardille et al., 2001). Furthermore, land clearing and hunting were cited as the major causes of wildland fires. Most A1 resettlement farming areas of Zimbabwe have limited resources and equipment to clear and prepare the land using mechanical methods; hence farmers frequently use fires for land preparation (Nyamadzawo et al., 2013). Besides land clearance, households in Mazowe use fire in harvesting wild honey and hunting wild pigs. This concurs with the Secretariat of the Convention on Biological Diversity (2001) that wildland fires in the tropics are due to land clearing with fire, accidental or escaped fire, and fires connected with resource extraction.

In a study in Cashel Valley, Zimbabwe, 60% of the respondents agreed that land clearing was the major cause of fires in the area (Nkomo et al., 2009). Hunting is another major cause of wildland fires in the area mainly because the hunting season coincides with the dry season when the fuel load is high in addition to hot and windy conditions which enhance the initiation and spread of wildland fires (Kilahama, 2011). These findings are also supported by Panzer and Schwartz, (2000); Svotwa et al. (2007) and Nkomo et al., (2009). Most of the causes of wildland fires were human caused, and the same was reported from 10 year study in the USA with recorded 88% of the fires as human caused (NFA, 2001).

Several reasons were given to justify the need to suppress wildland fires. The main reasons were to prevent economic damage to crops, livestock and the environment. In addition, the protection of human life was also highlighted as a major reason to fight wildland fires. In previous fires seasons, human life has been lost due to wildland fires. A total of 10, 25, 5 and 5 people lost their lives in 2009, 2010, 2011, and 2012 respectively due to wildland fires (Nyamadzawo et al., 2013). The results showed that the majority of women are more concerned about the effects wildland fires than men since most of their economic activities such as gardening and cultivation are more susceptible to fire damage.

Non-livestock owners were less concerned about of fire suppression and control. The main reason was that livestock owners are more concerned about potential loss of ~~on~~ pasturelands for their livestock. This is in agreement with Nkomo et al., (2009) who noted that wildland fires destroy pastures which are a source of feed for livestock. However, some farmers who owned livestock asserted that they would not fight wildland fires as long as their crops and property are not threatened. They argued that wildland fires assist in tick-control and to ensure the regeneration of good pasture grass. They only lamented the timing of burning since it has to be done just before the onset of the rain season to allow the grass to quickly regenerate and provide feed to livestock.

The other challenges faced in controlling wildland fires included the lack of firefighting equipment such a beaters, water bowsers and knapsack sprayers. This has an effect on response levels. Well-equipped members of the community had higher levels of responses wanting to put their equipment to full use. They had security against fires as a result of firefighting equipment. Some respondents were interested in wildland fire control but would end up not doing so because of lack of firefighting equipment. Without proper firefighting equipment it becomes difficult to control wildland

fires. The lack of financial resources hampers the procurement of firefighting equipment. This is obvious in A1 farms where the majority of the households are living in poverty hence acquisition of firefighting equipment could be a major challenge.

Another challenge that was faced in fighting wildland fires was the lack of knowledge and experience on wildland fire control. People with a fire fighting team in their area had knowledge of the major causes of fire than those who did not have a fire fighting team due to ignorance and reluctance to be involved in fire suppression. People who were once involved in suppression had knowledge on the most prevalent causes of wildland fires (Gan et al., 2015). Choga and Nyamadzawo (2016) (unpublished) in a study in Makoni reported that up to 70% of resettled people came from urban areas, 15% from nearby villages and 15% from rural areas. People with no fire that it was a crime not to take part in the suppression of wildland fire.

Ignorance and lack of concern about impact of fires was also a challenge in controlling wildland fires. If there is no one taking responsibility over the fire then even though it affects everybody, no one would take the initiative to mobilise others. The villagers revealed that they have a NIMBY (Not in my backyard) syndrome that entails that they are not worried with fires that do not threaten their property directly even though they derive benefits from the environment which is prone to fire damage. The community's negative attitude towards fires was illustrated by the fact that of the 46 fires that were recorded in 2013 in ward 24, only 5 were extinguished on time. The people also took long to respond to fire outbreaks such that the fighting teams in their area and who have never been involved in fire suppression are less likely to respond quickly to a fire incident and be involved in fire suppression compared to those with firefighting teams and experience (Gan et al., 2015). McCaffrey (2008) and Toledo et al., (2013) reported that the land owner's knowledge towards prescribed burning and suppression of wildland fires is associated with previous experiences.

There was blame game between the structures of society in ensuring that policies and legislation on wildland fires are put into practice. For example, the local leaders stated that they are not adequately empowered by the other institutions to deal with those caught committing crimes involving wildland fires. The Environmental Management Act (20:27) has contributed to a reduction in the occurrence of wildland fires since the legislation acts as a deterrent to would-be offenders. However, some respondents also indicated that they were not aware

fires rapidly spread to long grass and became dangerous and difficult to extinguish. As such wildland fires of high intensity are generally more difficult, and costly to fight small fires (Daniel et al., 2007).

Whilst respondents appraised the critical role of local leadership in dealing with the issues of wildland fires through raising awareness and promoting the upholding of indigenous knowledge systems, there has been a notable level of resistance from other groups mainly the farm workers left in the compounds by former farm owners and newly resettled farmers who moved in from other areas and do not uphold the local cultural and traditional conservation ideologies. Local leaders were also concerned about new comers who were not following the norms and values of the area, hence making it difficult to control wildland fires. The

lack of cooperation amongst community members on the aspect of wildland fires was a challenge.

CONCLUSIONS

Education was a key factor in determining the level of involvement in wildland fire issues. Response to wildland fires, increased as the level of education increased. Wildland fires were caused by several activities but the most common cause were farmers who use fires for land preparation and hunting. The challenges faced in controlling wildland fires included inadequate education or lack of it and lack experience on wildland fires and ignorance of legislation on wildland fires which is a result of inadequate education of community members. There is also lack of fire-fighting equipment, and lack of resources and finances to purchase the required equipment. Lack of unity and oneness amongst the community members is another challenge to reducing wildland fire in the community. The annexation of the powers of local leaders also poses a challenge to fighting wildland fires as they are failing to punish effectively perpetrators of wildland fires Regardless of the numerous challenges faced in fighting wildland fires in Mazowe, wildland fires should be controlled at any cost for the conservation of the environment. It was concluded that multiple challenges exist in managing wildland fires, and it is recommended that more emphasis should be placed in preventive policy measures such as training and equipping communities with fire management skills and provision of firefighting equipment. A multi-sectoral approach is also recommended for implementation and enforcement of fire management regulations in the A1 resettlement farming areas.

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