Assessment of fire prevalence and reduction strategies in Miombo woodlands of Eastern Tanzania

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ABSTRACT

An assessment of the proximate causes, effects and factors contributing to fire prevalence was conducted in three districts covered by miombo woodlands in Eastern Tanzania. Three miombo woodlands under different management regimes and governance structures (central government forest reserve, local government forest reserve and village land forest) each were investigated in Handeni, Kilosa and Kilwa districts. Data were collected from three villages selected in each District through household surveys, Participatory Rural Appraisal (PRA), interviews of key informants and field observations. The analysis of data involved content analysis for documentary materials, descriptive statistical analysis for household surveys and Chi square was used to test whether there were differences in responses of local communities across forest management regimes. Results indicate that the major five human activities contributing to fire prevalence across the miombo woodlands include farm preparation (34.1%), hunting (28.5%), arson (21.5%), livestock grazing (9.3%) and charcoal making (0.7%). The causes were fairly the same across forest management regimes. August, September and October were the peak fire months and they were not influenced by different management regimes but by geographical locations within Eastern Tanzania. Results further show that fires in miombo woodlands usually start inside the woodland (67.2%), around residential area (22.9%) and from farms (9.9%). The origin of fire inside the woodland becomes more serious because it combines the hunting, arson, livestock grazing and charcoal making which are usually done inside the woodland. Chi-square test indicates significant difference on origin of fires across the forest management regimes (χ^2 = 13.341 and p = 0.031). The local communities acknowledged fires having both positive and negative effects and these effects were the same across the management regimes. Further, across the surveyed villages, strong social ties existed between fires and the daily life of local communities. Poverty, ignorance, weak law enforcement and climatic factors were identified as underlying factors contributing to fire prevalence. Fire incidences are predicted to increase given the increasing climate change. Potential strategies to reduce fires incidence identified were awareness creation, law enforcement, making fire breaks, introduction of alternative income generating activities, and improving agriculture practises. Furthermore, the use of prescribed burning to reduce effects of late fires and developing fire management plans to enhance miombo woodland management

are among the strategies worth consideration by the local communities.

Key words: fire prevalence, management regimes, miombo woodlands, Eastern Tanzania

INTRODUCTION

Miombo form a dominant vegetation type in Sub Saharan Africa (White 1983; Campbell *et al*. 1996). In Tanzania, miombo woodlands are found mainly in Tabora, Lindi, Morogoro, Manyara and Katavi regions. They constitute the largest and most important single vegetation in the country, estimated to occupy 90% of total forest cover (URT 1998; Abdallah and Monela 2007). They supply a variety of ecosystem goods and services which contribute to household and national economies. Services from miombo woodlands include soil erosion control, protection of water catchments, provision of shade, modifying hydrological cycles and maintaining soil fertility, biodiversity conservation and spiritual well-being (Monela *et al*. 2000). The ecosystem goods derived from miombo woodlands include honey and beeswax, gum arabic, ropes, fruits, vegetables, mushrooms, fodder, thatches, medicines, building poles, firewood, charcoal and game meat (Mbwambo 2000). The miombo woodlands also have a huge economic potential over the benefit that Reduced Emissions from Deforestation and Forest Degradation (REDD) financial mechanism offers. But fires which are a common feature in miombo woodlands pose substantial loss to resources and environmental services offered by the woodlands (FAO 2011; Kideghesho *et al.* 2013).

The World Summit for Sustainable Development (WSSD) held in Johannesburg, South Africa in 2002 provided the groundwork for an action programme to reduce the negative effects of fires on the environment and humanity. This led to holding an International Wild land Fire summit in Sydney, Australia in October 2003 to develop synergistic solutions to strengthen international cooperation in order to reduce the negative impacts of forest fires on humanity and the global environment. In Tanzania, it has been estimated that between year 2000 and 2009 fires affect about 65,000 ha of forests and woodlands annually of which more than 75% occur in miombo woodlands (FAO 2011; Kideghesho *et al.* 2013). This has alarmed the government, forest managers, researchers and communities leading to different efforts to address the challenge. The efforts include for example design and implementation of Community Based Fire Management Plan (CBFMP) and by-laws in East Usambara (WWF 2006) and Community Based Fire Management (CBFiM) in the miombo woodlands of Bukombe District, Tanzania (Nssoko 2002).

More recently, some efforts have been made including the Tanzania-South Africa Fire Management Project which aims to enhance integrated fire management at national and local levels and develop an operational framework for regional fire management coordination (TFS 2013). These efforts have been advanced after realizing the damage that fire is causing and the need for collective commitment in solving these problems. There are several effects of fires to biodiversity and global environment. These include carbon emission to the atmosphere that leads to global warming; changes in productivity and population structure of forest tree species (Zolho 2005; IPCC 2007), reduction of fodder for grazing animals (Hassan and Rija 2011), killing of animals that are unable to escape or avoid excessive heat (Frost 1996), loss of habitats (used for cover, shelter, structure and breeding conditions), and increased risk of predation (WCS 2009). Furthermore, fire contributes to changing the landscape structure and species composition including grasslands, savannahs, closed forests and woodlands (Tyler 1995).

Despite all these efforts, fire incidences, especially in the miombo woodlands, are still increasing. This paper aims at answering the following questions: what are proximate causes of fires? What are the effects of fire to the environment, economic and biodiversity based on the observable features and on people's perception? What factors are contributing to the prevalence of fires? What are the best strategies available for reducing fires? But all these research questions were addressed using the lens of different management regimes with hypothesis that fire prevalence is greatly influenced by different management regimes. In this paper these questions are discussed using empirical data from local communities across the three districts and appropriate mitigation measures to minimize this environmental disaster in the miombo woodlands are proposed.

MATERIAL AND METHODS

Study area and data collection

The study was done in three districts namely Handeni (Tanga), Kilosa (Morogoro) and Kilwa (Lindi) (Figure 1) chosen purposively based on existence of miombo woodlands, annual fire incidences and different management regimes . Handeni district covering 7,080 km^2 is located between Latitudes 4°55' and 6°04' S and Longitudes 37°47' and 38°46' E and receives around 800 mm annual rainfall (Mbwambo *et al.* 2013). Kilosa district with a total land area of 12,394 $km^2$is located between Latitude 5°55' and 7°53' S and Longitudes 36°30' and 37°30' E. Average annual rainfall ranges from 1000 mm to 1400 mm for the Southern flood plains and ranges from 800 mm to 1100 mm for the Northern part of the District. Mountain forest areas can receive up to 1600 mm annually. Temperature in the district varies with altitude. Average annual temperature in the district is 25°C (KDC 2012a). Kilwa district with an area of 13,347.50 km^2 is located between latitude 8°15' and 10°00'S and longitude 38°40' and 39°40'E. The district has a coastal climate with a mean annual temperature ranging from 22°C to 30°C and a mean annual rainfall of 1,034 mm (KDC 2008b). In each district, three woodlands, one under Central government (CG), Local authority (LA), and Village government (VG) were selected for the study. Miombo woodlands under village government included un-reserved forests on village lands and village land forest reserves and this regime is abbreviated as VLFR. A purposive sampling was used to select one village closest to the selected study miombo woodland for the assessment of the causes and effects of fires (Table 1).

Table 1: Selected study miombo woodlands and villages in Handeni, Kilosa and Kilwa

District	Woodland name	Area (ha)	Management regimes	Name of adjacent village
Handeni	Bumba URVF	Not surveyed	Village government	Madebe
	Handeni Hill CGFR	544	Central government	Vibaoni
	Kiva Hill LAFR	655	Local authority	Kwedibangala
Kilosa	Mbilili VLFR	3,005	Village government	Ihombwe
	Palaulanga CGFR	10,610	Central government	Madizini
	Magubike South LAFR	15,055	Local authority	Mamboya
Kilwa	Kikole VLFR	450	Village government	Kikole
	Mitarure CGFR	60,480	Central government	Migeregere
	Kiwawa LAFR	Not surveyed	Proposed local authority	Kiwawa

Note: URVF - Un-reserved woodland on village land; CGFR - Central government forest reserve; LAFR - Local authority forest reserve; VLFR – Village land forest reserve

A combination of methods namely Participatory Rural Appraisal (PRA), key informant interview and household survey were used to collect data on socio-

economic activities, fire incidences, miombo woodland conditions, and availability of extension materials for awareness creation. PRA involved sharing experience with local people by using different tools including participatory resource mapping, time line, matrix pair wise ranking and Venn diagrams. The PRA team involved women and men, young and old, newcomers and old-timers, different occupations (pastoralists, agriculturists, employees and merchants). Semi structured interview was conducted to key informants in order to supplement information collected through PRA and household surveys approaches. Key informants were heads of organizations such as leaders of village government, members of Village natural resources committee (VNRC), non government organizations (NGOs), community based organizations (CBOs), projects, informal groups dealing with forest management and district natural resources officers. Questionnaires were administered to 9 villages. In each village 30 households were selected randomly from village registers making a total of 270 households. Literature review was done in order to supplement primary data. Reliable sources of information such as scientific papers, reports and policies were accessed in libraries and internet.

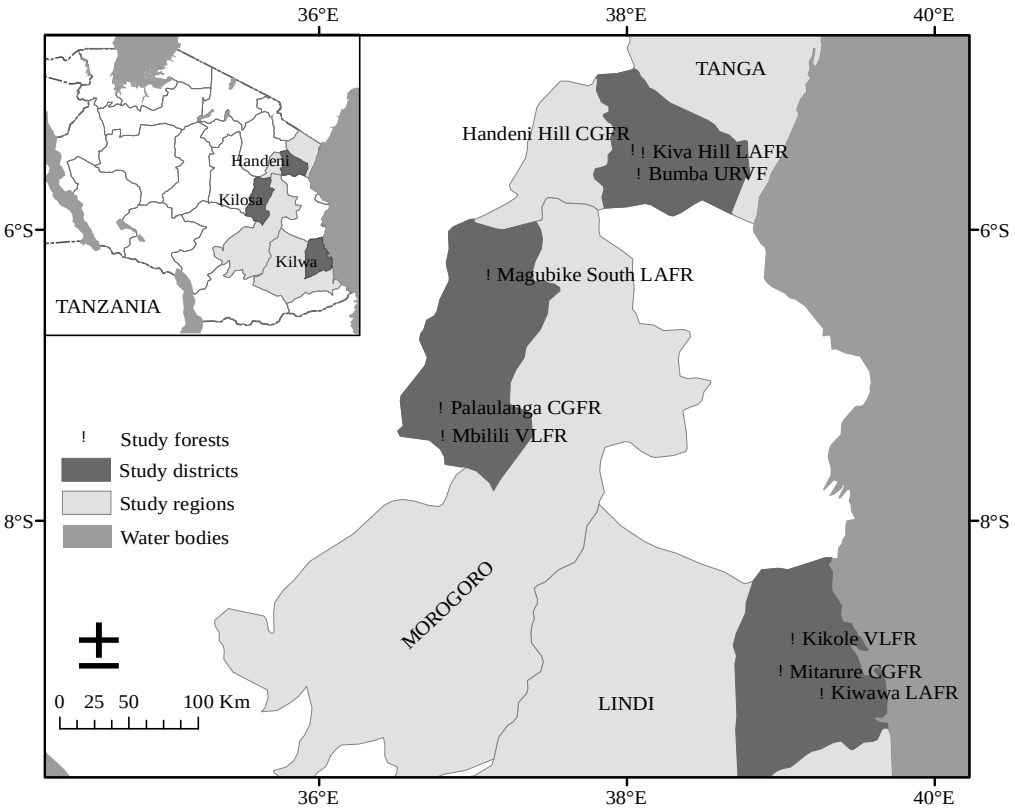

Figure 1. A map showing study ditricts and miombo woodlands

Data Analysis

Both qualitative and quantitative methods of data analysis were employed in order to address the study objectives. Data collected through PRA and key informants were subjected to content analysis. Detailed analyses of some documentary materials were done to produce information that could be linked to explain the situation in the field regarding fires in miombo woodland. The quantitative data collected through household surveys was

summarized and coded and analysed using Statistical Package for Social Sciences (SPSS version 16). Descriptive statistical analysis was used in exploring the data for distribution of responses and central tendencies. Chi square was used to test whether there were differences in responses of local communities across management regimes.

RESULTS AND DISCUSSION

Historical trends of fires outbreak in the study areas

Fire outbreaks were common across all study miombo woodlands and surrounding areas and usually fire incidences occurred during dry season and their severity increased with increasing period of dry condition (drought). This was perhaps due to the weakness in enforcement of local regulations during the fire seasons. PRA results indicate that before 1990s, many forest reserves were rarely burnt largely due to consistency and reliability of rains, complemented by existence of functioning formal and informal institutions governing forest and woodland management. During that period, exceptional few incidences of fires occurred in 1950 and 1974/5 in Ihombwe and Kwedibangala villages, respectively due to many years of no fires in Ihombwe, which resulted into high accumulation of fuel load in the miombo woodland. Fire of 1974/5 in Kwedibangala village was associated with establishment of the Ujamaa (Community) villages where the old homesteads were demolished and burnt to create nucleated villages. Fire from burnt houses jumped and destroyed the village adjacent forests and woodlands. It was further reported that after 1990, incidences of fires increased due to climate variability mainly increasing of dry spells exacerbated by institutional failures. Respondents also reported that fires occur almost every year in the forests and woodlands with varying intensity and severity depending on the length of rain/dry season. The result corresponds with observations made by Frost and Robertson (1977) that complete absence of fire in miombo woodlands is rare and probably limited to dense miombo woodlands with an evergreen understorey and little grass. Also, the result corresponds with observations made in rangeland ecosystems across the country (Butz 2009; Kideghesho *et al*. 2013) which part of it is composed of open miombo woodlands.

Proximate causes of fires

Five proximate causes of fires mentioned by local communities in order of prevalence was 34.1% of respondents mentioned farm preparation while 28.5%, 21.5%, 9.3% and 0.7% mentioned hunters, arsonist, livestock keepers and charcoal makers respectively (Table 2). About 6% of the sampled households were not aware of proximate cause of fires in miombo woodland. We hypothesised that causes of fires differed based on differences in forest management regimes. Farm preparation was identified as the most important causes in CGFR (38.9%) as compared to VLFR (30%) and LAFR (33.3%). This situation is likely to be due to/or caused by the weakness of respective authority to enforce existing laws hence allowing slash and burn practice during land preparation which was reported by 58.2% of the respondents as cause of fire. The practice was most (94.4%) common in Kilwa district followed by Kilosa (45.6%) and least in Handeni district (34.4%). Kilwa is leading in such practice due to abundance of general land and low population density. The district had a population density of 13 people/km^2 compared to 31 people/km^2 in Kilosa and 77 people/km^2 in Handeni district (NBS 2003).

Fires caused by livestock keepers were most (15.6%) reported in LAFR compared to 6.7% in VLFR and 5.6% in CGFR. It was further established that illegal hunting was most reported in CGFR while arson was most reported in LAFR (Table 2). Charcoaling was reported by few respondents from villages adjacent to

VLFRs. Most of these villages have access to suitable market of charcoal, hence local communities engaged in charcoal production as alternative source of household income. Charcoaling is a potential cause of fire for CGFRs and LAFRs due to increasing demand of charcoal in big cities as the result of rising price of gas and electricity and construction of tarmac roads connecting these districts to markets in big urban centres. Forest clearing and charcoal making have been responsible for the rapid loss of forest land cover and deterioration of local biodiversity along the main roads in Tanzania (Ahrends *et al.* 2010; Kideghesho *et al.* 2013). Chi square test revealed no significant difference (χ^2 = 16.391 and p = 0.089) on the most important cause of fire across management regimes implying that there is similarities regarding causes of fires in miombo woodland.

Table 2: Causes of fires as identified by respondents during household survey (n=270)

	VLFR		CGFR		LAFR		Total		Chi square tests		
Proximate causes	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**χ^2-value**	**df**	**Sign**
Farm preparation	27	30.0	35	38.9	30	33.3	92	34.1	16.391	10	0.089
Livestock keepers	6	6.7	5	5.6	14	15.6	25	9.3			
Hunters	28	31.1	30	33.3	19	21.1	77	28.5			
Arsonist	21	23.3	14	15.6	23	25.6	58	21.5			
Charcoal makers	2	2.2	0	-	0	-	2	0.7			
Not aware	6	6.7	6	6.7	4	4.4	16	5.9			
Total	90	100.0	90	100.0	90	100.0	270	100			

F = Frequency

Occurrence of fires in miombo woodlands were either deliberate (arson) or accidental. The former was a result of fire due to anthropogenic activities such as taboos (indicator of life span e.g. in Tanzania, some tribes believe that a person who starts a fire that lasts longer and spreads over long distance is considered to live a long life); clearing of landscapes to allow safe and free movement in the woodlands during hunting or collection of forest products; stimulating forage production; controlling pests (e.g. ticks, tsetse flies, and vermin); and reducing vegetation cover to keep away dangerous animals (e.g. lion). The use of fire during hunting of small mammals such as Giant rats (Ndezi) was practiced in all study miombo woodlands. Such traditional hunting involves burning of bush on one side and waiting for escaping animals on opposite side of the bush. The traditional use of fire among agro-pastoral communities for land preparation and stimulating new grasses has also been reported to cause forest fires among the Wamaasai communities in Northern Tanzania (Butz 2009). Accidental fires were a result of fire escaping from crop field to miombo woodland during farm preparation through slash and burn. The causes of fire in this study have been acknowledged also in other studies and farm preparation being the main cause (FAO 2007; FAO 2011; URT 1998; Fitzgerald 1971).

The pattern of fires occurrences indicated June to December as a fire season with a peak in August, September and October as reported by (20.5%), (25.5%) and (26.6%) respondents respectively. In the study sites, dry season starts from June and culminates in December. The months of June, July, November and December had low fire incidences as reported by 2.3%, 6.9%, 13.5% and 5% of respondents respectively. It was observed that June and July were onset months of dry season with little fuel load and fresh grasses. November and December had low fire incidences because of the short rains that minimize combustibility of fuel biomass. In addition, during that period, most villagers are usually engaged in farm activities with little

engagement in risky activities such as hunting that could cause fire eruption.

Further analysis showed that the period of peak fire season is not determined by forest management regimes but rather determined by geographical locations of study sites. Minor variations were observed among the sites. For instance, Handeni hill CGFR and Kiva hill LAFR (in Handeni District) experienced peak fire season in September and October while Bumba VGLF (in Handeni District) experienced fires in September. Variation in peak fire season was also revealed in Kilosa District whereby Mbilili VLFR experienced peak fire season in August while Palaulanga CGFR and Magubike South LAFR experienced fire season in October. In Kilwa, Kikole VLFR and Mitalule CGFR experienced peak fire season in September and October while in Mitundumbeya LAFR experienced peak fire season in October. Across all miombo woodlands, very few fire incidences were reported before and after peak fire season. Such findings suggest that prescribe burning and any campaign attempting to reduce fires incidences should start at the end of rainy season mainly in May and June. Similar peak fire seasons have been reported elsewhere (Kashula and Gobbo 2011; Chidumayo 1997). Furthermore, Frost (1996) and Kall (2006) argued that fire burning in the early dry season (May-June), when the ground layer is still moist tends to be very low in intensity and limited in extent and hence affects grasses and mammals negatively while woody plants are less affected. Late season fires often completely burn up ground layer vegetation, cause substantial leaf scorch in the canopy and cover large areas. Cauldwell (2000) pointed out that late season fires inhibits regeneration of trees, leading to overtime loss of the tall canopy forming trees of the genera *Brachystegia spp, Julbernardia spp,* and *Isorberlnia spp*. and most mammals found in miombo woodlands.

Origin of fires

The origin of fires were identified to be around residential areas, inside the woodland and around farms. The respondents showed that fires start inside the woodland (57.8%), around residential area (19.6%) and from farms (8.8%). Findings across forest management regimes revealed uneven distribution of people's responses on where fires starts. About 59%, 46% and 69% of respondents adjacent to VLFRs, CGFRs and LAFRs respectively revealed that most fires start from inside the woodland (Table 3). The high proportion of fires starting from inside the woodland suggests the existence of illegal anthropogenic activities. Such illegal activities include hunting, honey harvesting, livestock keeping, charcoal making and lumbering which usually happen inside the woodland. About 16%, 28% and 16% of respondents adjacent to VLFRs, CGFRs and LAFRs respectively reported that fires start from around residential areas. Fires that start around farms were common in VLFR as reported by 10% compared to CGFR and LAFR reported by 7.8% of the respondents. The chi-square test indicated that the difference in origin of fires across forest management regimes was statistically significant (χ^2= 13.341 and p = 0.031) (Table 3). This findings show that there is significant variation among forest management regimes on origin of fires.

Table 3: Origin of fires as identified by respondents during household survey (n=270)

	Type of forest management regime						Total				
	VLFR		CGFR		LAFR				Chi-square tests		
Places where fire starts	F	%	F	%	F	%	F	%	χ^2-value	Df	Sign
Around resident area	14	15.6	25	27.8	14	15.6	53	19.6	13.341	6	0.031
Inside the woodland	53	58.9	41	45.6	62	68.9	156	57.8			
Around farms	9	10.0	7	7.8	7	7.8	23	8.5			
Not aware	14	15.6	17	18.9	7	7.8	38	14.1			
Total	90	100	90	100	90	100	270	100			

Effects of fires in the study villages and miombo woodlands

Fires had considerable positive and negative effects among the local communities. Across the surveyed villages, strong social ties existed between fires and the daily life of local communities. Local communities used fire for land preparation, hunting small mammals, eliminating cover for dangerous animals such as snakes and lions around homesteads, and enhancing crop and livestock production. Ash was traditionally believed to improve soil fertility especially in millet fields, hence improving productivity. This effect of ash motivated many millet growers to burn crop residues and grasses on their fields or till in burnt areas. Economically, fire was perceived to increase production by reducing costs of land preparation as well as stimulating new grasses for livestock thereby reducing costs associated with disease treatment caused by ticks and tsetse flies. Moreover, the clearing of miombo woodlands to ease harvesting of forest products was also mentioned among the positive effects of fires. For example, it was noted by participants during PRA exercise that the 1997 famine event in Kiwawa village led to increased incidences of fires to ease collection of edible roots of wild yam locally known as *Ming'oko*, (*Diosconea sp*). Culturally, fire is also believed to be a yardstick of lifespan of individuals involved in torching miombo woodlands, e.g. in Tanzania some tribes believe that if one starts the fire and it lasts longer and spreading to a large extent such a person is considered to live a long life.

On the other hand, local communities were aware of the negative effect of fires that include loss of biodiversity through burning of young trees, killing animals and micro-organisms, migration of wild animals, drying of water sources and reducing plant growth. It was reported that burnt area has no life except for big trees, big animals and birds which can resist or escape fires. For instance, the 1977 fire in Kwedibangala village led to disappearance of Mnwahungo forest. Zohlo (2005) pointed out that organisms differ widely in their response and tolerance to fire and in their capacity to recover afterwards. Moreover, interviewees associated fires with soil erosion, persistent drought, unreliable rainfall and climate variability. Further, fires caused loss of property through burning of houses and facilities, crops and livestock as well as decline of crop production. Loss of soil fertility due to fires was reported by respondents to have affected crop production especially for paddy farms.

The long term impact of frequent fires may result in changes in productivity and population structure of the plant and animal species due to reduced plant biomass and litter, thereby altering the energy, nutrient and water fluxes between the soil, plants and atmosphere (Matimbwi 2013; Zolho 2005; Frost and Robertson 1977). Herbivores and birds are also specifically affected by fire through changes in their habitat that are used for cover, shelter and structure and breeding conditions, food supplies and increased risk of predation due to loss of vegetation. In Tanzania, it is estimated that fires destroy more than 65,000 ha of forests and other wooded areas annually and most of these fires occur in miombo woodlands (75%), followed by

forest plantations (20%) and least in high forests (5%) (FAO 2011; FAO 2013).

Factors underlying fire incidences

Figures 2a-c present socio-economic, institutional and climatic factors contributing to incidences of fires. These are poverty, weak law enforcement, climate condition and ignorance of local people. Many respondents (34%) adjacent to LAFR acknowledged that poverty was a major factor underlying fires as compared to those adjacent to VLFR (22%) and CGFR (28%). According to the respondents, poor economic situations drive local communities to engage in unsustainable and often destructive means of accruing income or food from the miombo woodlands. Such destructive means that involve the use of fire include illegal hunting, extraction of forest products and shifting cultivation.

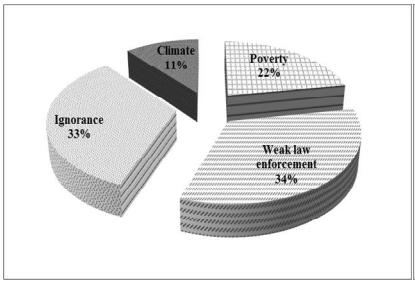

Figure 2a: Factors underlying occurrence of fires in VLFR

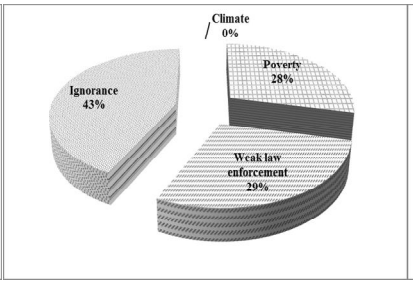

Figure 2b: Factors underlying occurrence of fires in CGFR

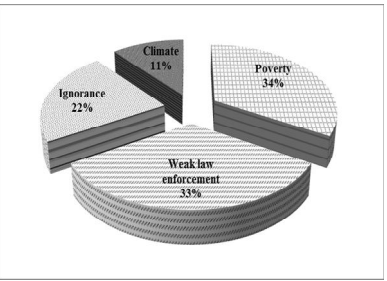

Figure 2c: Factors underlying occurrence of fires in LAFR

Lack of understanding (ignorance) on effects of fires was more perceived by many respondents (43%) adjacent to CGFR as contributing to fire incidences as compared to those adjacent to VLFR and LAFR. This could be due to the fact that most of the forests under central government are usually protected for biodiversity and water catchment conservation and hence there is little involvement of local communities in their management except for special arrangement such as Joint Forest Management (JFM). Ignorance can also be partly explained by the fact that majority of respondents failed to link fires and loss of biodiversity. This could be due to lack of knowledge on ecological relationship between biotic and abiotic component of the environment. Ignorance of local people on the effects and impacts of fires is also attributed to the traditions and local beliefs related to the use of fire. Such traditions include the use of fire in hunting, measuring of individual life span, stimulating soil fertility, attracting rainfall, land preparation and stimulating plant growth. Persistence of traditional uses of fire that causes fires could be attributed to weakness of formal and traditional institutions (i.e. norms and customs) that would penalize people starting fires.

Weak enforcement of existing laws and by-laws was acknowledged by many respondents (34%) and (33%) adjacent to VLFR and LAFR respectively as underlying factor of fires as compared to those adjacent to CGFR. Lack of funds, vehicles and staff to do patrols were singled out as the most important hindering law enforcement. Climatic factor mainly drought and wind were also reported by respondents adjacent VLFRs and LAFRs as underlying factor of fire.

Factors underlying fires depend on the socio-economic and environmental context of the region concerned. Socio-economic factors include unemployment rate or variables linked to agricultural activity. Factors related to weather, fuel and topography are the most significant

environmental factors that drive ignition of forest fires (Ganteaume *et al.* 2013)

Potential strategies to reduce fire incidences in the study area

Five potential fire reduction strategies (awareness creation, law enforcement, making fire breaks, provision of alternative income generating activities (IGAs), and improving agriculture through provision of subsidies) were identified by communities living adjacent to forest reserves (Figure 3). Awareness creation, which was the most prioritized strategy in VLFRs and CGFRs entail provision of conservation education. There were limited extension and publicity services provided in the study sites including fire campaigns aimed at creating awareness on effects of fires to biodiversity and climate change. For instance, only 38.9%, 37.8%, 36.3% and 32.2% of respondents acknowledged to have seen fire campaigns conducted in their respective villages for LAFR, VLFR and CGFR respectively. The chi-square test indicated that the difference in perceptions of villagers regarding fire campaigns was not statistically significant (χ^2= 0.993, p = 0.609) between forest management regimes (Table 4). This suggests that there is no variation across forest management regimes, which is due probably to most of fire campaigns were organized by central government through zones of Forestry Extension and Publicity targeting all forests and woodlands.

It was suggested during key informant interviews that extension materials such as posters, brochures, calendars, and magazines were urgently required to enhance awareness on conservation. Awareness creation is important if fires are to be minimized in the area as it has been confirmed to work efficiently in conservation of forests in Western Tanzania where fire incidences have been reduced by 80% through sensitization meetings and extension materials (Kashula and Gobbo 2011).

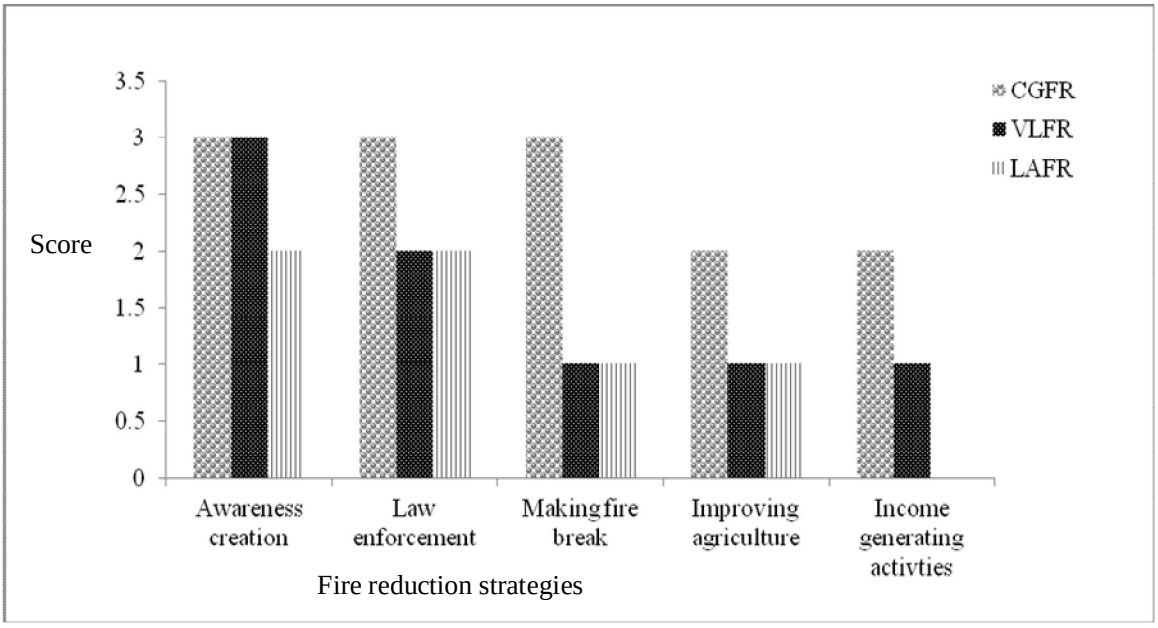

Figure 3: Strategies to reduce fire incidences identified by local people during household survey

Table 4: Responses of local community on presence of fire campaign

	Type of forest management regime						Total				
	VLFR		CGFR		LAFR				Chi-square tests		
	F	%	F	%	F	%	F	%	χ^2-value	df	sign
Yes	34	37.8	29	32.2	35	38.9	98	36.3	0.993	2.0	0.609
No	56	62.2	61	67.8	55	61.1	172	63.7			
Total	90	100	90	100	90	100	270	100			

Enforcing existing laws and by-laws as strategy of reducing fires was ranked first by respondents adjacent to CGFR and second by respondents adjacent to VLFR and LAFR. Both laws and by-laws have provisions on restricting burning of vegetation. For instance, Sections 70–76 of the Forest Act Cap 323 [R.E. 2002], restrict burning of vegetation (URT 2002). Enforcement of laws and by-laws involves conducting patrols to identify illegal activities within forest and woodlands, investigating cause of fire incidence, and taking legal action against people found starting fire. During PRA exercises, villagers acknowledged the importance of regular patrols to detect fire incidences, and enhance suppression. This has the potential to prevent success of community-based fire management (CBFiM) widely advocated by FAO (2002). It was further reported that status of by-laws varies across villages located adjacent to the forest reserves. Villages such as Kikole (in Kilwa District) and Ihombwe (in Kilosa District) which manage their own forests and woodlands under Community Based Forest Management (CBFM) arrangement have approved bylaws. Existence of by-laws enables actors of local institutions at village levels to punish people involved in torching forests and woodlands.

Making fire breaks was identified and prioritized by communities living adjacent to all forest reserves. Fire breaks help to protect forest reserves from fires started outside the reserves. Out of the nine miombo woodlands surveyed, only Kikole VLFR had fire breaks which were constructed by the communities. The fire break was made by communities themselves to protect their woodlands against fire. The use of fire breaks around farms and involvement of villagers in fire suppression were pointed out by the participants of PRA exercise as potential strategies that could be employed to prevent fire escaping during farm preparation. Furthermore, IGAs were identified by local communities living adjacent to all forest reserves as another potential strategy. The local communities reiterated that adoption of alternative IGAs such as fish farming, beekeeping and commercial tree planting could increase income of the rural poor and reduce pressure on the forest reserves. Adoption of such environmentally friendly activities will instil a sense of ownership of the forest resources, ultimately protecting the forests and biodiversity (Songorwa 1999). Increasing agricultural production through the use of tractors, fertilizers, improved seeds and pesticides could relieve the forests and woodlands from human pressure, consequently reducing the potential eruption of fires. While this may be a plausible strategy to save the forests and woodlands, its practicability may be limited given that majority of the local communities are still trapped in abject poverty and therefore they need to be facilitated by the government. Also apart from agriculture, most rural people rely mostly on illegal extraction of resources such as game hunting, lumbering, pole cutting and charcoal making which are potential causes of fires.

CONCLUSION AND RECOMMENDATIONS

This study hypothesized that fire prevalence is influenced by different forest management regimes. Only origin of fires were statistically significantly different across forest management regimes namely VLFR, CGFR and LAFR. However, other variables including causes of fire, factors contributing to fire prevalence and best strategies to reduce fires were not statistically significantly different but their patterns reflected the difference in forest management regimes. Furthermore, fire peaks were not influenced by forest management regimes but rather by geographical locations. Emphasis on discarding destructive indigenous practices such as torching forest and woodlands to measure someone's life span as well as empowering actors of existing local institutions to enforce existing by-laws and regulations should be given priority. In order to reduce fire prevalence, it is recommended that awareness creation on socio-economic and environmental effects of fires be increased, prescribed burning to reduce effects of late fires in certain habitat types where this could be appropriate be promoted and fire management plans to enhance forest and woodland management be developed.

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