Assessment of Wildfires in Tanzania Forest Plantations: A Case of Sao Hill in Mufindi District

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ABSTRACT
The study investigated the wildfires in Sao Hill Forest Plantation (SHFP) in Mufindi District with a focus on causes, impacts, and challenges in fire-fighting. The inadequate data and studies on forest fires rationalized the choice of the study area. Mixed approach and a case study design were used. The sample of 45 respondents were purposively selected out of which 15 were key informants as an entrance point and 30 were other respondents snowballed as proposed by key informants. Descriptive and thematic analysis was used for quantitative and qualitative data respectively. Land preparation which involved clearing of forest harvest debris for tree replanting; slash and burning practice that farmers use traditionally for farm preparation was the major cause of wildfire in SHFP. The negative impacts outweighed the positive through the loss of trees which was ecologically and economically destructive. Inadequate facilities and community participation were the frequently mentioned challenges. The study recommended for the prerequisites in controlled burning to be followed, enhanced rational allocation of resources like equitable harvesting permits and farming land to avoid arsonism. More researches on biological means of land preparation are suggested to reduce fuel load through efficient technology and improved recovery.

Keywords: *Wildfires, Arsonism, Forest plantation, controlled burning, Fuel load*

INTRODUCTION

Traditionally, fire has been associated with the history of human development. In ecological sense, fire has been an important factor in the dynamics of the Earth's climate and in the development of biomes since its widespread occurrence began 400–350 million years ago (Doerr and Santı´n, 2016). WWF rates fire to be among the top threats of ecosystems., for example, in April 2020, the number of fires alerts the

globe was up by 13% compared to last year which was already a record year for fires. Persistent hotter and drier weather due to climate change and other change and other human factors such as land conversion change and other human factors such as land conversion for agriculture and poor forest management are the main drivers behind the increase. It is estimated that humans are responsible for around 75% of all wildfires, and much of the increase in fire incidents during 2020 can be directly linked to human actions (WWF, 2020).

Despite the absence of precise figures that reflect the loss of forests, it is well established that broad areas of tropical forests have diminished inspite of conservation efforts over the last 25 years (Keenan *et al*., 2015). Africa is the leading continent, where out of 9,200 million tons of biomass affected by fire in 2000, 42% belonged to Africa which is quantitatively equivalent to 7 billion Tanzania shillings loss (Madoffe *et al*., 2000; Aloo, 2001; FAO, 2003; FAO, 2005 and FAO, 2011). Tanzania is also significantly affected by wildfires when used in land preparation, hunting, control burning and pest control. Wildfires result from a number of interacting factors like ignitions, conditions amenable for fire initiation and spread, and landscapes with vegetation that can support the combustion process (Moreno, 2014).

The current increase of fire incidences is related to global warming and the alarming global deforestation rate of 5.2×10^6 ha per year (Fernandez *et al*, 2017). A study by FAO (2013) showed that Tanzania as a country has been experiencing wildfires throughout the year whereby around 65,000 ha of plantation forests and other wooded areas (FBD, 2002) are destroyed annually. The average forest plantation area burnt annually is 2466 ha and 40% of which is from Sao Hill where the fires are frequent (Malinga, 2011). Fire is identified to be one of the major deforestations causes in Tanzania. Other causes of deforestation include: consumption of forest products, encroachment and clearing for agriculture.

In Tanzania, government plantations are the major supply of wood raw materials, where Sao Hill Forest Plantation (SHFP) alone has been supplying over 85% of raw material consumed by wood industries (Ngaga, 2011). However, fire outbreaks have been one of the major threats to the sustainability of the Sao Hill plantation forest since its establishment in the late 1930s. From 1970 to 2007 the forest

experienced at least ten fire incidents every five years coming from the adjacent villages. Between 1985 and 1987 at Sao Hill Forest Plantations, there were 105 incidences of forest fires destroying 5 665 ha (Lulandala *et al*., 1995). From 1990 to 2000 forest fires in Tanzania plantations (excluding Sao Hill) caused a financial loss of Tshs 8.8 billion (MNRT, 2001). In a period from 1999 and 2001, a total of 7 644 ha of forest plantations were destroyed by forest fires at Sao Hill alone (MNRT, 2001). Between 2000 and 2011 the number of fire incidences increased to 143, and there were 400ha burnt at Sao Hill in 2018. The later occurred in four consecutive days from 25 to 28 September 2018 of which 11 compartments were severely destroyed (TFS, 2018). According to the study by Nyongesa and Vacik (2019) in Kenya; fire records from 1980 to 2017 show that Mount Kenya Forest Reserve and National Park experienced about 210 wildfires. Most of these wildfires occurred in the months of January, February, March, September, and October. The fire records also show that from 1980 to 2017, more than 668 Ha of plantations, 21,276 Ha of bush land and grassland, 267 Ha of bamboo, 6727 Ha of indigenous/natural forests and 11,175 Ha of moorland were burned by wildfires in MKFRNP. According to the KFS and KWS, fire records from 1980 to 2015, the estimated fire fighting cost and the fire damages were $134,759.84 and $4,712,384.96 respectively.

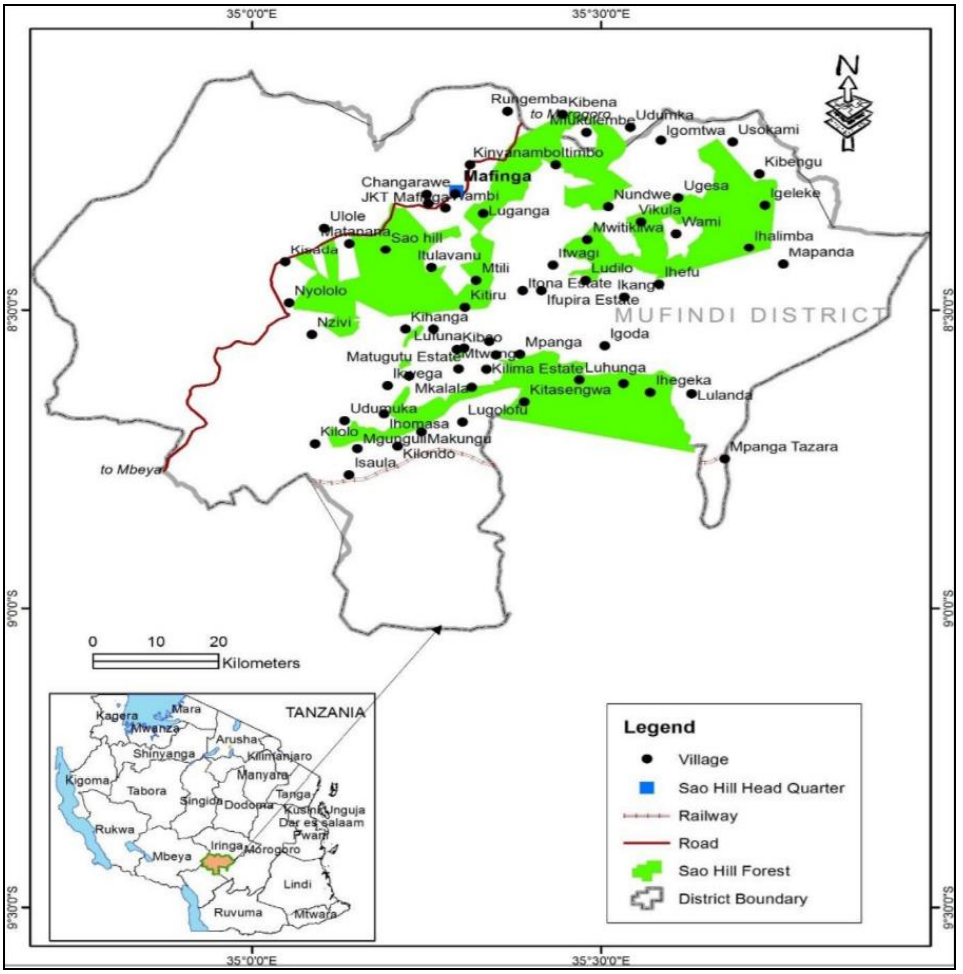
These alarming trends of wildfires called for national and international fire management intervention agenda like the 5th version of the International Wild-land Fire Conference in Sun City, South Africa, 9-13 May 2011. In East African countries like Kenya, the parliament passed the country governments' fire and disaster management bill that prepared the ground for the country to establish and implement integrated fire management approaches in the future in 2014 (Nyongesa and Vacik, 2019). Programmes like Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD) were introduced with a focus on integrated fire management and community-based fire management approaches (Kilahama, 2005; FAO, 2011). In Tanzania, the related programmes include Participatory Forest Management (PFM) strategies, sustainable agriculture programmes which were adapted to ensure sound fire management and improving livelihoods of rural communities (Yanda *et al*, 2008; URT, 2012). In line with these programmes, the Tanzania National Forest Policy spotted fires as the major threats that have been leading to degradation of forests and woodlands (URT, 1998). However, lack of specific policies and

institutional frameworks to address the problem of fire have compromised the effectiveness of fire management in Tanzania. Despite the strategies devised by responsible authorities, forest fires have been persisting (FAO 2013). FAO (2011) asserts that efforts like establishment of Community Based Forest Management and Joint Forest Management are thought to have reduced the annual net loss of forest, but reliable figures on their impact are not yet available. On the other hand, the data on extent, nature, impacts and sources of wildfires have been inadequate, and most statements on the fire issue are based on anecdote and opinions (Madoffe *et al*., 2000; FAO, 2013). This paper investigated the causes of forest fires focusing on Sao Hill Forest Plantation as a case study. It determined the impacts of wildfires and challenges in fire-fighting hence establishing the measures for combating forest fires.

METHODOLOGY

SHFP is located in Mufindi district, Iringa region. Its altitude ranges between 812 mm and 2,009 mm with heavy rains from November to January and March to April, and short dry spell of approximately two weeks in the first half of February and a long dry spell from May to November. The highest wind velocities occur during May to November, which offer fire risks season (Ngaga, 2011).

The study adapted mixed approach which enriched data, added value and allowed comprehensive understanding of the problem. The case study design was used. The term ‘case’ contextually implies ‘an instance of’ and fundamentally it focused on investigating one or more specific ‘instances of’ something or issues which established the cases in the study. In this context, Sao Hill Forest plantation (SHFP) was a case as an organization (Map 1). Case design allowed multiple sources of data like interviews, direct or indirect observation, and archival document; sometimes the inclusions of the physical environment, in this case the burnt forest area. This triangulation guaranteed the authenticity of the research findings. The study used the face-to-face individual interview to get the qualitative data. This was mainly from the key informants. Interviewing is a great way of learning about attitudes and values. And it is a great way of finding out what people think and what they do. When you want to know what people actually do, there is no substitute for watching them or studying the physical traces their behaviour leaves behind.



Map 1: Map of Mufindi district showing the coverage of Sao Hill Forest Plantation

Source: GIS (Geographical Information Systems), University of Dar es Salaam, June 2016

The study adapted direct observation (watching people and recording their behaviour on the spot) and indirect observation which investigated peoples' attitude, culture and perception on forest protection through the archaeology of human behaviour (Russell, 2011). Ethnographic research offers an orientation to understand the process and structure of a social setting and employs research techniques consistent with this orientation. It is the study of both explicit and tacit cultural knowledge. Observing user in the field is always the best way to determine their usability

requirement. Key informants established the entrance points during data collection. This offered connection for more respondents to be engaged in the study. The interview was adopted due to its tendency to gather voluminous deep information, which can answer the research objectives (Yin, 2009; Creswell, 2009).

The study employed judgmental sampling where a sample of 45 was purposively incorporated. Such a method allows the researcher to decide on units to be involved in the study. Fifteen (15) key informants out of 45 were purposively selected and interviewed due to their knowledge and skills about the problem. They comprised of the general plantation manager, division managers and key stakeholders and heads of departments. The questionnaires were provided to the 30 remaining respondents who were snowballed as directed by the key informants until a saturation point was reached according to Sapsford and Jupp (2006). The snowballed informants included some elders who were familiar with the Sao Hill context, private tree out-growers, timber dealers, fire guards, foresters and heads of villages where fire incidences occur regularly.

The data were analyzed through thematic analysis. Thematic analysis involved disintegrating the recorded discussion into smallest meaningful units or themes to capture types, patterns and sequences of fires (Creswell, 2009). Data were reduced into simpler categories and specific themes. The themes were related to causes of forest fire, forest fire impacts and challenges during fire prevention, fire suppression and controlled use of fire in the communities. Subthemes were developed from the data to capture knowledge of the communities on fire context, practices and customary norms in relation to fire management.

FINDINGS AND DISCUSSION

This section discusses the results guided by study objectives. The causes of forest fires at SHFP were mainly human centred. Table 1 shows the findings on the perceived major causes of forest fire. Majority of the respondents (68.9%) viewed land preparations done by farmers near forest stands, and land prepared before tree replanting in the formerly harvested forest compartments as a major cause of wildfire in the area. 15.6% of the respondents spotted arsonism while the remaining 11.1% emphasized on accidental fires.

Table 1: Causes of Forest fires at SHFP; N=45

Statement	Response	Frequency	Percent
Causes of forest fires``	Accidental fires	5	11.1
	Land preparations	31	68.9
	Arsonism	7	15.6
	Honey harvesting	2	4.4
	Total	45	100.0

Source: Field data (2018)

The interviewed forest officer who was in-charge of fire and road department had these to say:

> "We normally use fire in cleaning the harvested area before replanting trees. This is practically dangerous since the chance of fire escaping to unintended destination is too high. Despite the fact that this act is done on cool/calm days from evening to night, the changing patterns of weather may result into escaping fires which eventually impose risk to the plantation. In some cases, local farms preparation result into escaping fires which find their way into the plantations. We address this by insisting villagers to prepare their fields after seeking permits from authorities including division managers in respective areas. This is permitted after proper assessment of weather trends and after ensuring that the fire crew is stand-by just in case of any fire emergence" (July, 2018).

The findings reflect the World-Wide Fund (2006) report that, fire has been and is still used because it is one of the least expensive methods of clearing and preparing land for agriculture and other land uses. It is a tradition attributed to by poverty, inadequate knowledge, skills and awareness on the appropriate agronomic practices and sustainable environmental management. At Sao Hill Forest, fire is used to prepare land for replanting, after trees harvesting (Figure 1).

Figure 1: Forest Compartment Affected by Escaped Fire during Land Preparations
Source: Field data (2018)

Besides, fire is used when preparing the virgin land for tree planting and communities use fire to prepare land during cultivation. In 2010 the Sao Hill plantation conducted a survey whose results indicated that honey harvesting, farm preparation, hunting, arson, loggers' camps, fishermen, herders and envious people were the main causes of fire outbreaks from the adjacent villages (Kangalawe, 2018).

Although fire resulting from land preparations is a major threat in the area, there are seasons of low and high fire incidences. Land preparations and fire peak seasons are especially the case in months of August and September. It was noted that the rainy season has been experiencing a lesser number of fire incidences. During this season, the weather at Sao Hill area is calm, less windy and there is plenty of moisture. The moisture makes the total amount of combustible material (fuel load) like grasses and debris wet. This reduces the chance of fire occurrence and limits the rapid spreading of fire in case of such incidence.

However, in practice, this is not a relaxation stage; rather it is a transition stage, which invites preparation towards the fire intense dry season. Such observations are in line with the records by World Wide Fund (2006) on their study on bush fires in East Usambara landscapes, where it was noted

that, bush fires are the most common and widespread in the lowlands especially during the dry season (July to November) when people are clearing the land for cultivation. The interview with a member of fire stand- by crew reveals more on the season of likely forest fire incidences:

> "The dry season is normally the peak. It is the peak of hot seasons, the peak of harvesting operations and the peak of land preparation activities before starting tree replanting and farming onsets. In our place it starts from mid July to September, it is normally the most dangerous period" (July, 2018).

As suggested from the quotation above, the dry season is also the peak of harvesting season. Activities like logging and timber processing result into accumulation of wood wastes which could become dangerous during dry season (Figure 2). It has been estimated that in order to produce 45 tons of timber, 55 tons of waste is created in the form of sawdust, treetops and branches, and is left to decay, burnt on site or collected as wood fuel, hence creating a potential danger to the forest plantation if left unmanaged.

Figure 2: Poorly Handled Tree wastes Left after Harvesting Operation

Source: Field data (2018)

Rate of forest fire incidences

The statistics related with the result on the number of fire incidences in the area is shown in Table 2, where 31.1% of the respondents indicated that there were 25 to 35 fire incidences per year.

Table 2: Rate of Fire Incidences N=45

Statement	Response	Frequency	Percent
Fire incidences per year	< 5	3	6.7
	5-15	8	17.8
	15-25	11	24.4
	25-35	14	31.1
	>35	9	20.0
	Total	**45**	**100**

Source: Field data (2018)

The fluctuation of fire incidence was also reflected in the study by Poletti (2016) who noted a constant increase per decades, whereby the number lowered from 2000 to 2009 and gained a bigger mean size from 2010 - 2015. However, critics suggest the rate may not directly convey the seriousness of the problem! Hence suggest that the type of fire can be more crucial than the number of incidences. For example, experience from Europe – Southern France as studied by Ganteaume *et al* (2013) showed that, less than one percent of fire incidences was recorded during this period but accounted for 78 percent of the burned area.

Negligent causes of forest fires have mainly been cigarettes' smokers, honey collectors and timber processors. For example, those who are operating mobile sawmills inside or near the forest stands or burning of wood leftovers like slabs and sawdust during timber processing can cause forest fires (Figure 3).

Figure 3: Burning of slabs near Forest Stand can Facilitate Forest Fire if done without Precautions

Source: Field data (2018)

Negligence causes are characterized by features of frequent repetition; concentration, distribution pattern, and relationship with human seasonal activities hence change with time horizons. Polleti recorded that from 1980 to 1999 negligence sources were dominant, but after 2000s the arsonists and charcoal burners became dominant causes of forest fires (Polleti, 2016). In Sao Hill context, arsonists perceived that they were not acquiring direct benefit from the forest plantation in the form of trees harvesting permits, or farming lands. This concurs with the statement from interviewed forest officer who stated that:

> "We have no recent records of naturally induced fire like thunderstorms at Sao Hill. Most of the fire incidences are human induced either accidentally or purposely" (July, 2018).

This finding also concurs with Garcı ´a-Ortega *et al* (2011) who showed that, natural causes of wildfires are either absent per year or represent only a small percentage of all fires and are mostly explained by lightning, which can be very important in some areas of several European countries.

Arsonism was the next cause of forest fires as mentioned by the respondents (15.6%) in Table 1. Arsonism is facilitated by conflicting interests and opinions among stakeholders in aspects of unfair distribution of farming lands, harvesting permits, temporary employment in terms of man-days which are perceived to be unjustly given hence resulting into revenge among arsonists. Polleti (2016) observed that, the arsonists, followed by the honey collectors played the most relevant role in causing forest fires. Tedim *et al.*, (2016) asserted that arsonists have been causing fires for profit gain where interests are related to setting fire for monetary profit like insurance fraud, or non-monetary profit like setting a fire to maintain seasonal employment. Interview with one of the stakeholders in saw mill industry revealed the following:

> "I am holding the view that fire is purposively caused by arsonists. These are people who think they don't benefit directly from forest products. Arsonists are individuals who couldn't get harvesting permits, licenses or farming lands. They therefore burn the forest as part of revenge" (July, 2018).

This observation invites the need for policy review to advocate the matter. At plantation level, there is a need to incorporate issues related to how communities surrounding the forest plantation could benefit. Such matters need to be reflected in the annual budget and in the management plans. The issues of community support need to be firmly established. Besides, they could also be incorporated into forest policy and regulations for legitimacy purposes. Other strategies could involve allocating tree seedlings to communities in order to establish their own forest stands. This could reduce pressure for tree raw materials from Sao Hill plantation. This can work in line with educating community members to form sawmill groups and get assured of tree raw materials on contractual basis. A part from creating employment, such a strategy would also widen the market for forest produces.

Another view was from the forest officer who had the following observations with regard to arsonism and fire causes:

> "My experience is that the patches of the plantation that are closer to human activities make the area more prone to fire incidences. In some cases, fire emerge as a result of business conspiracies; where the scarcity of raw materials makes arsonists burn the part of the forest on the belief that the forest management will finally allow the

> burnt plots to be harvested by community members. In some cases, arsonists burn the plantation due to being denied access to the harvesting permits. However, it is not easy to detect the true intention of the doers as many are not caught ready handed. Those who are caught are those who caused fire during land preparation" (July, 2018).

The observations above are parallel with the report by World Wide Fund (2006) that forests adjacent to communities that are poor, own small farm sizes insufficient to cater for their annual livelihood demands. This results into such communities becoming involved into other alternative economic activities. This highlights the fact that, the forest stands will be prone to encroachment and other illegal activities like hunting, collecting fuel wood, honey collection, cultivation, charcoal making, collecting non timber products like medicines and fruits. In Sao Hill forest, such activities are the causes of some of the ongoing bush fires in the area.

Accidental causes of forest fires include failure of electric lines, sparks emitted by vehicles. This is especially dangerous in mobile sawmills which operate inside the forest stands in situation whereby the terrain is too difficult to justify pulling the logs out of felling site. During field survey the researchers witnessed the sparks from operating machines, which caused escaping fire by wind force to the nearest forest leftovers (Figure 4).

Figure 4: Fire caused by Sparks from Machines that make Forest Stands Prone to fire Incidences

Source: Field data, (2018)

In forest stands passed by the Tanzania to Zambia highway there are cases where forest fires have been resulting from combustion or ignition from vehicles (Figure 5). This includes combustion from vehicles and other machinery especially those employed in road construction, timber processing and heavy trucks used in loading and unloading of logs.

Figure 5: Combustion from Moving Vehicles can Result into Forest Fires when fire sparks get contact with dry grasses

Source: Field Data (2018)

Interview with timber processor indicated that this situation normally occurs during dry season, where the grasses are dry and the temperature is high, in which ignition from cars could produce sparks which might result into fire. This could further spread fires to the nearby forest stands. Though the SHFP management has tried to conduct silviculture operations like road side grasses slashing, and trees pruning the number of incidences resulting from this cause have been significantly notable.

Impacts of Forest Fires

Findings in Table 3 indicate negative impacts of forest fires on ecology and economic development.

Table 3: Impacts of Forest Fires

Statement	Response	Frequency	Percent
Forest fire impacts	Destruction of assets	6	13.3
	Deaths of animals	1	2.2
	Loss of trees	35	77.8
	Land degradation	3	6.7
	Total	45	100.0

Source: Field Data (2018)

Forest fire is ecologically and economically destructive at SHFP, and the loss of trees was the top ranked impact (77.8% of the respondents) followed by destruction of assets like houses, saw milling machines and vehicles. Forest fires suppress the re-growth of more resistant species and prevent woodland canopy which suppress herbaceous production and reduce fuel loads. Furthermore, fires slow down ecological regeneration capacity and impact the future extension strategies. Forest fires destroy land structure and make the area prone to soil degradation (Thompson *et al* 2013; Sebata, 2017 and Neary & Leonard, 2020). Fires destroy soil, microbes, pollinating insects and wild animals that support biological functioning that finally affect regeneration (Figure 6).

Figure 6: Forest Fires Destroy Planted Trees and General Ecosystem
Source: Field Data (2018*).*

Interview with one of the respondents in timber processing industry recorded that:

> "The impacts are broad; in some cases, impacts like land degradation could not be quantified into monetary significances but eventually result into declining forest quality. The burnt trees are sold at a cheaper price hence reducing the government revenues. Furthermore; fires result into destruction of buildings and other infrastructures, wastage of valuable time and disturbances to people, and they impose stress to the community" (July, 2018).

This finding tally with several literatures which reveal that wildfire affects many hectares of forests and damage biodiversity, human life and infrastructures (Ganteaume and Jappiot, 2013; FAO, 2013; Jhariya & Raj, 2014; Foldi & Kuti, 2016; Jua´rez-Orozco, Siebe & Ferna´ndez, 2017).

Fires threaten budget and jeopardize future investment. One SHF officer had these to say:

> "We constantly replant the burnt areas rather than extending or opening up the new unplanted areas, this slows down our strategies. We invest a lot in forest protection, I doubt if the investment levels relate with the final yield prices. We are also losing benefits accrued from the forest, burning trees before harvest means you are losing from what you invested!! On the other hand, forest fires have created a fear atmosphere among other investors. The alarming rate of fire incidences make people afraid of taking risk into the ventures they are uncertain if the trees will reach the rotation age, or get return on their investment' (July, 2018).

The respondent's view is reflected by records of fire at Sao Hill in September 2018 alone, where 10,034 ha from 1996 to 1999 were affected by 6 fire incidences equivalent to Tshs. 4 billion loss. In 2005/2006, 1450 ha were affected by fire where 600ha were destroyed (TFS, 2018).

This view is supported by Nyongesa and Vacik (2018) in their study on Fire Management in Mount Kenya where it was pointed that commercialization of forest plantations when coupled with the intensification or cultivation of exotic fire-prone tree species like cypress (Cupressus lusitanica Mill.), patula pines (Pinus patula Schiede Ex Schltdl. & Cham), radiata pines (Pinus radiata D. Don), blue gum (Eucalyptus saligna Smith), and rose gum (Eucalyptus grandis W. Hill Ex Maiden) will increase fire hazard in the future. This is based on the fact that; such species are less resistive to fire threats and they do not produce coppices compared to many indigenous trees' species. This could jeopardize future investment in the sector.

Findings in Table 4 indicate that though forest fires are common to a whole plantation, it was severe at Division I and III by a proportion of 33.3 % each.

Table 4: Severe Fire affected Areas at SHFP N=15

Statement	Response	Frequency	Percent
Most fire affected areas	Division one	5	33.3
	Division two	4	26.7
	Division three	5	33.3
	Division four	1	6.7
	Total	15	100.0

Source: Field data (2018)

Observations related to severity of forest fires showed that division I, II and III were close to villages and urban area with wood industries and a highway passing through the forest. The interview with a division manager recorded that:

> "The plantation is divided into four management areas. Division 1, II and III have more interaction with villagers hence they are prone to forest fires; thus, resulting from socio- economic activities like saw milling and farming which may cause escaping fire. There can be 5-15 fire incidences at division two alone" (July, 2018).

The prolonged fires contribute to climate change by the release of green house gases and contribute to massive heat and smoke which might hinder other socio-economic activities (Figure 7).

Figure 7: A Queue of Cars Stopped by Heavy Smoke from Burnt Forest at Sao Hill Forest: Source: Field Data (2018)

Challenges in Forest Fires Fighting

Respondents were asked on the challenges they were facing during forest fire management. From Table 5, inadequate fire fighting equipment had a proportion of 33.3% while inadequate community participation had 28.9%. These were the two top rated challenges.

Table 5: Fire Fighting Challenges

Statement	Response	Frequency	Percent
Challenges	Inadequate fire fighting equipment	15	33.3
	Poor road network to reach the burnt area	8	17.8
	Little skills in combating forest fires	9	20.0
	Inadequate Community participation	13	28.9
	Total	45	100.0

Source: Field Data (2018)

The limited number of vehicles, pumps, and motor bicycle which hindered fire fighting; other tools were pangas, fire beaters and tree branches. During field survey there was no motorized pump that was observed though the fire crew had power saw for clearing felling trees during fire fighting which may obscure the road. There was one bulldozer and vehicles (pick-ups) at the stand-by area (fire assembly point). Interview with key informant under the fire department noted:

> "Fires here are of sky and ground type. They are difficult to suppress due to ground fuel richness resulting from accumulation of leaves, felled branches over years. While the plantation is large nearly over 60,000 ha of planted trees, the facilities are few and centralized. The wide spread nature of the plantation makes risk management more challenging. Imagine with over 60,000 ha there is only one modern and efficient fire rescue truck. Modern fire fighting equipment like protective gears when coupled with proper fire detection methods can enhance rapid fire detection and suppression hence serving the valuable forest from further destruction" (July, 2018).

The reflection above is in line with the findings by Malinga (2011) in a study on management cost in government and private forest plantations in Tanzania: case study of Sao Hill and Mapanda plantations, Mufindi

district, Tanzania. The study established that purchases of fire protective gears are very costly to the extent that affordability becomes difficult, even though prevention is better than cure. It was found that Sao Hill has a good number of fire protective gears more than Mapanda but was bought in the 1980s when World Bank financed the project. It was further revealed that some equipment is running wear and tear and replacement or buying new equipment is becoming difficult due to high prices.

Another challenge was community participation in forest protection (Table 5, 28.9% of the respondents). During survey, forest officer under publicity department claimed that:

> "The major challenge is community awareness and how people conceptualize the forest benefits. The forest is an ocean for the surrounding communities where they need to fish their livelihood. This makes them view it in one perspective of benefiting them in monetary gain alone. I think we need to invest in creating awareness. Value chains should be made from the forestry where people could benefit in various styles rather than benefiting directly from harvesting the forest" (July, 2018).

The problem of participation has not been observed in SHFP alone; the study by World Wide Foundation (2006) noted the same, although traditionally people used to mobilize themselves. This invites awareness creation, enthusiasm and where necessary legal enforcement. Communities should not be overburdened by such arrangements, especially where tangible benefits are unlikely to be realized in the near future.

Despite the difficulties, Participatory Forest Management (PFM) approaches have been practised at SHFP whereby villagers would cultivate maize in the trees harvested areas for one season before planting trees (Figure 8). They collect herb and other non-wood forest products like fruits, vegetables, though critics blame the practice to have been associated with fire incidences in the area. This is in line with the study by Dewan and Vacik (2010) where it was highlighted that agriculture was ranked as the second most relevant objective and thus it is at the heart of community interests. This suggests that most of the communities in developing countries are more concerned with socio-economic activities aimed at achieving their livelihood benefits such as employment, farming

activities, firewood collection, water collection, grazing, honey collection, tourism, herbal medicine, and hunting or timber production. However, such practices had associated impact if not correctly monitored. Interview with an officer in the publicity department commented that:

> "We initially thought that PFM could address the dilemma. However, it is against all odds. Apart from continuing incorporating PFM principles, we are also using the special security guards to protect the forest because there are community members who do not adhere to principles" (July, 2018).

Figure 8: Farmers are allowed to Cultivate Maize in Trees Harvested Areas through Participatory Approach Communities

(*Source: Field data, 2018)*

Infrastructure problem was also noted, there were unsatisfactory access roads, communication networks and water supply as evidenced in interview with key informant:

> "In my management area, water supply is a big challenge in case of fire emergence. We are allocated far from water sources and the water pumps. Infrastructures like bridges, well maintained access roads, feeder roads and fire lines / fire breaks tend to hinder our efforts in suppressing forest fire timely" (July, 2018).

Inadequate coordination of fire fighting planning operations like pruning and sub-standard construction of fire breaks, control burning and road side slashing can have a net effect of spreading forest fire.

The appropriateness of fire fighting measures depends on the type of fire (Sawe, 2008). For example, firebreaks suit ground fire. Thus, fire-based operation requires good plan, organization of resources and coordination of the fire crew. Interview with responsible officers indicated that there were no reliable weather detectors and data. The fewer fire towers which detect fire by observing smokes were in place. This suggests that, climatology data pertaining to temperature, humidity, wind speed and direction were missing which make fire management challenging. Interviewee at fire department commented that:

> "We are lacking reliable data sources. This makes it difficult to establish trends, which would ensure predictability of the incidences depending on the analyzed data and hence enabling future decision making. We need to have facilities for collecting and analyzing data specific to our area. We rely on satellite data from the headquarters (Dar es Salaam). But the satellites we are using just inform that there is fire at Sao Hill without giving specific details on the site location. Remember Sao hill is big plantation!" (July, 2018).

This deficiency was vivid in the study by FAO (2013) on sustainable forest management in a changing climate - A Fire Baseline for Tanzania showed that, the data on extent, nature and impacts of wildfires have not been compiled and analyzed which preclude developing accurate and reliable data for recent and future comparisons. Besides, such findings relate with study by Nyongesa and Vacik (2019) on evaluating management strategies for Mount Kenya Forest Reserve and National Park to reduce fire danger and address interests of various stakeholders. It was noted that, most of the fires are recorded by Kenya Forest Services had unknown causes, making it difficult to estimate their social, economic, cultural and ecological effects. This study, though specific to Sao Hill Plantation has contributed to the few existing knowledge on plantation fires and its fighting challenges for policy interventions.

In summary, the study found that land preparation was the major cause of forest fire at Sao Hill forest plantation. This included preparing land by local farmers at nearby forest stands and land prepared before replanting of trees in the formerly harvested forest compartments or extension areas. On the other hand, arsonists were the second contributor of forest fire in the area. Loss of trees was the major identified negative impact of forest

fires followed by destruction of assets. Challenges include; inadequate firefighting equipment and inadequate community participation which were impeding the plantation strategies to address the fire problem.

CONCLUSION AND RECOMMENDATIONS

The findings of this study exposed the need for the decision-makers, forest managers, tree growers and policy actors to consider the issue of forest protection. This is critical for conservation purposes, maintaining ecological balance and for social economic benefits. All stakeholders should coordinate harmoniously through a participatory process. Besides, the study findings could also be adapted in management of natural forests. It is critical to practice forests protection evaluation, enhance forests protection records and adopt relevant frameworks that would facilitate forest protection management practices. Enhancing protection records will also bridge the present information or data gap among decision makers and managers or practitioners at grass root level. This will enable to establish relevant policy, regulations and budgets in forest protection.

In addressing proper land preparation, all the prerequisites for successful controlled burning must be thoroughly followed up as per the agreed Community Based Fire Management Plan (CBFM). For example; villagers were to report to the nearby forest station. This would enable the forest in charge at the station to organize appropriate time or man power to monitor the preparation farming land by fire. This is based on the fact that, the use of fire for land preparation is cost feasible which means that it cannot easily be burnt Use of controlled fire, fire lines, fuel breaks, fuel load removal and mapping of fire sensitive areas are key principles to minimize fire risk. In addressing arsonism, the plantation management needs to carefully plan for the just and equitable allocation of resources such as trees harvesting permits, farming land among communities and establishing community relations programmes through participating in social events like supporting health services, funeral services, education, sports and games activities. Farmers must ensure proper land use to reduce competition to the forested land; for example, practising multiple purposes land uses like agro-forestry or mixed cropping with trees for future timber uses. The later can also be sold as poles at the local and urban markets. Furthermore, employing the use of Remote sensing techniques such as Geographical Information Systems (GIS) can facilitate early detection and hence timely suppression of forest fires.

Training of fire fighting crew and ensuring the availability of fire fighting equipment, radio devices like "walkie-talkies" are recommended for communication among fire fighting crews and head quarters at Sao Hill main office. There should be a good network of fire towers for monitoring and detection of possible fire signs, adequate protective gears for crew safety during fire fighting and means of transport like standby vehicles, motorbikes and bicycles for fireguards. This should be in line with good forest road network to enhance immediate access and hence response to fire incidences. Besides, the need to enhance social relationship through supporting adjacent communities in form of materials and services, and joint forest management between plantation management and surrounding villagers is important for forest protection against arsonists.

There is a need to review the management practices. This can be achieved through redefining the mission of the forest plantations. Recently, managers have been putting much emphasis on extension of unplanted areas and some on conservation of biodiversity. However, lesser concentration has been invested on other goals such as improving wood production in terms of recovery, forests and energy, quantification of social economic values of forests, non-timber or non-wood forest products and matters associated with climate change.

Commercial companies and other stakeholders should come up with means to utilize the after harvest remains from timber processing. This will in turn reduce the fuel load left during harvesting operations. Policy makers and the government should enhance the legal legitimacy and budgetary favourable atmosphere. It is crucial to establish new policies, laws, new penalties and sanctions for emerging forest fire related offences. Policy coherence and harmonization should be ensured; for example; wildlife policy, national forest policy, national land policy, water policy, agriculture development policy, energy policy etc. Such policies need to work in harmony as they are all being affected directly or indirectly by forest fire threats.

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