

Understanding the Causes, Socio-Economic and Environmental Impacts of 2019 Veld Fires in the Kingdom of Eswatini

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Abstract

Veld fires have become a frequent and devastating phenomenon in the predominantly savanna ecosystems of the Kingdom of Eswatini. While fire damages have become more common and recurrent in recent years, their causes and impacts in the country are less understood, with extremely limited literature. This study aimed at filling up this existing information gap by investigating the causes, socio-economic and environmental impacts of veld fires, as well as highlighting the challenges and/or limitations in fire management and control in Eswatini. It used mixed methods approach to collect both primary and secondary data. These included household questionnaires and face-to-face interviews with key informants. The results showed that the major causes of fires are mainly anthropogenic, and these include arson and conflicts, controlled burning, ignorance of proper fire management practices, collision of electric cables, and acts of negligence, among others. Major impacts of veld fires in Eswatini were found to include disruption of rural (and urban) livelihoods, infrastructure damage, social and psychological wellbeing



of affected individuals, loss of biodiversity and destruction of important environmental resources, to mention but a few. The study concluded that fires contribute to biodiversity loss and that fires continue to be a major threat to the country's economy. Lack of fire management resources is one contributing factor to the widespread fire damage in the country, while quantifying the direct economic loss resulting from fire remains a challenge due to lack of standardized fire damages data collection and reporting tools. The study recommended a development of a standardized tool for reporting fire damages, improvement of fire prevention and management, and development of an early warning system (in addition to capacity assessment of fire emergency operators) to improve fire management and to minimize fire-related damages nationally.

Keywords

Biodiversity Loss, Fire Management, Veld Fire, Environment, Kingdom of Eswatini

1. Introduction

Veld fires are becoming increasingly common, recurrent, intense, and costly in the face of drying landscapes, more so in the climate change era which is marked with rising temperatures (Tasker & Arima, 2016). Global studies highlight that fire incidences are a common phenomenon globally and are high profile events in countries such as Australia, USA, United Kingdom, Chile, China, Germany, Singapore and Indonesia (Eves, 2003; Tasker & Arima, 2016; Kiel & Matheson, 2015; BBC, 2011; Hamed, 2019; Californian Department of Forestry and Fire Protection, 2010; Fire Research Technical Report, 2006; Neighbour, 2019; Kop-litz et al., 2015; Sheldon & Sankaran, 2017). Although forest fires are largely thought to be attributed to natural causes, most forest fires in the world are associated with anthropogenic activities (Hardesty et al., 2005; Njume & Krah, 2020). These fires have widespread and varied impacts from the burning of vast tracts of land, leading to the loss of biodiversity and sometimes endangered plants and animal species (World Bank, 2016). Other global impacts of fires include the destruction of crops, homes, forest resources and infrastructure (Kim et al., 2017). Fires and the resultant smoke can also adversely affect the physical and mental health of communities in the vicinity of the fire spot (WHO, 2022), with significant mental impacts on those affected (Laugharne et al., 2011). Douglas et al. (2003) concluded that veld fires create a myriad of psychological and socio-economic challenges, in addition to detrimental impact on forest and rangeland vegetation.

1.1. Fire Disasters, Causes and Impacts in Developing Countries

While forest fires are a threat to the livelihoods globally, developing countries remain highly vulnerable due to their highly vegetated landscape (Wokekoro,

2020). The Environmental Literacy Council (2015) records that forest fires contribute to forest loss and loss of biodiversity, causing deforestation in most countries in the global South. Vast pieces of land are burnt annually in most countries in the developing world such as Zimbabwe, Tanzania, Zambia and Mozambique (Jha et al., 2016; Nyamadzawo et al., 2013; Mbanze et al., 2013). Chinamatira et al. (2016) and Mbanze et al. (2013) concur that the tropical savannas of Africa and elsewhere are among the most fire-prone ecosystems, with most of these experienced fires being anthropogenic in nature.

According to Wokekoro (2020), forest fires are a major cause of degradation in developing countries and 90% of the forest fires are ignited by human beings. Major driving forces for fire outbreak in developing countries, and particularly in Africa, are arson and conflicts, smoking out beehives, cooking or trying to keep warm, and clearing land for cultivation (Mbanze et al., 2013; Phiri et al., 2011; Chinamatira et al., 2016). Other causes of veld fires include burning of homestead surroundings to improve visibility, burning of crop residues, and creation of fire breakers, vehicle and locomotive accidents, and electron clouding of power lines (Chinamatira et al., 2016; Frost, 1992). The use of fires to settle disputes, particularly those relating to land issues, is also becoming a common feature in most African countries (Nyamadzawo et al., 2013; Nepstad et al., 1999). Nepstad et al. (1999) and Wokekoro (2020) noted that these fires have both direct and indirect devastating impacts on businesses, infrastructure (e.g., clinics, schools, power plants, power lines and roads), and lead to the destruction of important facilities such as educational, agricultural and recreational facilities, and at times, loss of human life.

1.2. Fire Disasters, Causes and Impacts in Eswatini

Every year during the austral winter months (April-September), the Kingdom of Eswatini experiences fires of varying magnitudes and extent, with accompanying devastations and losses which undermine the country's economic progress, as a predominantly agrarian-based economy. During the winter period where more fire episodes are reported, dry weather conditions are in prevalence due to the dominance of high-pressure system circulation over the region (Addai et al., 2016). This is fuelled by the dominance of bulky vegetation from deciduous trees shedding their leaves in response to the winter season, ultimately contributing to the build-up in surface fuel loads (Giusti, 2016). While objective burning of fires exists in Eswatini, which include burning for pasture regeneration, vegetation clearing (for farming) and weed control, misapplication of fires has also been reported (Manyatsi & Mbokazi, 2013; Nunes et al., 2019). This has not been without impacts in the country, such as the loss of biodiversity, reduction in grazing lands and fodder, disruption of critical infrastructure, loss of life (animals & humans), loss of jobs and livelihoods, and homelessness (World Bank, 2016; Kim et al., 2017).

The overreliance of the country on agriculture (including livestock farming),

and tourism for sustenance, which are consistently under fire threats, increase the vulnerability of the rural population to poverty. The increasing intensity of fire-related damages and frequency of fire episodes in the country is a cause for concern, and has attracted policy reactions in most recent years. For example, the sporadic widespread of veld fires countrywide during the months of April to July 2019 caused public outcry, panic and concerns due to its enormous impacts on societal wellbeing of communities and the country's economy.

Unfortunately, there remains limited literature on fires in Eswatini. Nationally, documented past fire disaster information remains scanty and exists as published newspaper reports or articles by individuals who took interest in a particular fire incident and its impacts. Documented fires in recent history of the country are the August 2007 fire that were declared a national disaster as they swept through parts of the Kingdom, engulfing as many as 300 homesteads (*The New Humanitarian, 2007*). The devastating fire destroyed about 20,280 ha of pine and eucalyptus forest, resulting to an estimated loss of E645 million (US\$45 million) of forest resources, putting about 21,100 livelihoods at risk through direct and indirect job loss (728 and 4368 jobs, respectively) (*Jha, 2010*). United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA) reported that the fires destroyed approximately 80% of the Mondi Forest Plantation that covered about 19,500 ha and provided employment to 1200 people in the country. The raging fires also affected the Sappi Usutu Forests in Bhunya in the same year, resulting in a loss of approximately 4000 ha of forest plantation (representing about 7.5% of the man-made forest cover).

2008 fire incidence occurred in the same month of August, destroying 40% of the Sappi Usutu Forests, further affecting more than 100 homesteads, and resulted in loss of life and injuries (*Dlamini, 2010*). Due to the cumulative severe impact of the fire damage and adverse market conditions, Sappi Usutu Pulp Mill was deemed no longer sustainable and subsequently closed, leading to job losses. In 2018, the Shiselweni Forestry Company incurred some losses from devastating fires that blazed through over 200ha of wattle plantation whose causes remain unknown. Alongside the quantified economic impacts, these companies and surrounding communities incurred losses. According to the Eswatini Disaster and Risk Profile, wildfire incidents have increased in frequency and currently stand at 11.1%, and wildfire mortality is currently estimated at 5.87%. Fire outbreak has been declared a national crisis, hence the country allocates yearly budgets to the fire emergency services and response (*The World Bank Group, 2021*).

Documentation of the major fire causes, prominent fire management practices, and main impacts of fires in the country has become a critical first step towards fire management in the country. This highlights the need for a study that will consolidate the existing information and supplement it where necessary to capture the causes, impact and fire management practices employed to minimize incidences and damage in Eswatini. This study contributes to the natural resources

and fire management discourse by investigating the causes, socio-economic and environmental impacts of the 2019 fires in the Kingdom of Eswatini and highlights the management practices employed to control and manage fire in the Kingdom. The paper sought to respond to the following questions: What are the major causes of fires in Eswatini? What are the socio-economic and environmental impacts of fires in Eswatini? What are the challenges and/or limitations in fire management and control in the Kingdom of Eswatini? The study does not only provide insight on the causes, impacts and management of fires in the country, but also helps inform policies aimed at improving fire management and curbing fire-related damages on the nation of Eswatini and their environment.

2. Methods and Materials

2.1. Study Area

Eswatini, formerly Swaziland, is a landlocked country in Southern Africa, bordered by Mozambique in the East and the Republic of South Africa in the west, north and south (**Figure 1**). The country lies south of the Tropic of Capricorn, between latitudes 25°43'S and 27°19'S and longitudes 30°47'E and 32°08'E (**Dlamini & Mabaso, 2011**). The Kingdom of Eswatini had a population of 1.2 million people as of 2018, with a land area of 17,364 km², and a population density of about 66.8 people per km², making it one of the highly populated countries in Southern Africa (**World Bank, 2020**).

The country has four main ecological zones namely: Lubombo region, Lowveld, Middleveld and Highveld. As such, the country has a varied geography, ranging from mountains along the Mozambique border to savannas and tropical forests on the west. The climate of Eswatini, therefore, varies from temperate to tropical and the country is marked by reverse seasons to those in the Northern Hemisphere, with June being mid-winter and December being mid-summer (**World Bank, 2020**). Notably, rain falls mostly during the summer months, often in the form of thunderstorms usually accompanied by lightning. Winter is the driest season which is usually associated with veld fire outbreak.

Annual rainfall is highest in the Highveld in the West, ranging between 1000 and 2000 mm, and lowest in the Lowveld region where the range is between 500 and 900 mm per annum. Variations in temperature are also related to the altitude of the different regions, with the Highveld being the coolest (24°C on average) and Lowveld being the hottest (35°C on average) (**Dlamini & Mabaso, 2011**).

Veld fires have become one of the main disasters in the Kingdom of Eswatini, and have become widespread and very devastating, affecting the entire country (**Figure 2**). Although the wettest region, the Highveld tends to be the most affected by veld fires due to the large forest plantations that characterize the area. The country has incurred severe economic losses to fire incidences which damage forest plantations and forest products (**Dlamini et al., 2017**).



Figure 1. Location of Eswatini in Africa/Southern Africa.

2.2. Methodology

The study used both primary and secondary data in order to understand the causes and impacts of fires in Eswatini. Scholarly articles on fire related issues globally, regionally and nationally were consulted, and these include journal articles, books and internet sources, in addition to national reports on the subject under investigation. This information was very useful in providing the contextual basis for understanding fire patterns in Eswatini, causes of veld fires, management

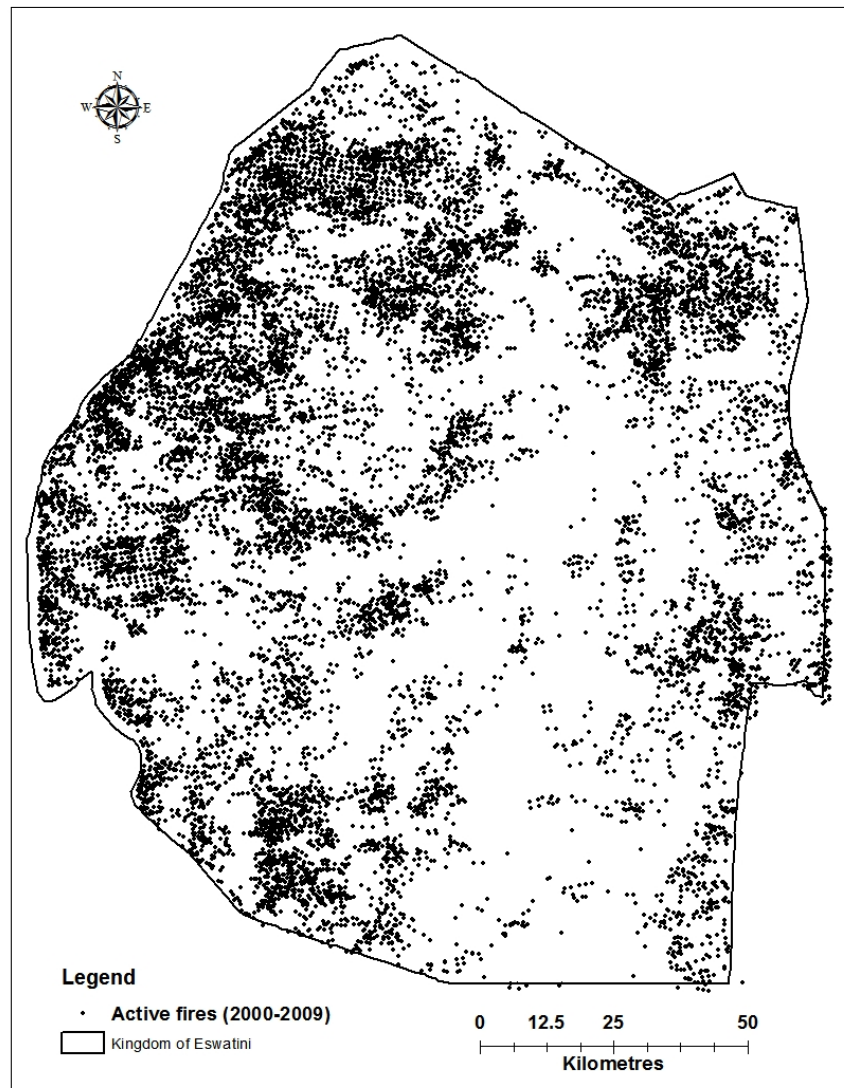


Figure 2. Map showing spatial distribution of active fires in Eswatini mapped using MODIS satellite imagery between 2000 and 2009.

practices, and response mechanism to fire incidence at national, regional and global level. Primary data was collected from almost all heads of households that were reported to have been directly affected by wildfires, nationally, during the period April-July 2019. These were purposively selected in all the 59 constituencies (*tinkhundla*) where fire incidences were reported through the community volunteers under the National Disaster Management Agency in the April-July 2019 period. This was done to ensure spatial representation of all the affected areas in the country, as fire impacts may vary by geographical location and socio-economic profile of the affected population. The selected areas are also recorded as fire-prone areas in the Kingdom of Eswatini, due to their geographical location and the dominant vegetation cover and land use type. A structured questionnaire (consisting of both closed- and open-ended questions) was

used to solicit information from 347 households' heads which were reported to have incurred losses during the April-July fire outbreak in the Kingdom of Eswatini. Key information collected through the questionnaire include, but not limited to: household losses related to education, health, housing, livelihoods, food items, water supply, and human heritage, among other important data. Other data collected using the questionnaire include data on the causes of fire, existence of fire prevention and management methods and community/household's challenges related to fire management.

Data was also collected from 15 key informants which were purposively and strategically selected based on their mandate, placement/occupation knowledge, and experiences on fire related matters. These include, but not limited to personnel from fire management institutions such as National Fire and Emergency Services (NFES), agriculture and forestry companies, as well as personnel from key stakeholders such as municipalities, non-governmental organizations working with communities, game parks (tourism), the water service department and telecommunications service providers. The data required related to how the fires affected the critical infrastructure, productive assets, forestry, wildlife, and humans during the period April-July 2019.

Collected data (both household and institutional data) was coded and analysed using the Statistical Package of the Social Sciences (SPSS) which was used to compute frequencies and percentages on household losses related to education, health, housing, livelihoods and food items, water supply, and human heritage, among other important variables. SPSS was also used to perform cross tabulation to establish relationships among variables. On completion for each level, the data was then exported into Microsoft Excel. The resultant data files were shared with all stakeholders for validation purposes (for quality assurance), and errors identified were rectified. Additional consistency checks and cleaning continued in-house in order to produce cleaner datasets before the analysis process was undertaken. For both datasets, tables, graphs and pie charts with percentages or frequencies were used to present the collected data. These graphical techniques helped to present the data in a concise and clear manner to facilitate understanding of the causes and impacts of fires in the country and how different people (and institutions) respond to fire outbreaks.

For ethical reasons, the researchers requested permission to conduct the research in the affected households and communities after explaining the contents and intention of the study to the traditional authorities and participants. Informant consent was sought from all participants and only participants who consented to be part in the survey were included. The participants were also informed that their participation in the research was strictly voluntary, with no form of coercion, and that they reserved the right to withdraw from the research at any stage and for any reason whatsoever. All information gathered was kept confidential.

3. Results and Analysis

3.1. Underlying Causes of Fire Hazards in Eswatini

All information gathered was kept confidential. The results of the study point to several anthropogenic causes of fires in Eswatini, which are either deliberate or accidental. Deliberate fires are those used for waste management (2.1%), vegetation control and ecosystem maintenance (deliberate grass burning for regeneration) (3.8%), creation of firebreaks, arson and conflicts (3.8%) and smoking out bees during harvesting of wild honey (2.9%), among others (Figure 3). Accidental fires are those in which the proven cause does not involve any deliberate human act to ignite the fire and these include improper disposal and handling of combustible material (mainly by children), lightning (2.1%), burning candles and collision of electric cables (5.5%) (Figure 3).

3.2. Socio-Economic and Environmental Impacts of Fires in Eswatini

The study revealed direct and indirect economic losses due to the sporadic widespread fires. While some impacted ecosystems will be able to recover within a shorter period, some suffered irreversible and long-term impacts. The wildfires resulted in loss of income and opportunities for surrounding local communities following the loss of the vast forest resources from which they derive livelihoods (e.g., firewood, handicraft, medicinal etc). They also resulted in loss of homes/houses and property (Table 1), which resulted to depletion of family resources as most households had to channel their resources to rebuilding damaged houses and replace lost assets and properties, which all had a bearing on the economy of the country. Apart from direct economic losses and impacts, the fire resulted in social and environmental impacts.

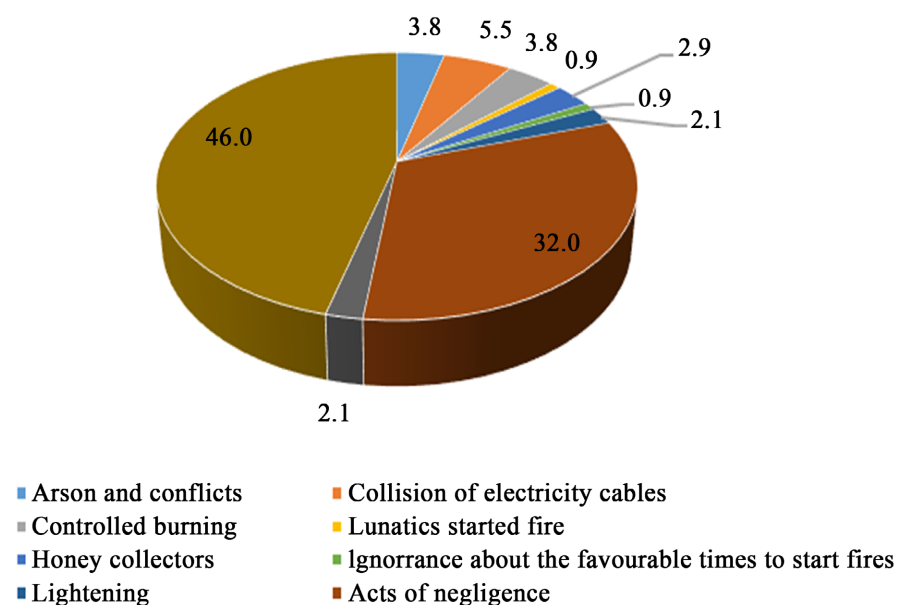


Figure 3. Causes of fire in Eswatini.

Table 1. Types of house structures damaged and/or destroyed by veld fires.

Housing type	Severity of damage			Percentage
	Damaged	Destroyed	Total affected	
One house with many rooms	21	15	36	20
One room	34	71	105	60
Several houses within the household	3	16	19	11
Other	4	13	17	9
Total	59	115	14	100

Impacts of veld fires on livelihoods and food security

The results also revealed that the 2019 fire outbreaks resulted in the loss of productive assets in many households. 70% of the population of the country live in the rural areas and the livelihoods are made up of a range of on-farm and off-farm activities that provide for a variety of strategies for food and cash. As such, each household has several possible sources of entitlement that constitute its livelihood. The findings point to some disruptions of the main sources of livelihoods for some households, nationally. Over 30% of the affected households lost agricultural assets to the fires exacerbating the fragile food security situation of these communities and threatening their livelihoods. To improve agricultural productivity some of the better off smallholder farmers use irrigation equipment and systems to augment their productivity and not to be dependent on the erratic climate system. More than 15% of the affected households reported to have lost irrigation pipes and sprinkler heads, respectively to fire (Table 2). 39% of the affected population indicated that their crops were disturbed by fires while 29% of households reported to have their wage labour (unskilled) affected by the fire outbreaks. About 17% of households studied reported to have lost livestock and poultry to the 2019 wildfires (Table 3).

The study also ascertained, specifically, the number of cattle and poultry that were lost due to wildfires nationally. As it can be observed (Table 4), some households lost livestock to veld fires while others lost poultry. About 12 cattle (7% of the livestock lost) were reported to have died due to veld fires, while about 156 poultry (93% of the livestock lost) were reported to have been killed by the veld fires outbreak (Table 4). Some households and key informants also reported destruction of rangelands (Plate 1) which affected several livestock-rearing families owing to fodder shortage. This has an implication on beef quality, livestock prices, milk quantity, and ultimately income for most farmers.

Number of people affected by the 2019 fires

It was crucial that the number of people affected by the 2019 veld fires were captured, to determine the extent of the impact of the fire on human life. Results revealed that 740 people were directly affected by the fires and these included

Table 2. Productive assets destroyed by fire between April and July 2019.

Productive asset type	Severity of damage			
	Damaged	Destroyed	Total affected	Percentage
Agricultural assets	54	12	66	32
Building tools	9	10	19	10
Drum		1	1	0.5
Generator	1		1	0.5
Traditional mat maker		1	1	0.5
Water pipes and tanks	12	3	15	7
Telecommunication equipment		23	23	11
Repair and test pool		5	5	2
Power system		13	13	6
IT equipment		2	2	1
Sprinkler heads		29	29	14
Irrigation pipes		30	30	15
Soil moisture probe		1	1	0.5
Total	76	130	206	100

Table 3. Productive assets destroyed by fire between April and July 2019.

Productive asset type	Severity of damage			
	Severely damaged	Slightly affected	Total affected	Percentage
Agricultural commodities/trade	3	1	4	8
Crop production	9	9	18	39
Employment	1	1	2	4
Landowner/Rentals		1	1	2
Livestock and poultry	6	2	8	17
Remittances				
Skilled wage labour	1		1	2
Unskilled wage labour	1	11	12	26
Other		1	1	2
Total	21	26	46	100

Table 4. Livestock/poultry affected by the fires.

Animal type	Animals affected	
	No. of affected	% affected
Cattle	12	7
Poultry	156	93
Total	168	100

people who had suffered loss of property and food, as well as people who either sustained injuries or lost their lives due to veld fires. The study found that out of these 740 people, 13 were injured, with 10 needing to be hospitalized. Worse, 19 died of veld fires, needless to say, out of the 19, only 9 were retrieved as dead bodies, with the rest were bent to ashes.

Impacts of veld fires on the educational sector

The effects of veld fires were also felt in the education sector through the destruction of educational infrastructure, equipment, and materials. As presented in **Table 5**, a larger proportion (46%) of the studied households reported to have experienced destruction of schoolbooks by fires while 33% stated that fires



Plate 1. Livestock on burnt grazing land at Mlilwane Wildlife Sanctuary.

Table 5. Educational infrastructure affected by fire.

Educational infrastructure/ material asset type	Severity of damage			
	Damaged	Destroyed	Total affected	Percentage
Fencing	1	5	6	5
School garden	2		2	2
Toilet	1		1	1
Water pipes	1		1	1
School uniforms	11	30	41	33
School books	3	53	56	46
School bags	1		1	1
School shoes		1	1	1
Other	1	13	14	11
Total	21	102	123	100

destroyed school uniforms. The results also showed that 5% of schools had their fences damaged or destroyed by veld fires.

Health impacts of veld fires

As already noted, the study captured that veld fires claim lives (e.g., the 2019 veld fires claimed 19 souls) and cause injuries (13 injured in the 2019 fire incidence). Household members also reported to have experienced different effects from fumes and smoke, especially household members with respiratory and visual health conditions. It was also gathered that children, elderly and people with disabilities live in fear following the recurrent fire incidences due to their high vulnerability to fire hazards. Respondents also registered their concern that damaged crops and food losses expose them to hunger while the damaged houses lead to exposure to harsh weather conditions that threaten their health.

3.3. Environmental Impacts of Fires on Biodiversity

Several plant and animal species were lost to fire in the burnt areas. In addition to the loss of plant and animal species, community members also noted that fire resulted in increased soil erosion and land degradation following loss of vegetal cover. Nature and game reserves also reported loss of conserved plants and animals. The study recorded, for instance, loss of 10 wildebeests, 4 zebras, 6 nyalas and 10 impalas to fire at Mlilwane Wildlife Sanctuary (**Plate 2**).

3.4. Challenges in Current Fire Management Practices

As highlighted, the study found that fires affect both institutions and communities in Eswatini, and both face challenges in managing fires. Most communities reported the late response of the National Fire and Emergency Services (NFES) as a major challenge (61%), while lack of resources (5.5%) and lack of National Fire Emergency Services resources and personnel (3.7%) were other notable challenges (**Table 6**).



Plate 2. Inyala burnt during Mlilwane Wildlife Sanctuary wildfire.

Table 6. Challenges that hinder receipt of assistance during fire outbreaks.

Challenges encountered during fire outbreaks	Frequency	
	No. of affected	% affected
Community members do not report wildfires in fear of fines	1	0.9
Lack of assistance from community members	3	2.8
Late response from community members	3	2.8
Late response from NFES	66	61.1
NFES stations are too far from community	3	2.8
Non-response from NFES	2	1.9
Not enough NFES resources to respond to fires	4	3.7
Poor communication whenever there is an outbreak	3	2.8
Poor road networks to reach affected areas	7	6.5
Residents are not aware of fire precautions	8	7.4
Fire hydrants are not enough for the fire engines to refill	1	0.9
Poor repercussions when people start fires on high risk days	1	0.9
Lack of resources makes it difficult to put out fires	6	5.5

3.5. Capacity Assessment of the National Fire and Emergency Services (NFES)

The study found that the NFES operate with about 450 fire fighters across seven fire stations and two satellite stations, providing fire emergency and rescue services to the approximately 1.1 million population in the country. The institution operates a 24 hour on - 48 hour off shift system with between 8 to 10 fire fighters per shift in each station. Each station provides a back-up to its neighbouring station in case of an overwhelming event for the nearest station. It was reported that the institution does not have nor use any technology for fire detection and early warning systems, systems critical for proactive, timely and efficient response to save lives, property, and the environment. Instead, the NFES relies on telephonic alerts in the event of fire outbreaks. The study also gathered that the NFES is limited on the firefighting equipment and has one firefighting vehicle appropriate for tall buildings and one vehicle appropriate for tackling extreme fires, which is kept at the NFES headquarters. The study also gathered that commercial forest companies in the country are unhappy with fire management in Eswatini and registered their dissatisfaction on the existing fire legislation and fire coordination in the country, which is due for review and update.

4. Discussion and Conclusion

The study sought to understand the causes, socio-economic and environmental

impacts of veld fires in the Kingdom of Eswatini. Specifically, the study intended to respond to the following research questions: what are the major causes of fires in Eswatini? What are the socio-economic and environmental impacts of fires in Eswatini? What are the challenges and/or limitations in fire management and control in the Kingdom of Eswatini?

4.1. Major Causes of veld Fires in Eswatini

The study found that veld fires have become a frequent and most devastating phenomenon in the different ecosystems of the Kingdom of Eswatini. The results of the study point to several anthropogenic causes of fires in Eswatini, which are either deliberate (e.g. fires for waste management, vegetation control, creation of firebreaks, harvesting of wild honey etc) or accidental (e.g. burning candles, and collision of electric cables), and a few natural (e.g. lightning-induced fires). These results find support from several scholars such as Hardesty (Hardesty et al., 2005), Njume and Krahl (2020), and Wokekoro (2020) who also noted that the majority of fires are largely human-induced rather than natural.

As far as human-induced fires are concerned, acts of negligence in the country tend to be one major driving force of the widespread veld fires that characterize most parts of the Kingdom. Incidences of this nature arise when persons handle fires in an unsafe manner during fire usage, either on their daily livelihood or line of work. These range from fires left unattended during burning of waste material and field clearing, improper disposal of hot ash, improper use of candles (common lighting system in rural Eswatini), to improper disposal of cigarette butts, among other common habits. These are the most common causes of veld fires in the Kingdom of Eswatini where it is still largely used as a management tool, especially in the agricultural sector. It is still used for pasture regeneration, vegetation clearing for settlement and agricultural purposes, pest management (to reduce insects and rodents), and killing of invader weeds (Addai et al., 2016; Manyatsi & Mbokazi, 2013). The management of waste in the country is also another driver of veld fires. Waste handling is a process that requires a skill, particularly when large quantities of waste are to be burnt. Uncontrolled burning of waste in backyard pits, dumpsites and illegal waste sites in the country is common and leads to 2.1% of the reported fires that damaged the environment and caused health problems to animals and humans in 2019. This is confirmed by Dlamini et al. (2017) and Nxumalo et al. (2020) who concluded that open burning is still a very common management technique in the rural areas of the country where there is no formal waste management system in place, and in some urban areas where waste is disposed in dumpsites. Such fires pose a great environmental, health and economic risk to the environment and can, in most cases, become “viral”.

Arson and conflicts are also responsible for some fire outbreaks in the Kingdom of Eswatini. Although not a very common phenomenon in the country, this occasionally occurs as a result of various issues that include labour disputes,

family disputes, suspicions of witchcraft, as well as community and economic disputes. Disgruntled employees, aggrieved communities and family members resort to destruction of property as retaliation for dispute and labour matters. These types of incidents may be few in number, but statistics reveal that they tend to carry significant economic impact. The study found that about 3.8% fire incidences in the country are attributed to arson and conflict. These findings are supported by [Mbanze et al. \(2013\)](#) who found that arson and conflict are responsible for some of the fire incidences in the forest plantation of Niassa Province, Mozambique, and that they dominantly occurred in the night. This is further supported by [Chinamatira et al. \(2016\)](#) who also noted that in most African countries, fires are caused by arson where they are intentionally used to settle disputes, particularly related to land tenure. Honey collection is also one of the causes of veld fires in Eswatini, and about 2.9% of the fire incidences in the country are related to this activity. The makeshift fires resulting from burning during honey collection are a cause for concern in Eswatini, especially as they are also recorded in the forest plantations. Needless to say, the favourable oxygen levels in beehive pits allow for fires to reignite a long time after the honey has been collected.

Natural forces, as already noted, are also responsible, to a lesser extent, for the fire incidences experienced in the country. Among the common natural fires are lightning-induced fires ([Hardesty et al., 2005](#)). Although not very common, lightning-induced fires are common in summer, but this is when vegetation is still live, hence their damage is not significant in the country. It is important to note though that, even though not as common, lightning fires can be destructive to households and property. These findings align with [Chinamatira et al. \(2016\)](#) who also reported that lightning was responsible for 6% of fire occurrences in Zimbabwe. Collision of electric cables is also one common cause of fires in Eswatini. In as much as service providers take the necessary precaution to install power lines in a safe manner, incidents involving collision of power cables occur and 5.5% of such incidents were reported in the country. Strong winds, oversized cargo, cranes and falling trees (or tree branches) are among the drivers of electric power lines collision, resulting in sparks that trigger fires which ultimately spread to grasslands, houses and forests. Other common causes that were found by the study also include poor workmanship and illegal connections.

The results of this study revealed that 46% of the reported fires in the country are wildfire occurrences, whose causes are attributed to natural forces. [Schoenagel et al. \(2004\)](#) state that wildfires are a result of complex human-environment interactions involving a number of factors driving the occurrence of the wildfires. These factors include fuel, climate and fire-weather conditions, and topography which contributes to the wide spread of fire occurrences. During the dry fire season (May to August), climate conditions lead to dry and dormant vegetation which acts as fuel for fires. Fires move faster in high topography and uphill than in lowlands, as such, the Highveld Region of Eswatini, which is marked

with the highest and rugged topography, tend to be the most vulnerable region to veld fires in the Kingdom (See **Figure 2**). In addition, this is the region dominated by commercial forests.

4.2. Socio-Economic Impacts of Veld Fires in the Kingdom of Eswatini

The impacts of veld fires in the Kingdom of Eswatini are widespread and varied. They range from socio-economic to environmental impacts, and they present a great challenge to property, human assets, human life and the environment at large. Quantification of the immediate and direct costs provide a metric for understanding the social, economic and environmental impact of fire and for assessing progress in fire prevention and protection. Impacts may be temporary, short-term and reversible while others can be permanent, as well as long-term.

The impacts of veld fires in the country are manifested through infrastructural damage, assets loss and livelihood disturbance (crop production & food security). Different households in most parts of the country have witnessed damage and loss of shelter to fire which left some families homeless, grieved and traumatized due to fire related property loss, which includes the destruction of dwellings (homes) and/or damage to personal goods. Over 80% of the affected households reported to have lost their dwelling places due to the fire, which reveals the magnitude of destruction caused on shelter and household assets. In addition to lacking shelter, these families also lacked food supplies and proper water and sanitation facilities, and were exposed to harsh weather conditions, collectively resulting in stress on individuals. This aligns well with [Silveira et al. \(2021\)](#), [Machilis \(2002\)](#) and [Rosenthal et al. \(2021\)](#) observations that damage of property, especially shelter due to fire cause psychological trauma, leading to mental and emotional stress ultimately affecting the emotional well-being of the affected community.

The study also gathered that there were feelings of helplessness among people whose lives and property were threatened by veld fires which could potentially trigger stress and other psychological and stress-related problems/sicknesses ([Jones & Ribbe, 1991](#)). These findings are confirmed by several scholars such as [Chinamatira et al. \(2016\)](#) and [Neighbour \(2019\)](#) who all observed that veld fires usually result in massive property loss and homelessness of larger populations in some countries. [Chinamatira et al. \(2016\)](#), for instance, found that the 2010 fire outbreak in Zimbabwe caused property loss worth over US\$200 000, while [Neighbour \(2019\)](#) noted that over 33 000 people were left homeless in China following the extensive fire outbreak in 1984.

The results also revealed that the 2019 fire outbreaks resulted in the loss of productive assets in many households in the Kingdom of Eswatini, affecting the main sources of livelihood for most households. The study showed that over 30% of households lost agricultural assets such as irrigation pipes and sprinklers. This undoubtedly affected agricultural productivity and ultimately food avail-

ability, access and food security in general. The findings align with Nyamadzawo et al. (2013) findings who observed that fire outbreaks in Zimbabwe resulted in loss of agricultural assets and increased loss of agricultural produce, affecting food availability for both humans and animals. The VAA Report (VAC, 2019) was also in support as it recorded a decrease in the 2019 harvest where about 46 percent households were reported to have harvested less yield compared to the previous season—an incidence attributed to the 2019 veld fires outbreak.

In addition to loss of productive assets and the related impact in the agricultural sector, the fires outbreak in the country resulted in the disruption of livelihoods owing to livestock death, given that livestock (cattle in particular) constitutes an important aspect of household economy and the country's economy at large. In this fire crisis, 17% households reported to have lost livestock and poultry to the 2019 wildfires outbreak. There was also severe destruction of rangelands such that livestock had little or no grazing land, a situation that was also recorded by Nyamadzawo et al. (2013) in Zimbabwe. It is important to note that the risk of livelihood disturbance directly or indirectly determines the level of vulnerability of households to income, food, health and nutritional insecurity. Livelihoods are secure when households have secure access to resources and income earning activities, including reserves and assets to offset risks, ease shocks and meet contingencies.

When capturing the number of people who were affected by the 2019 veld fires, the results revealed that over 740 people were directly impacted by the fires in different ways. In addition to property loss and loss of food, some people sustained injuries (WHO, 2022) and others died (CDFFP, 2010) due to veld fires. Chinamatira et al. (2016) made a similar observation in Zimbabwe where he recorded five and twenty-five fire-related deaths in 2010 and 2011, respectively. The study also found some education-related impacts of fires which included destruction of schoolbooks (46%), school uniforms (33%) and school property such as fences (5%). It is important to note that these are educational essentials, and their loss affects the learning process which is a critical element of skills development in the youth. Schools rely heavily on government subsidy as well as contributions of parents to maintain educational infrastructure, and as such, the fire incidents dent any developmental efforts. Replacing these losses requires finance that may not be readily available at the moment of occurrence, which then affects the learning process.

It is clear from the results that fires have resulted in serious economic damages to various sectors of the Eswatini economy. However, many of the economic losses are not quantified in monetary terms. In many cases, wildfires caused heavy financial losses in terms of households losing their homes and property. Probably the biggest economic losses from fires were felt by the local communities who depend on the forest for services and goods, recreation, spiritual values, biodiversity and the provision of forest services and ecological functions (e.g., erosion control, soil formation, nutrient cycling, water supply and

regulation, waste treatment and storage of carbon). Most of the rural populations rely heavily on resources derived from forest and woodlands, thus it can be said that the economic cost of these fires is substantial. Looking at the amount of productive assets and critical infrastructure, huge amounts of money was lost as these assets were used for production, thus limiting economic growth. Also, the livelihoods affected result in households struggling to provide for the basic needs for their families.

The study also recorded health impacts of fires. Fires can drastically affect individuals with respiratory and visual health conditions. Surviving fumes from a household blaze or veld fire by immune-compromised individuals such as children and the elderly is highly unlikely. These dependent groups also cannot escape the fire danger on their own since fire can be overwhelming physically. Physical burns in varying degrees on burn victims can leave them in excruciating pain and visible scars for years or entire lifetime, and especially with psychological trauma. Loss of food due to fires can compromise an individual's nutritional levels which can lead to malnutrition and stunting to children. Exposure to harsh weather conditions because of destroyed housing can lead to catching colds and other sicknesses. Uncontrolled burning of medical waste is not only an air quality risk, but a health risk to individuals inhaling fumes.

4.3. Environmental Impacts of Fires in Eswatini

As already noted, fire plays a major role in maintaining the health of certain ecosystems, but because of their misuse/misapplication, they are now a threat to biodiversity. Forest fires have many implications for biological diversity as they affect both apparent diversity (observed directly) and hidden diversity. Results from the study reveal cases of wetlands in the Shiselweni and Manzini region as well as open grasslands all over the country to have been affected by veld fires. It is important to note that these are habitats for different organisms such as indigenous grass species and micro-organisms that live within these environments. The results reveal that these fires typically resulted in the mortality of individual stems and plants, thus strongly promoting fire-tolerant species. The consequence of repeated burns is detrimental as it leads to the impoverishment of biodiversity and the extinction of some tree species and the replacement of vast areas of forest with grasslands. The clearing of the soil blanket may lead to degradation of the soil if heavy rains come and these continuous rains can wash the top soil, leading to zero germination of plants and crops which produce oxygen for human survival. Scholars such as [Chinamatira et al. \(2016\)](#) attest to the fact that fires contribute to the loss of biodiversity globally and result in the extinction of several plants and animal species.

The fires experienced had further devastating impacts on fauna by not only killing them, but also leading to long-term indirect effects such as stress and loss of habitat, territories, shelter and food. Areas where fauna was affected by fires were in the Lubombo Region, as well as Mlilwane Wildlife Sanctuary, where 10

wildebeests, 4 zebras, 6 nyalas and 10 impalas were killed by veld fires. These findings are similar to those found by [Tasker and Arima \(2016\)](#) who also noted that veld fire outbreak in 2015 in Indonesia resulted in a loss of 2.6 million hectares of forest land with its varying biological diversity. This is further confirmed by the [World Bank \(2016\)](#) which also record that the 2015 veld fires in Indonesia resulted in loss of rich biodiversity and the death of a number of endangered plants and animal species such as tigers, elephants and rhinos.

4.4. Challenges in Current Fire Management Practices in Eswatini

The study found that fires affect both institutions and communities in Eswatini, and both face challenges in managing fires. It was gathered that the fire management systems currently used in the Kingdom of Eswatini are not enough to meet the standard, leading to high incidences and widespread fires. The greatest challenge faced by most communities and institutions is the late response of the NFES (fire fighters) (61%), who are being limited by lack of resources and personnel. The lack of resources (5.5%) and lack of National Fire Emergency Service Personnel (3.7%) are other key issues that pose a great challenge to fire management and control in the Kingdom of Eswatini.

The study sought to understand the capacity level of NFES to respond promptly to fire outbreak. It is important to state that the NFES operate under the King's Order in Council, 1975 and is currently housed in the Ministry of Housing and Urban Development. It is mandated to respond to fire outbreaks of any nature and provide emergency and rescue services that include attending to road accidents and rescue of people trapped in buildings and lifts. According to information from the NFES, the institution does not have, nor does it use any technology for fire detection and early warning systems for proactive, timely and efficient response to save lives, property and the environment. However, the NFES relies on telephonic alerts in the event of fire outbreaks. The study also gathered that the NFES is limited on the firefighting equipment and has one fire fighting vehicle appropriate for tall buildings and one vehicle appropriate for tackling extreme fires, which is kept at the NFES headquarters. In case of fires, especially at a location away from the station where the special equipment is kept, the capacity of the NFES to efficiently deal with fire outbreaks is greatly compromised taking into consideration the rugged terrain, country road networks and geography of the country.

The fire relevant legislation in the country includes the Grass Fire Act (44) of 1955, the Forest Preservation Act (14) of 1910 and the Private Forests Act (3) of 1951. It is noted that these pieces of legislation are outdated and likely to have challenges when pitched against the current day social economic and environmental conditions. As alluded to, commercial forest companies registered their discontent with fire management and the existing fire legislation and fire coordination in the country and prayed for a review of the fire legislation to be in line with current time and to comprehensively deal with existing challenges re-

lated to fire management and prevention in the country.

4.5. Conclusion

This study investigated the causes, socio-economic and environmental impacts of veld fires in the Kingdom of Eswatini and sought to highlight the challenges and/or limitations in fire management and control in the Kingdom. The study concludes that veld fires have become a frequent and most devastating disaster in the predominantly savanna ecosystems of the Kingdom and that these are mainly driven by anthropogenic activities which include arson and conflicts, uncontrolled burning of waste and improper handling and management of fires, and to a lesser extent, natural causes such as collision of electric cables. The study also concluded that veld fires have several impacts to both people and the environment and such impacts range destruction of flora and fauna, loss of biodiversity, loss of production assets and destruction of property and infrastructure, which may trigger stress and other psychological and stress related problems on the affected people. Generally, the impact of fire within the country was felt as a number of livelihoods, water supply, environment and biodiversity, infrastructure and production assets. Majority of the fires were caused by wildfires and negligence and the greatest challenge faced by the country is the delays of the NFES in responding to fire cases and that most people in the country lack fire knowledge and information.

4.6. Recommendations

The study recommends a development of a standardized tool for reporting fire incidences and fire damages. It is also recommended that the existing awareness raising campaigns the dangers of fires and ways to minimize fire incidences be strengthened by NDMA and the other national fire management partners. It is also recommended that a Bill for a National Fire management plan (informed by a countrywide risk assessment) be developed under the guidance and leadership of the NFES that will incorporate the response strategy, communication strategy, stakeholder engagement, early warning systems, crisis level rating, resources, infrastructure and capacity (personnel) assessment. Illegal honey harvesting should be strongly discouraged and measures to educate the public on professional harvesting of honey be put in place by NFES and commercial foresters. There is a need to strengthen regulations aimed at environmental protection and to heighten the monitoring level of the environment through Eswatini Environment Authority and Eswatini National Trust Commission.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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