Fire Management in Mount Kenya—A Case Study of Gathiuru Forest Station

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Abstract: This paper proposes an Integrated Fire Management (IFM) framework that can be used to support communities and resource managers in finding effective and efficient approaches to prevent damaging fires, as well as maintain desirable fire regimes in Kenya. Designing and implementing an IFM approach in Kenya calls for a systematic understanding of the various uses of fire and the underlying perceptions and traditional ecological knowledge of the local people. The here proposed IFM framework allows an evaluation of the risks posed by fires, while balancing them with their beneficial ecological and economic effects, and thus developing effective fire management approaches. A case study of the proposed IFM framework was conducted in Gathiuru Forest that is part of the larger Mt. Kenya Forest Ecosystem. Focus group discussions were held with key resource persons, primary and secondary data on socio-economic activities were studied, fire and weather records were analyzed and the current fire management plans were consulted. Questionnaires were used to assess how the IFM is implemented in the Gathiuru Forest Station. The results show that the proposed IFM framework is scalable and can be applied in places with fire-dependent ecosystems as well as in places with fire-sensitive ecosystems in Kenya. The effectiveness is dependent on the active participation, formulation and implementation of the IFM activities by the main stakeholder groups (Kenya Forest Service (KFS), Kenya Wildlife Service (KWS), and the Community Forest Associations (CFA)). The proposed IFM framework helps in implementing cost-effective approaches to prevent damaging fires and maintain desirable fire regimes in Kenya.

Keywords: fire management; human activities; participation; firewood; charcoal; grazing; water; honey; farming; community forest association

1. Introduction

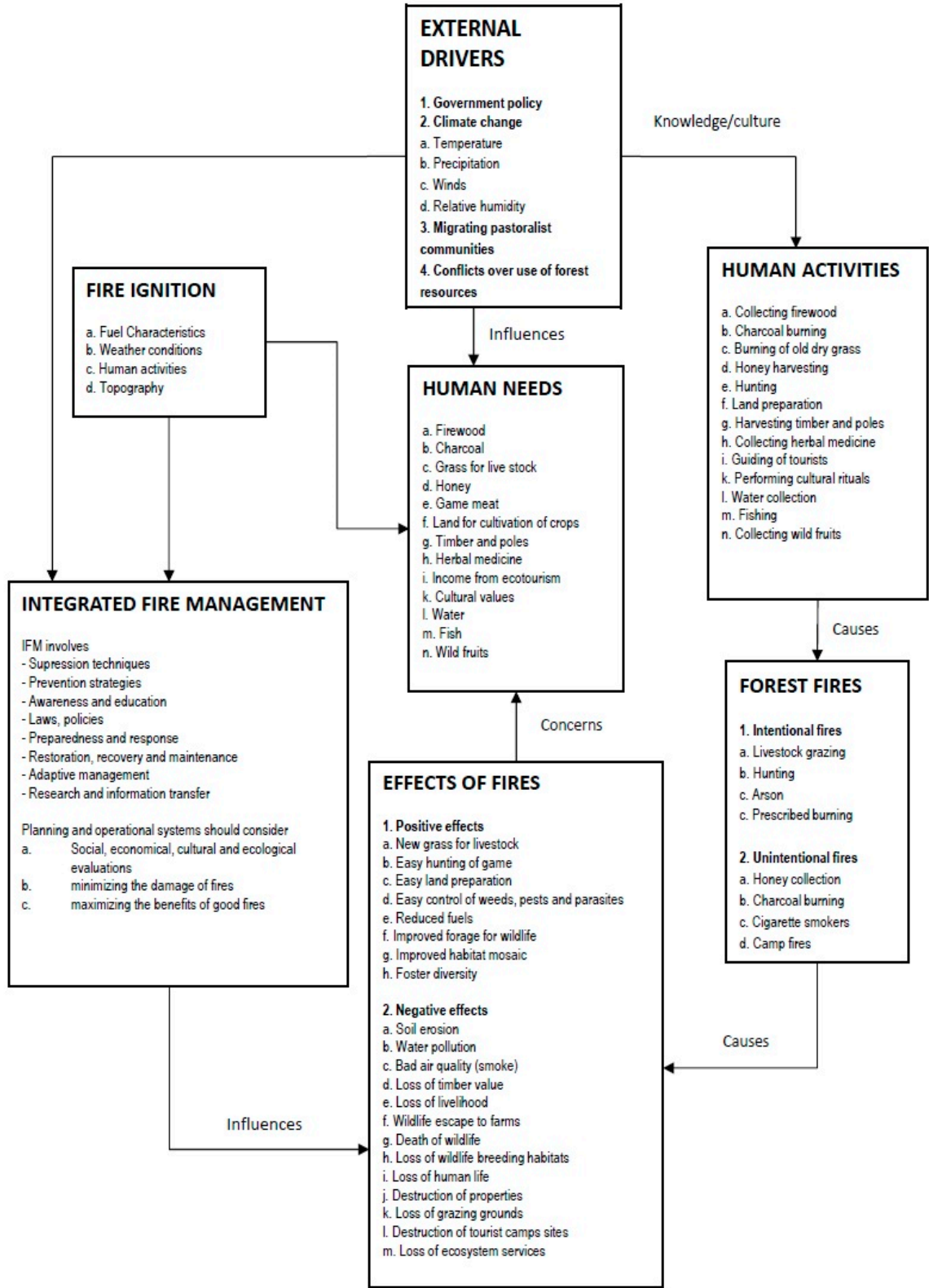
Establishing and implementing Integrated Fire Management (IFM) approaches in Kenya calls for understanding the various uses of fire, along with the underlying perception and   traditional ecological knowledge of the local people[1–3]. Almost every landscape has a complex history of human land use and natural disturbances [4] and the distinction between 'natural' and 'cultural' landscapes is not always obvious [5]. Anthropogenic fires have been common throughout the world since the discovery of fire [6]. Fire has been used as a tool in land management in many parts of the world to manipulate vegetation composition, structure, and fuel loads on farmlands, rangelands and other wildland ecosystems [7].

Perennial grassland fires are common in many parts of Kenya. Each year during the dry season, communities set grasslands on fire to keep them open and to facilitate the growth of new grass for livestock especially before the rain begins. Sometimes conflicts have occurred between communities who have the right to graze and burn the grasslands. In Kenya's forests and national parks charcoal burning is practiced, beekeepers and traditional honey gatherers regularly use fire to harvest honey and poachers on the other hand use fire as a tool for hunting and roasting game. Therefore many

46   community members in Kenya use fire to prepare farmlands, break impenetrable bushlands, control
47   weeds, pests and parasites and try to keep wildlife away from homes [8].
48   Kenya's fast growing population is increasing pressure on the available forest resources [9].
49   Human activities in forests to obtain firewood, charcoal, timber, poles and grass for livestock has
50   increased tremendously over the past three decades. Additional pressures arise from the demand for
51   good quality water, land for the cultivation of crops,   income from ecotourism, herbal medicine,
52   game meat or honey among others [9]. As a result, all five key forested water towers (Mt. Kenya, Mt.
53   Elgon, The Cherangani Hills, The Mau Forest Complex and The Aberdares) have experienced
54   human encroachment, deforestation, wildfires and degradation. The same applies to lowland and
55   coastal forests [10]. The changing climate, vegetation dynamics, human activities and forest
56   management influence the occurrence of fires [11]. Despite compelling evidence on the role of
57   climate change in influencing fire regimes, humans are most often the leading cause of fire ignition
58   [7] and because of climate changing fire season length and severity, these ignitions are more likely to
59   increase in Kenya's forests and national parks [13]. Kenya's forest and national parks have also
60   experienced fires caused by lightning. But most of the fires caused by lightning are recorded under
61   unknown causes, which make it difficult to estimate their social, economic, cultural and ecological
62   effects [7].According to the KFS, the number of forest fire incidences has increased causing more
63   damage to the forests, socio-economy and environment. Ground fires, surface fires and crown fires
64   have occurred in Kenyan forests [13]. As a response, the government of Kenya has initiated a
65   participatory forest fire management program that involves collaboration between the KFS, Kenya
66   Wildlife Service (KWS), the Kenya Defense Forces (KDF), the British Army, Community Forest
67   Associations (CFAs) and other stakeholder groups to work together in forest fire prevention and
68   suppression efforts. However, termination of donor funding, limited governmental funds to tackle
69   forest fire issues, retrenchment of human resources within the KFS and KWS, lack of adequate
70   equipment and well trained firefighters have seriously affected the capacity to effectively suppress
71   and combat wildfires [14]. Integrated Fire Management (IFM) considers the development of
72   concepts for planning and operational systems that combine prevention, suppression strategies and
73   techniques while integrating the use of technical fires and regulate traditional burning by
74   considering the social, economic, cultural and ecological evaluations with the objective of
75   minimizing the damage and maximizing the benefits of fire [14]. This paper highlights the
76   importance of developing and using an IFM framework to support communities and resource
77   managers in finding effective and efficient approaches to prevent damaging fires, as well as
78   maintain desirable fire regimes in Kenya. The objectives of this publication are (i) to propose a
79   framework for an integrated fire management approach, (ii) to apply the framework in a case study
80   and (iii) to propose fire management guidelines considering the challenges faced by the KFS and
81   local CFA. In the following sections we will introduce the framework for IFM, present the Gathiuru
82   Forest Station case study, the methodological steps for analysis and draw some conclusions on fire
83   management.

1.1. Integrated fire management framework

85   There are several Integrated Fire Management approaches that have been suggested and
86   adopted in various countries. The Implementation of the British Columbia Wildland Fire
87   Management Strategy aims at achieving healthier forest and range ecosystems; communities that are
88   less at risk from fire and smoke; and more cost-effective fire suppression program [15].The Food and
89   Agriculture Organization of the United Nations (FAO) Fire Management Voluntary Guidelines
90   advise authorities and other stakeholder groups that fire-fighting should be an integral part of a
91   coherent and balanced policy applied not only to forests but also across other land-uses in the
92   landscape [16].
93   Mt. Kenya forest ecosystems are known to have a long fire history and fire has influenced the
94   vegetation in the landscape. Some plant species found in Mt. Kenya forest require fire to germinate,
95   establish, or to reproduce and total fire suppression not only eliminates these species, but also affects
96   the animals that depend upon them [3]. The indigenous woody species mostly found in regularly

97   burnt sites in Mt. Kenya include, *Juniperous procera* (Hochst. ex Endl.) and *Hagenia abyssinica* (Bruce)
98   J.F.Gmel while the herbaceous species include *Ferula communis* (Linnaeus), *Gomphocarpus*
99   *stenophyllus* (Oliv.) and *Cardius keniensis* (Linnaeus) among others [17].
100   The Kenya Grass Fire Act, Cap 327 provides a regulation for planned burnings of bushes,
101   shrubs, grass, crops and stubble within protected areas. However, KFS and KWS have continued to
102   practice fire suppression campaigns instead of using prescribed burning activities to manage fuel
103   accumulation in forests and national parks. This was mainly based on the belief that any
104   disturbance, such as fire, disrupts the progress towards an equilibrium state. Total fire suppression,
105   in combination with other human-caused environmental changes, resulted in huge and catastrophic
106   fires in Mt. Kenya forest ecosystems [7].
107   More recent ecological research has shown, however, that fire is an integral component in the
108   function and biodiversity of many natural habitats, and that the organisms within these
109   communities have adapted to withstand, and even to exploit, natural wildfire. More generally, fire is
110   now regarded as a 'natural disturbance', similar to flooding, wind-storms, and landslides, that has
111   driven the evolution of species and controls the characteristics of ecosystems [3]. Based on these
112   findings from international scientific literature an IFM framework shown in Figure 1 was designed
113   to support the management of fire sensitive ecosystems as well as of other ecosystems with more
114   frequent historical fires in Kenya. It considers the fact that ecological benefits of wildfires often
115   outweigh their negative effects. A regular occurrence of fires can reduce the amount of fuel build-up
116   thereby lowering the likelihood of a potentially large wildland fire [12]. Fires often remove alien
117   plants that compete with native species for nutrients and space, and remove undergrowth, which
118   allows sunlight to reach the forest floor, thereby supporting the growth of native species [12]. The
119   ashes that remain after a fire add nutrients often locked in older vegetation to the soil for trees and
120   other vegetation. Fires can also provide a way for controlling insect pests by killing off the older or
121   diseased trees and leaving the younger, healthier trees [12]. Burned trees provide habitat for nesting
122   birds, homes for mammals and a nutrient base for new plants. Overall, fire is a catalyst for
123   promoting biological diversity and healthy ecosystems. Fire fosters new plant growth and wildlife
124   populations often expand as a result [12].
125   The proposed IFM framework helps communities and natural resource managers to address
126   both damaging and beneficial forest fires within the context of the natural environments and
127   socio-economic systems in which they occur, by evaluating and balancing the relative risks posed by
128   fires with the beneficial ecological and economic effects they may cause in a given conservation area,
129   landscape or region. It helps to identify factors influencing fire ignition as it relates human needs
130   and land use activities to factors influencing fire ignition. The role of external drivers for influencing
131   fire danger are estimated as well as positive and negative effects of fires are ascertained. It also helps
132   in evaluating the benefits and risks of different management activities and developing fire
133   management guidelines considering human needs and land use activities (Figure 1).

134
135   Figure 1: A proposed Integrated Fire Management (IFM) for Kenya forests and national parks

136   **2. Materials and Methods**

137   **2.1 Description of the study site:-Gathiuru Forest Station**

138   Gathiuru Forest is part of the larger Mount Kenya Ecosystem and is one of the 18 forest stations.
139   It covers an area of approximately 14,978 ha which comprise of 612.5 ha of grassland, 1187.9 ha of

140   bush land, 8525.3 ha exotic plantations and 1557.3 ha indigenous forest areas. The map of Gathiuru
141   forest vegetation types and management units is shown in Figure 2. The station is highly prone to
142   wildfire outbreaks and has a high number of recorded fire incidences [18]. The station has
143   experienced 63-fire incidences from 1980 to 2015. These fires burned a total area of 4509.1 ha and the
144   KFS spent a total of $ 41,917 to fight the fires. The total damage caused by forest fires from 1980 to
145   2015 is estimated to be $ 443,837.
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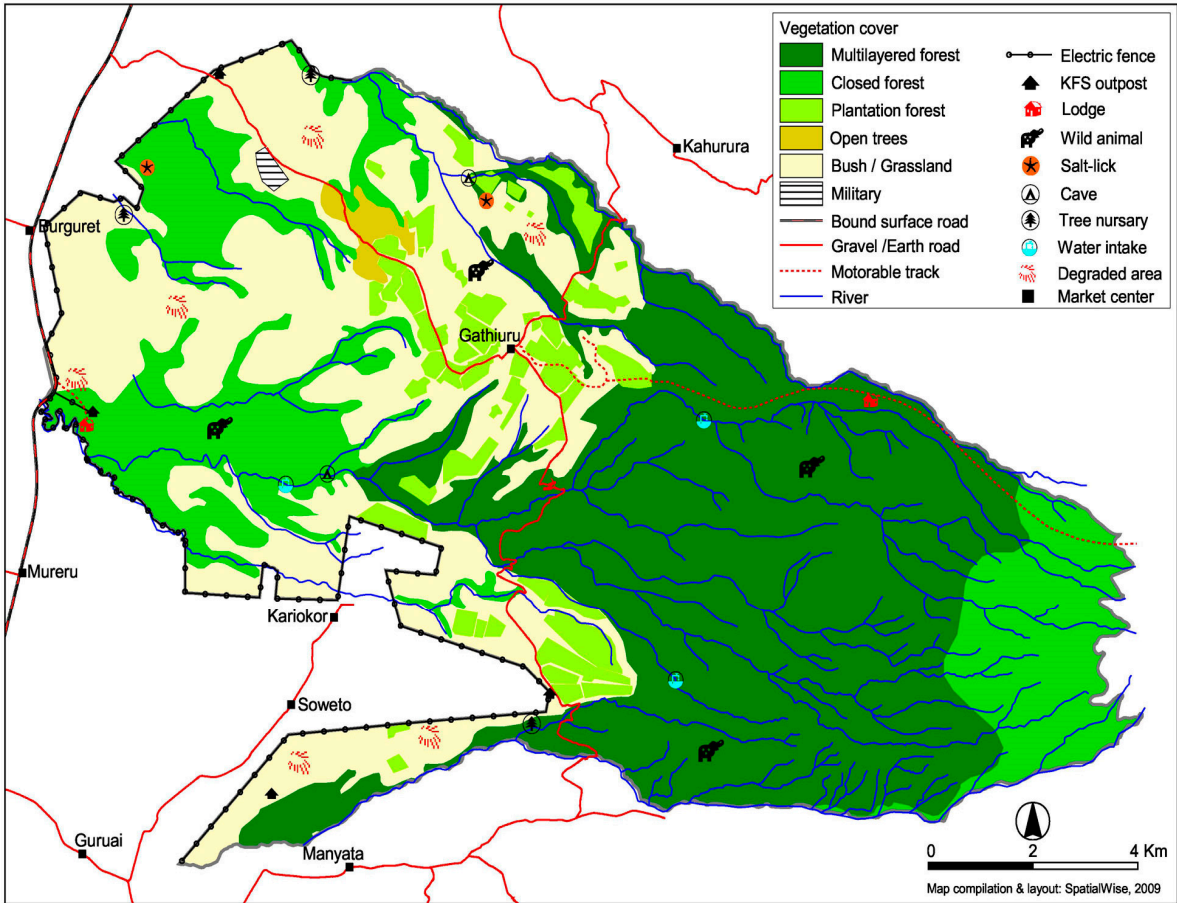
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148   Figure 2: Gathiuru Forest Vegetation Types and Management Units, 2009.

149   **2.2 Methods for analysing the conditions**

150   A visibility study was done from the 1st to 30th September 2015 in the 18 forest stations that form
151   the Mt. Kenya Forest Ecosystem to establish forest stations that are prone to fires.   Gathiuru forest
152   station was then selected based on the number of fire incidences recorded in the recent past and the
153   existence of a fire management plan. Formal, informal meetings and focus group discussions were
154   held with key resource persons from KFS, CFA members and other stakeholders that are involved in
155   the management of the Gathiuru Forest. A study of primary and secondary data on socio-economic
156   activities, fire records, weather records, observation and documentation of the fire management
157   plans in Gathiuru Forest Station was done. An assessment of how well Gathiuru forest station was
158   implementing the fire management plan was also done.

159   **2.2.1 Questionnaires**

160   Questionnaires were designed and a pilot test was conducted to refine the questions. The
161   questionnaire included: Yes or No responses, some questions allowed responses on a Likert type of
162   scale ranging from a very great extent (5) to no extent at all (1) and no response (0), while others were
163   required to express their personal opinions verbally. The questionnaires were used to interview 16

164 respondents from Gathiuru Forest Station (1 KFS manager, 1 ranger, 2 CFA leaders and 12 CFA
165 members) between October, 2015 and December, 2016. The level of education, gender and
166 socio-economic activities, motivation, potential and constraints (problems) affecting forest
167 managers, rangers, CFA members and other stakeholders' participation in wildfire management in
168 Gathiuru Forest and the surrounding villages were analysed. The awareness about the existence of
169 the fire management plan, fire preparedness plans, damage caused by wildfire to communities and
170 the environment, causes of wildfires, community participation in wildfire management, the
171 channels of communication preferred by forest managers and CFA leaders to receive and give
172 information on fires in Gathiuru Forest and the surrounding villages, training of CFA members,
173 rangers and forest scouts on fire fighting in Gathiuru Forest and the surrounding villages were also
174 surveyed using questionnaires.

2.2.2 Focus Group Discussions

176 A focus group discussion is a good way to gather together people from similar backgrounds or
177 experiences to discuss a specific topic of interest. On the 10th November 2016, a focus group
178 discussion was held with 24 participants that included the Chief Ecosystem Conservator, KFS forest
179 managers, rangers, Kenya Forestry Research Institute (KEFRI) personnel, CFA members and other
180 stakeholders. The group was guided by a facilitator who introduced and moderated the topics of for
181 discussion on: how human activities at Gathiuru Forest influence ignition of forest fires; the positive
182 and negative effects of fires in Gathiuru Forest and; how the KFS, KWS and CFAs were collaborating
183 in the implementation of fire management plans, fire monitoring, fire prevention, fire-fighting,
184 reduction of hazardous fuels and maintaining ecosystem health. The focus group discussions helped
185 to gather information on how back firing has been used by firefighters in Gathiuru Forest to stop fire
186 from spreading to other parts of the forest. The focus group discussions also helped in generating
187 different ideas on IFM and how it is implemented in Gathiuru Forest Station.

2.2.2.1 Ranking of benefits and concerns in Gathiuru Forest

189 Focus group participants were actively involved in the importance ranking of their needs and
190 benefits obtained from Gathiuru Forest. Participants were instructed by the moderators to come up
191 with a list of the needs and benefits that they obtained from Gathiuru Forest and another list
192 showing the concerns about fires in Gathiuru Forest. They voted by putting X or √ autonomously
193 without being influenced by members of their user groups. The same procedure that was used to
194 vote for the needs and benefits was repeated for the concerns about fires in Gathiuru forest. A final
195 tally was done to establish the total number of votes for each ranking. In case there was a tie in the
196 first tally (TALLY I) of the ranking, then a second voting was done (TALLY II) to determine the final
197 rank of the benefits and concerns.
198 Data entry of respondents' views collected from the questionnaires, focus group discussions
199 and processing by a ranking procedure was done. Analysis was conducted by using IBM SPSS
200 Statistics. .

3. Results

202 The presentation of the results follows the IFM framework. The human needs and the related
203 land use activities are presented in relation to the major causes for fire ignition. The concerns related
204 to fire and the assessment of the external drivers allows the design of fire management approaches.

3.1 Humans needs and benefits in Gathiuru Forest

206 Common human needs accessed by the local communities in Gathiuru Forest include water
207 use, timber, firewood, livestock grazing, cultivation of crops, collection of herbs for medicinal
208 purposes, and generally contributing to a good life style. Results from focus group discussions show

209   that there are considerable environmental and economic values that support the livelihood of the
210   communities living around Gathiuru Forest. The forests offer diverse resources for consumptive use,
211   and local people are allowed to access these products through permit and licensing system. Table 1
212   shows the voting and ranking of the benefits obtained by the CFA in Gathiuru Forest where using
213   the land as farmland (PELIS) is ranked as first and providing cultural/religious benefits is ranked
214   last.

215   Table 1: The ranking of benefits obtained from Gathiuru Forest (N =24)

Rank of needs & benefits	Benefit Class	Number of votes for benefits	Importance
		Tally I & Tally II	
1	Farmland (PELIS)	17	0.71
2	Water	13	0.54
3	Employment/ income	12	0.50
4	Herbal medicine	10	0.42
5	Education & research	9	0.38
6	Timber	8 (11)	0.34
7	Grazing	8 (9)	0.33
8	Honey collection	3	0.13
9	Firewood	2	0.08
10	Cultural and religion	1	0.04

216   **3.2 Human activities and their influence on fire ignition in Gathiuru Forest**

217   **3.2.1 Perception about factors influencing fire ignition**

218   Fuel characteristics, the weather conditions, topographic factors and the human activities
219   influence fire ignition in Gathiuru Forest. The analysis of data collected using questionnaires on the
220   perceptions of the local people on the leading causes of fires in Gathiuru Forest is shown in Figure 3.

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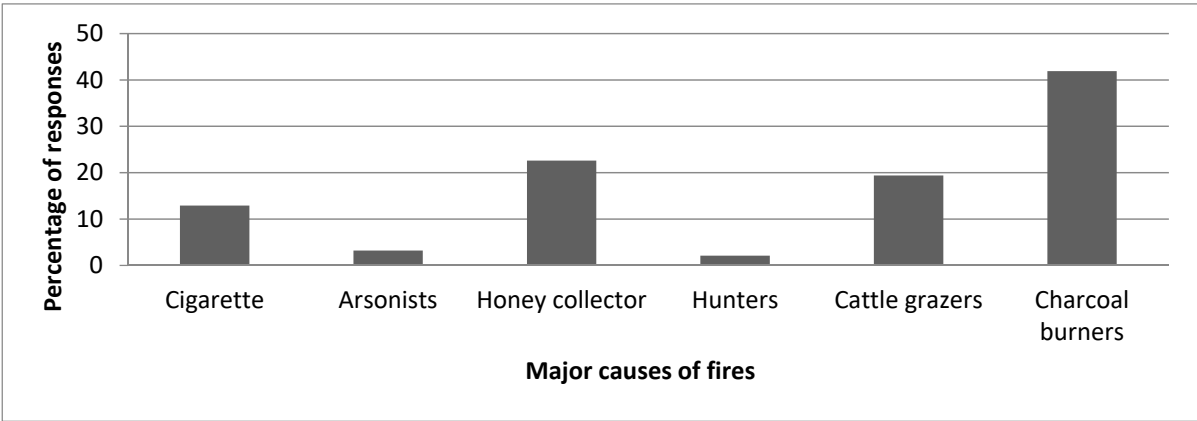
222   Figure 3: Major causes of fires in Gathiuru Forest indicated by questionnaire respondents (N=16)

223

3.2.2 Legal human activities in Gathiuru Forest

According to the focus group discussions, farming (PELIS) is one of the activities practised by rangers and CFA members in Gathiuru Forests. Results from the voting and ranking of needs and benefits show that farmland (PELIS) got 17 votes and is ranked as the first benefit obtained by the communities from Gathiuru Forest. But, the use of fire to clear farm plots has been abolished and all CFA members declared that using fire to clear a farm plot would cause a loss of the farmers' user group rights and the plot will be given to a new member.

Communities obtain water from rivers that originate from Gathiuru Forest of the larger Mt. Kenya Water Tower for domestic use, watering of livestock and irrigation of crops. Water abstraction has been licensed in Gathiuru Forest and a water user group has been formed. Results show that water use is ranked as the second most important benefit.

Rangers and CFA members conduct some casual jobs like thinning and pruning of forest plantations. They get cash payments for these jobs. To reduce the fuel load, they are allowed to collect and sell some of the poles and firewood from thinning and pruning operations. Results show that Employment/income is ranked as the third most important benefit.

The collection of herbs and spices for domestic use or commercial purposes by the local communities is currently not licensed and a user group has not been formed. Results show that herbal medicine and spice collection is ranked the fourth most important benefit in the Gathiuru Forest and their collection might cause a reduction of the available fuel.

Several national and international institutions have been doing education and research projects in Gathiuru Forest. The forest also provides a learning place for the traditional non-formal education that has been passed down for generations about plants and animals and their uses. Results show education and research is ranked as the fifth most important benefit, which shows the potential for providing a sound training for fire management.

Saw millers and communities obtain poles and timber from Gathiuru Forest. Logging has been licensed and is one of the leading economic activities as the demand for timber is higher than the supply. Results show that timber harvesting is ranked as the sixth most important benefit.

Grazing and cutting of grass to feed livestock has been licensed and a grazers' user group has been formed in Gathiuru Forest. Additionally migrant pastoralists do graze their cattle (*Bos-Taurus* Linnaeus.) in Gathiuru Forest illegally during years of extreme drought (2009 and 2017). Results from the focus group discussions show that grazing and cutting of grass is ranked as the seventh most important benefit and the questionnaires indicate that grazing and burning of old grass contributes to 19.4% of the fires in Gathiuru Forest.

Honey collection is practised by communities living around Gathiuru Forest. Bee keeping has been licensed and the bee keepers' user group has been registered. Results show that honey collection is ranked as the eighth most important benefit. However, illegal honey collection is also practised in Gathiuru Forest and the results from the questionnaires show that honey collection contributes to 22.6 % of the fires in Gathiuru Forest.

Firewood collection by CFA members is practised in Gathiuru Forest as part of fuel management. It has been licensed and the firewood collectors' user group has been registered. It helps to reduce fuel build up and contributes to lowering the risk of large fires occurring. Results show that firewood collection is ranked as the ninth most important benefit that local people gain from Gathiuru forest.

Gathiuru Forest contains caves that over centuries have been used by the Kikuyu, Embu and Meru communities as sacred cultural and religious sites. Some trees have also been declared as sacred trees and no one is allowed to cut them for any use or set them on fire. Results show that cultural and religious sites are ranked as the tenth most important benefit from the Gathiuru Forest.

3.2.3 Illegal activities in Gathiuru Forest

Illegal charcoal burning is practised in Gathiuru Forest by communities living around the forest. This has caused fire outbreaks and destroyed large parts of Gathiuru Forest in the past.

274 Results from the questionnaires show that illegal charcoal burning contributes to 42.6% of the fire
275 outbreaks in Gathiuru Forest. However, the practice of illegal charcoal burning is on the decline due
276 to good collaboration between KFS and CFA members in Gathiuru Forest. The illegal charcoal
277 burners have been arrested in the past. The CFA has also trained community members on using
278 solar energy, gas and other energy saving stoves.

279 Results from the questionnaire show that poachers are perceived to contribute to 2.1% of fire
280 ignitions in Gathiuru Forest. Illegal hunters use fire as a hunting tool and to roast game meat in
281 Gathiuru Forest. It was reported from the focus group discussions that sometimes poachers cause
282 fires so that the rangers have to concentrate on fighting the fire, while the poachers escape from
283 being arrested. Interestingly both the illegal activities of charcoal burning and poaching were not
284 mentioned as an important benefit for the local people in the Gathiuru Forest.

285 Conflicts have occurred between KFS, KWS, CFAs and other stakeholders over the right to use
286 forests resources. Focus group discussions revealed that conflicts do arise when locals are arrested
287 by KFS staff, forest scouts or CFA members for conducting illegal logging, grazing, collecting
288 firewood, collecting honey, herbal medicine, burning charcoal or hunting in Gathiuru Forest.. The
289 culprits usually set the forest on fire as revenge (arson). Results from the analysis of data from
290 questionnaires show that arson contributes to 3.2% of the fire ignitions in Gathiuru Forest.

291 **3.3 Concerns related to fires**

292 Fires can have several effects on the social, economic and cultural aspects of the livelihood of
293 the local people. Focus group discussions indicated that the participants support the idea that when
294 fire is used and managed properly, it has some positive effects for the communities, but there are
295 also concerns about the damages that can be caused by wanted and unwanted fires that are lit
296 intentionally or unintentionally in Gathiuru Forest (Appendix A). Table 1 shows the voting and
297 ranking of the concerns related to the negative effects of fires by the CFA in Gathiuru Forest where
298 loss of grazing grounds (pasture) is ranked as   first and loss of livestock is ranked last.

299 Table 2: The votes and rank of concerns related to fire effects in Gathiuru Forest (N=24)

Rank of concerns	Concerns	Number of votes for concerns	Importance
		Tally I & Tally II	
1	Loss of grazing grounds (pasture)	9	0.38
2	Loss of wildlife habitat/ escape to farms	6	0.25
3	Loss of wildlife	5	0.21
4	Water pollution	4	0.17
5	Bad air quality	3 (3)	0.13
6	Soil erosion	3 (2)	0.12
7	Loss of life	2	0.08
8	Loss of livestock	1	0.04

300

301 The respondents of the questionnaires have also indicated two main fire seasons per year. The first
302 fire season is from January to March and the second from August to October as shown in Figure 4.
303 Their perceptions nicely correspond to the documented number of fire records per month during the
304 year. This indicates the high awareness of the CFA members regarding the fire seasons in Gathiuru
305 Forest.
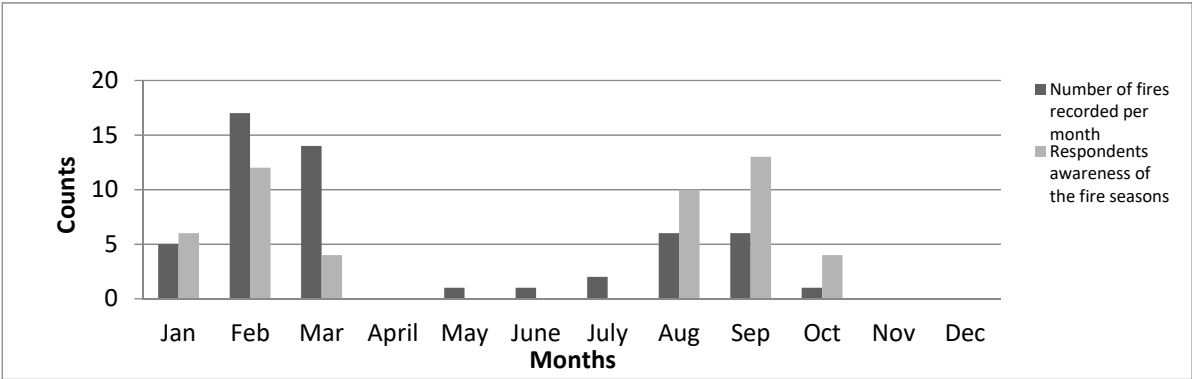
Figure 4: Number of fires recorded by KFS and the fire seasons in Gathiuru Forest based on the perceptions of the local people (N=16).

3.4 Implementation of Integrated Fire Management

3.4.1 Stakeholder involvement

The involvement of different stakeholders in the implementation of IFM guidelines varies. Results from the questionnaires show that the leading stakeholders involved in IFM in Gathiuru Forest are forest managers with 34%, CFA members with 33%, rangers with 27% while the other stakeholders have only 7%. Appendix B shows the detailed results of the main stakeholder groups involved in the establishment of guidelines for responsible Integrated Fire Management activities in Gathiuru Forest, their interest, roles and responsibilities.

3.4.2 Provision of fire training and technical support to improve IFM

Results from the analysis of the questionnaires show that KFS and KWS have to some extent been providing fire educational programmes and firefighting training programmes to rangers, CFA members and forest scouts with the aim of improving their knowledge and skills in fire prevention and suppression in Gathiuru Forest. It also indicates that the government of Kenya has only to a little extent been providing firefighting equipment to the Gathiuru KFS and CFAs as shown in Figure 5. This has greatly affected their ability to fight the huge fires that have been occurring repeatedly over recent years.
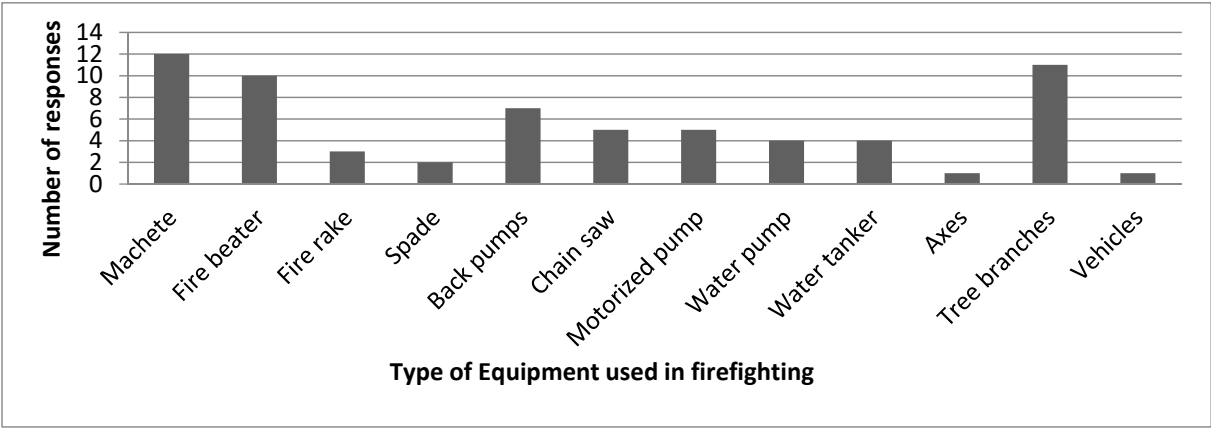
Figure 5: Type of equipment used to fight fires at Gathiuru Forest Station (N=16)

3.4.4 Existence and revision of IFM plans

Results from the analysis on the existence of IFM plans and their revision based on the records of the number of fires that have occurred, the damage caused by those fires and community

331 participation in Gathiuru Forest show that 6% of the respondents said to a very great extent, 38%
332 said to great extent, 19% said to some extent, 19% said to little extent, 6% said to no extent while 12%
333 gave no information. This means that the KFS, KWS and the CFAs have to a great extent given
334 special consideration to social, economic and environmental values of the local community in their
335 IFM planning.

336   **3.4.5 Land use and fire danger rating in Gathiuru Forest**

337   Results from the analysis of data from questionnaires show that 50% of the respondents said
338 that to a great extent there exists a fire risk analysis plan in Gathiuru Forest Station based on land
339 cover, daily weather conditions and socio-economic activities. Results show that 50% of the
340 respondents said to some extent there exists a regional early warning system about fire outbreaks in
341 the Mt. Kenya Forest.

342 **4. Discussion**

343   **4.1 Land use practices and fire ignition**

344   Gathiuru Forest Station is one of the Mt. Kenya forest stations with a high number wildfire
345 incidences recorded over the last three decades. According to the fire records and interviews
346 conducted, it was found out that the charcoal burners, honey collectors, cattle grazers, cigarette
347 smokers, arsonists and hunters are the main causes for fire ignition in Gathiuru Forest. However
348 other studies have shown that not all ignitions are directly linked to land use activities, for instance
349 fires due to arson, careless disposal of smoked cigarettes are related to social behavior [19-21]. It is
350 important to understand how at the local level communities utilize land resources with or without
351 the use of fire, the social behavior that drive ignitions and incorporate them into integrated fire
352 management approaches as a basis for addressing the risk of fires [22-23].
353   In many studies it was found that the growing human population and the increase in per capita
354 food consumption are driving agriculture expansion and affecting natural ecosystems
355 [24]. According to the 2009 Kenya Population and Housing Census, many of the communities
356 living around Gathiuru Forest are poor and do not have enough land for farming [25]. Communities
357 living around Gathiuru Forest also heavily depend on the land resources for preparing the farmland
358 and managing the forests for many ecosystem services and non-timber forest products. The
359 Gathiuru CFA was formed in 2009 to involve the community in Participatory Forestry Management
360 and at the same time to help regulate human activities according to the agreed user rights in
361 Gathiuru Forest. The user groups have the right to conduct their activities within Gathiuru Forest
362 which includes timber production and running saw mills, grazing, firewood collection, beekeeping,
363 collecting herbs, water abstraction, farming trout fish (*Oncorhynchus mykiss* Walbaum.), providing
364 hotel and cottage services as well as ecotourism and cultural exhibitions, conducting the PELIS
365 system on farms and acting as community scouts. The signing of the user group's agreement has
366 enabled the CFA to source funding from other key sources principally Green Zones Development
367 Support Project. Each of these user groups has been provided an area for their business and in the
368 case of   a fire outbreak, the whole group will lose their user rights [18].
369   According to the farming (PELIS) rules and guidelines, the growing of beans (*Phaseolus vulgaris*
370 Linnaeus.), potatoes (*Solanum tuberosum* Linnaeus.) and onions (*Allium cepa* Linnaeus.) has been
371 practiced in Gathiuru forest from 2008 to 2017. PELIS has helped to reduce poverty and to increased
372 food security amongst Gathiuru CFA members involved in the production of high quality potatoes
373 with an estimated production of 7,500 tons per year. From 2008 to 2017 total sales of food crops
374 (potatoes) amounted to KSh 756 million ($ 7.56 million) and this enabled CFA members to stop
375 depending on the forest resources and start other income generating activities.
376   Firewood is utilized in many parts of the world as a source of energy and is a major focus in the
377 management of primary and secondary forests [26-27]. According to the studies done by CIFOR [28],
378 the increased demand for fuelwood can lead to forest degradation if not controlled. We found out

379   that firewood collection plays an important role for the CFA members as well. It has been licensed
380   and the fee for collecting firewood 2 or 3 times per week ranges from KSh 100 to 150. However, the
381   Gathiuru CFA bought 1150 energy saving cooking stoves (jikos) and distributed them among CFA
382   women. This has helped to reduce the fire wood consumption and hence women do not need to go
383   to the forest daily to collect firewood-[18].
384   Several studies have been done to assess the impacts of cattle grazing on forests fires, water
385   quality, biodiversity, invasive species, soil fertility, regeneration, tree damages and soil erosion
386   [29-32]. Cattle grazing and cutting of grass to feed livestock is allowed and has been licensed in the
387   Gathiuru Forest. Grazing and cutting grass helps to reduce the fuel load and at the same time
388   minimizes the risk of rapid surface fires occurring. The CFA is responsible for collecting grazing fees
389   of Ksh. 100 per head of cattle. The agriculture officers have been involved in designing a carrying
390   capacity for cattle grazing in the forest to help reduce the problem of over grazing. When the grass in
391   the grazing area is over, the cattle grazers are reallocated to another grazing area according to the
392   carrying capacity. Nevertheless there have been cases of illegal grazing and fire outbreaks caused by
393   illegal grazers as well [18].
394   Studies of sacred forests and other sacred sites show that religious and spiritual beliefs can
395   sometimes be the motivation for conservation and environmental protection. African indigenous
396   religions view land and its resources as communal property that belongs not only to the living but to
397   their ancestors and to future generations [33]. Mt. Kenya is a holy mountain for the Kikuyu
398   community. The term Kikuyu originates from the Mukuyu tree *(Ficus sycomorus* Linnaeus.).
399   According to the Kikuyu culture, three sacred trees make the community believe to conserve the
400   forest: Mukuyu tree (*Ficus sycomorus* Linnaeus.), Mugumo tree (*Ficus thonningii* Blume.) and
401   Mukurwe tree (*Albizia gummifera (*J.F. Gmel) C.A Sm*). Nobody is allowed in the community to cut
402   down or set fire on these trees. This is similar to other places in Africa [34] and contributes to the
403   efforts of conservation.
404   Ecotourism can be an incentive for conservation activities, may provide socio-cultural benefits
405   [35] and income for local communities living around nature parks [36-37]. Fires burning camp
406   grounds, other tourist resorts, destroying the national park and causing evacuations of tourists from
407   fire-threatened recreation sites are a great concern [38]. Also the fires in Gathiuru Forest pose just
408   such a serious threat to ecotourism, which is an economic engine for the region. The perception of
409   risk and the knowledge about wildfire by tourists has to be considered, as some tourists are not
410   aware of the potential danger of becoming trapped by wildfires or causing a fire due to negligent
411   handling of barbecue fires or cigarettes [38]. The Gathiuru CFA has therefore established hiking
412   trails that are being used by tourists and also act as fire breaks [18].
413   Controlled small-scale fires are traditionally used in the African savannah to flush out small
414   mammals for hunting purposes. However, poachers in some areas have carelessly been deploying
415   crude versions of this practice, causing unmanageable bush fires and large-scale destruction [39].
416   Hunting of game-meat used to be a traditional practice of many communities in Kenya as well. The
417   communities used fire as a hunting tool and to roast game meat for centuries. With the introduction
418   of a ban on hunting in Kenya in 1977, the hunting practice was rendered illegal. But poachers have
419   continued to use fire as a hunting tool and to distract rangers from arresting them as the rangers try
420   to put out an early fire outbreak, which allows the poachers to escape [40]. The KWS, KFS and CFAs
421   are working together to ensure there is no more hunting of wildlife in the Gathiuru forest and
422   national Park. Now days the CFA members have been educated on how to keep rabbits (*Oryctolagus*
423   *cuniculus* Linnaeus.), chicken (*Gallus gallus domesticus* Linnaeus.), sheep (*Ovis aries* Linnaeus.), goats
424   (*Capra hircus*, Linnaeus.), cattle (*Bos Taurus*) for producing food and hence the need for game-meat is
425   declining. The legal fine for those involved in illegal hunting has also been increased tremendously
426   to discourage this bad practise [18].
427   In Africa, the North Western Province of Zambia emerged as the "Honey Province" because of
428   its historical tradition of trading beeswax, its remoteness, and its vast miombo woodlands and it is
429   presumed that beekeeping started in Ethiopia about 5,000 years ago [41]. Some CFA members are
430   involved in bee keeping within Gathiuru Forest. Their practice has been registered and licensed to

431 established apiaries within the forest and some have been trained by KWS on bee keeping, honey
432 harvesting and processing. The Ogiek tribe in the Great Rift Valley of Kenya is one of the honey
433 hunter-gatherer peoples in East Africa and honey plays a central part in the Ogiek society being used
434 for food, beer brewing and trade. Besides using beehives of hollow logs placed in tree branches the
435 traditional honey collectors in Gathiuru Forest illegally hunt for honey in tree hollows. They chop
436 down tall trees and use fire to produce smoke and keep away the bees (*Apis mellifera* Linnaeus.)
437 before collecting honey. Cutting the trees not only destroys the forest but can also cause huge fires if
438 the collectors act carelessly [18].

439 **4.2 Positive social and environmental benefits of fire**

440 The Kenya Grass Fire Act, Cap 327 provides a regulation for burning of bushes, shrubs, grass,
441 crops and stubble through issuance of permits to carry out planned burnings within protected areas,
442 trust land and in private lands. Prescribed burning as a conservation measure helps in controlling
443 pests and invasive plant species [42]. Traditionally communities living Kenya have used fire as a tool
444 for: burning old grass to facilitate the growth of new grass for livestock; hunting of game meat and
445 roasting; harvesting of wild honey; preparation of agricultural lands, breaking impenetrable
446 bushlands; controlling of weeds, pests and parasites; and keeping wildlife away from homes [6].
447 Gathiuru forest has some fire dependent species like *Juniperus procera* (Hochst. Ex Endl.),
448 *Bambusa vulgaris* (Schrad.) Ex J.C. Wendl. and *Hagenia abyssinica* (Bruce) J.F. Gmel that usually
449 regenerate after fire. Native perennial grasses also regrow from root systems that are rarely
450 damaged by fires that occur in Gathiuru Forest. Fire is the only natural factor also which supports
451 the reproduction of the subalpine forests as the grass layer of larger areas is cleared by occasional
452 burning [43]. Some scavenger animals like hyenas (*Crocuta Crocuta* Erxleben.) and bird species like
453 the black eagles (*Ictinaetus malaiensis* Temminck.)have been seen to move to burned areas in
454 Gathiuru Forest as the reduced vegetation allows them to catch prey easily [44].

455 **4.3 Negative social and environmental effects of fires**

456 The CFA members involved in farming (PELIS) activities in Gathiuru Forest are not allowed to
457 use fire for land preparation in Gathiuru Forest. It was noted that the use of fire for fuel management
458 is not practiced in Gathiuru Forest. This results in accumulation of fuel loads and the focus on fire
459 suppression will have a major role in future outbreaks [45]. Huge catastrophic fires burned large
460 areas of Gathiuru Forest destroying plant material and the litter layer. Shrubs, forbs, grasses, trees,
461 and the litter layer break up the intensity of severe rainstorms because of the stabilisation of the soil
462 by the plant roots, stems and leaves that slow down the water drops and provide time to percolate
463 into the soil profile [46]. The subsequent rains after fires have caused landslides, flash floods and soil
464 erosion in Gathiuru Forest. The ash from burned sites caused water pollution affecting trout fish
465 farming and heavy sedimentation has been recorded in the seven folk dams that rely on water from
466 rivers in Mt. Kenya Forest [9]. Other studies have also proved that surface water coming from
467 burned areas causes serious water quality problems in streams, lakes and reservoirs by introducing
468 hazardous chemicals into the water bodies [47].
469 Fires occurring in Gathiuru Forest have been causing smoke that is spread by wind several
470 kilometres away. Wildfire smoke composition depends on many factors, including the types of
471 vegetation burned and the pollutants in smoke can include deadly gases e.g. carbon monoxide and
472 many solid and liquid elements often known as particulates or particles [12]. Forest fires have been
473 polluting the air, irritating the eyes, reducing visibility for motorists and causing difficulty in
474 breathing to communities living around Gathiuru Forest and several kilometres further away.
475 Some wildlife has lost its life after huge catastrophic fires in Gathiuru Forest; especially slow
476 moving, sick or young birds/animals that cannot escape fire [44]. Fires cause a loss of their habitats
477 and provoke them to escape onto nearby farms destroying crops thus, causing huge losses to CFA
478 members who obtain their food and income from Gathiuru Forest. Tourism is also negatively

479 affected after huge fires, as the scenery is destroyed and some wildlife are forced to migrate to other
480 parts of Mt. Kenya Forest.
481   Conflicts often occur between nomadic groups in Kenya, Uganda, Sudan, Ethiopia and Somalia
482 over the use of pastures in fragile ecological environments [48]. During years of extreme drought,
483 immigrant pastoralists usually come to graze in Gathiuru Forest, set fire to the old grass to facilitate
484 growth of new grass and then move away in search of good pasture grounds. This practice has been
485 causing huge fires and loss of grazing grounds for the locals, who depend on the forest resources for
486 their livestock. Inter community conflicts over water and pasture grounds between the locals
487 (Kikuyu) and the pastoralists (Samburu and Maasai) are likely to increase [48].
488   The highest human fatalities from fighting fires occur in developing countries, up to nearly 80%
489 for the period between 1997 and 2006 [45]. This is also one of the most serious concerns in Gathiuru
490 forest. Volunteer fire fighters suffer from the lack of proper firefighting equipment which can be a
491 strong contributing factor in loss of life while fighting huge fires. Fires have also   destroyed houses
492 constructed by CFA members within Gathiuru Forest [18].
493   Loss of livestock has been reported after extreme shortage of pasture caused by drought and
494 fires in the Gathiuru Forest. The poor nutritional status of the livestock does not allow long distance
495 movement of livestock for pasture and water. Wildfires suppress grass production for about two
496 seasons and it is recommended that pasture grounds must rest for at least one growing season after a
497 runaway fire, and for at least one growing season before a planned burn. After huge fires the leftover
498 grass is grazed by wild animals, and may not be suitable for livestock grazing and this makes weak
499 livestock prone to die or the communities have to sell them at low prices [49].

4.4 External drivers influencing fire danger

501   From the discussions with the participants in the focus group, a lot of external drivers that have
502 an influence on the fire danger were identified. Besides the changing climatic conditions,
503 government policy and the role of migrating pastoralists were identified. The Kenya forest policy
504 stipulates rules for the establishment of forest management zones to guide the different
505 management strategies and future planning of particular areas to avoid conflicts among different
506 users [42]. The management zones reflect the priority of the different objectives, and generally
507 provide a direction for daily management as well as long-term decision making with respect to the
508 land use patterns in the ecosystem. The zones include: protection zone (National Park, water
509 catchments); biodiversity conservation zone (indigenous forest); plantation zone cypress (*Cupressus*
510 *lusitanica (*Mill.) D.P. Little), patula pines (*Pinus patula* Schiede ex Schltdl. & Cham*)*, radiata pines
511 (*Pinus radiata* D. Don), blue gum (*Eucalyptus saligna* Smith.) and rose gum *Eucalyptus grandis* W. Hill
512 ex Maiden) ; utilisation zone (glades, grasslands, NWFP, tourist sites); rehabilitation zone (these are
513 degraded areas marked for regeneration) and intervention zones-conflict area [9]. The zoning of
514 forests into management blocks affects the type of human activities allowed in those blocks. This has
515 an influence on the ignition probability of forest fires. Blocks zoned for grazing usually experience
516 more regular fires than blocks zoned for water catchment conservation [9].
517   An analysis of KFS records show that Gathiuru Forest Station has been zoned into three blocks
518 and subdivided into compartments and sub-compartments for easier management. The Gathiuru
519 Block has more plantations and less indigenous forests, the Mugeria Block has intensive PELIS
520 activities and the Burguret Block has indigenous forest and grasslands and is prone to fire caused by
521 cattle grazers. The cattle grazers' user group has been formed to monitor the number of livestock
522 entering the forest and to prevent any activities that are likely to cause fires in the forest. They also
523 help the forest manager to collect levies from all registered cattle grazers in Gathiuru Forest.
524   The Kenya forest policy also stipulates that there must be a forest fire protection unit within
525 every forest station organizational structure. The Ecosystem conservator of the forests appointed at
526 the headquarters helps forest managers to plan, organize, equip, train and provide follow up
527 supervision of a cost effective fire management at all levels with the KFS. They develop
528 comprehensive nation-wide programs to create awareness about the need for fire protection and
529 control and plan the implementation of risk and hazard reduction. In the field, the KFS Station

530 Forest Managers organize and supervise the activities of prevention and suppression of forest fires
531 within their areas [42].
532   The meteorological factors that influence the fire weather include high temperatures along with
533 a dry, low humidity and windy weather. Natural, cyclical weather occurrences, such as El Niño
534 events, affect the likelihood of fires by influencing precipitation and moisture content of plants and
535 lead to year-by-year variability. Changes in climate are likely to alter the two fire seasons in
536 Gathiuru Forest. According to the Kenyan government [13] projections temperature and
537 precipitation levels are likely to alter further in Kenya over the course of this century. However,
538 despite compelling evidence on the role of climate influencing fire ignitions, the majority of ignitions
539 in Kenya are caused by humans as noted in different parts of the world [11].
540   Droughts associated with climate change will cause annual flow reductions in most rivers,
541 conflicts over water resources and pasture and the complete disappearance of the Kilimanjaro,
542 Ruwenzori and Mount Kenya glaciers by 2015 - 2020 [50]. Conservation reports indicate that during
543 years with prolonged dry spells, the forests and national parks of Kenya will continue to experience
544 the huge pressure of livestock from pastoral communities thereby over stretching the available
545 resources [9]. This means that in all likelihood the pastoralists (Samburu and Maasai) will continue
546 to graze in Gathiuru Forest without considering the local CFA grazers user group agreements. The
547 setting of old dry grass on fire by pastoralists also contributes to fires at Gathiuru Forest Station.

548 **4.5 Integrated Fire Management Policy**

549   Kenya has made several steps in the establishment and implementation of Integrated Fire
550 Management approaches. That will help the country to address the problems and issues posed by
551 both damaging and beneficial fires in evaluating and balancing the associated risks. The existing fire
552 policies in Kenya recognize the positive use of fire in land management of natural ecosystems but at
553 the local level resource managers have largely been addressing fire as a hazard rather than a tool for
554 land management. The traditional use of fire in Kenya for supporting the livelihoods of the local
555 people needs to be considered in the establishment and implementation of IFM guidelines [16].
556 There is also a need to give special consideration to social and community values and engage the
557 community in IFM planning and implementation. This will help communities and resource
558 managers in Kenya to find cost-effective approaches to prevent damaging fires, as well as
559 maintaining desirable fire regimes.

560 **5. Conclusions**

561   This study investigated an Integrated Fire Management (IFM) framework to address both
562 damaging and beneficial fires. It also evaluated the various uses of fire, the underlying perceptions
563 and the traditional ecological knowledge of the local people. The risks posed by fires were then
564 balanced with the beneficial ecological and economic effects, will thus support the development of
565 effective fire management approaches. The proposed IFM framework helps in implementing
566 cost-effective approaches to prevent damaging fires and maintain desirable fire regimes in Kenya.
567 The IFM framework is scalable and can be applied in places with fire-dependent ecosystems as well
568 as in places with fire-sensitive ecosystems in Kenya. The effectiveness is dependent on the active
569 participation, formulation and implementation of the IFM activities by the main stakeholder groups
570 (Kenya Forest Service (KFS), Kenya Wildlife Service (KWS), and the Community Forest Associations
571 (CFA)). The proposed IFM framework also emphasises the need for the government of Kenya to
572 finance, educate, train, equip and motivate resource managers, rangers, CFA members and forest
573 scouts that are involved in fire prevention and suppression activities to achieve sustainable IFM
574 strategies. It also suggests ways to improve arbitration mechanisms in solving inter- community
575 conflicts over the use of forest resources in Kenya. It highlights the need to implement the relevant
576 international, national, county laws and policies for establishing or improving the legal, regulatory
577 and institutional framework required for responsible IFM activities in Kenya's forests. The
578 information from the proposed IFM framework may be used by resource managers, policymakers

579 and researchers to improve or advocate for sustainable land and resource management programmes
580 that consider the fire history of the areas, ecologically appropriate use and management of fire, and
581 the suppression of unwanted, damaging fire in Kenya's forests.
582

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590 "Kevin W. Nyongesa and Harald Vacik worked jointly on the study design including questionnaires; Kevin W.
591 Nyongesa performed the interviews and Focus group discussions; Kevin W. Nyongesa and Harald Vacik
592 analyzed the data; Kevin W. Nyongesa wrote the paper and Harald Vacik contributed to it."

593

594

595 **Conflicts of Interest:**

596 "The authors declare no conflict of interest." "The founding sponsors had no role in the design of the study; in
597 the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish
598 the results".

599 **Appendix A: Positives and Negatives about fires in Gathiuru forest.**

	POSITIVES ABOUT FIRES	NEGATIVES CONCERNS ABOUT FIRES
Grasslands	-There is no lighting of fire in grasslands, Grazing of livestock in forest is allowed to reduce fuel load, The CFA members cut grass in forest to feed their cattle that are now producing more meat and milk than in the past, because of keeping few but good quality breeds	Migrating cattle grazers come to the forest by force without regard for the agreement of the CFA. In 2009 there was more than 100,000 cattle which destroyed young trees, grasslands and food crops
Motivation	-CFA members are very responsive to fire alerts and meetings called by KFS and their leaders, Free firewood collection to CFA members who participate in firefighting, Some poles for use in farms to CFA members who participate in firefighting, Free grass for livestock to CFA members who participate in firefighting, Verbal congratulations to CFA members who participate in firefighting, Support is given to forest scouts by more than 4000 farmers, Scouts get 1st priority in land allocation based on user rights, More children are now going to school as CFA members got money from PELIS, CFA households/families bought land property from PELIS, Wealth creation: 17 people bought cars, 300 people bought motorbike from PELIS, Employment: There is casual employment at Ksh. 350/day.	-Less food rations is given to fire-fighters as they do firefighting at night. -The manager only records names of the firefighters with no financial appreciation
Trees/Forest/ dead wood	- Forest cover has increased and the ecosystem services, The number of fire incidences have reduced, Charcoal burning and Illegal logging in the forest has stopped, Firewood collection from forest has been licensed, CFA bought 1150 energy saving jikos (cooking stoves), each at Ksh.300, therefore they reduced energy consumption and hence women reduce the need to go to the forest daily to collect firewood.	None
Air/Wind	Has been used by fire fighters during back firing to stop fire from spreading to other parts of the forest.	Nose irritation when breathing and spreads fire.
Wildlife	-There is no more using fire to hunt of wildlife in forest. No need for game meat because there are enough livestock and food crops. KFS and the community made solar powered fence that protect young trees and their farms from wildlife damage.	None
Farmlands and food	-No use of fire to clear farms in forest, Since CFA started cultivating, they got good quality food and sold some for money, CFA members have food security at least 5 km from forest boundary and CFA members donate food to the hungry.	None
Policy	The CFA members propose that PELIS policy to continue forever.	None
Ecotourism	-Now there are very many wild animals because the use of fire in forests while poaching has	None

	reduced, There is a hiking trail being constructed and will also act as a fire break	
Equipment	Fire danger rating board, 2 working fire motorcycles, Machetes, Nose masks, Gloves, Spray pumps, Fire extinguishers, Slashers, Rakes, 2 Chain saws, Spades, 1 Fire tower, Jembes (hoes), Water buckets	There is need for water tanks, fire extinguishers, a vehicle to fire-fighters, fire beaters, slashers, rakes, chain saws, spades, hoes, spray pumps & water buckets
Water/Rain	There is more rain now days than in the past, Since 2011 the water volume in rivers has increased, The water in the rivers is more clean and fish farming (trout) is now practiced.	None
Communication	-CFA members have personal mobile phones to communicate with each other and forest manager, Forest scouts inform forest manager and CFA leaders of any fire outbreak before the fire is big, CFA members report those who cause fire in forests	None
Training	2 Forest managers, rangers and 7 CFA members have been trained in forest fire fighting at Laikipia Wildlife Forum	100 CFA leaders and members need to be trained in forest fire fighting
Honey Collectors	-Apiaries have been established in the forest by CFA members, Some CFA members have been trained by KWS on bee keeping (2012)	None

600   Source: Gathiuru forest management plan 2010-2019

601   **Appendix B: Stakeholders involved in the management of Gathiuru forest**

Stakeholder	Interests	Activities	Strengths	Weaknesses
KFS	Protection and conservation of forests	-tree planting, establishment of tree nurseries, revenue collection, awareness creation, carrying out patrols, zonation/mapping of forest areas, enforcing forest law and policy	-Forest Act and policy -expertise -support from lobby groups and donors	-inadequate machinery and equipment, inadequate staff, political interference, inefficiency among KFS staff
KWS	Protection and conservation of wildlife	-electric fencing, promotion of tourism, patrolling, enforcement of the wildlife act, establishment of tree nurseries, translocation of wildlife , information dissemination	-Forest Act and policy, Wildlife Act and policy, expertise, support from lobby groups and donors, adequate resources	-poor response to incidences, poor compensation laws, poor collaboration with the community
Saw millers	Profit making	-logging, conversion of logs to timber products, creation of employment, selling timber based products	-have money, Forest Act and policy	-They do not plant trees, illegal access to trees, big contributors to environmental degradation
CFA	Protection and conservation of the	-tree planting, establishment and management of tree nurseries, controlling forest fires,	-support from KFS, Forest Act and policy, support from	-lack of finances, poor awareness of CFA activities, among the

	forest for community benefits	community policing, generating revenue for the government, managing forest resources	community, support from donors and lobby groups	community members, lack of commitment from CFA officials
Greenbelt Movement	Increased tree cover	-tree panting -promoting community awareness -funding tree planting activities	-community support, support from lobby groups, forest act and policy, have expertise	-failure to fulfil promises -top-down approach in project activities implementation
Nature Kenya	Conservation of the biodiversity	-awareness creation	-adequate resources, support from government bodies such as KWS & KFS, have expertise	-not well known by the community, ineffective community outreach programme
BRWUA	Management and conservation of Burguret River	-supplying water tanks, regulation of water use, supplying drip kits, construction of water pans, construction of foot bridges and livestock watering troughs, tree planting on riparian land	-water act 2002 -support from water users -support from NGOs -support from KFS	-failure to fulfil promises -poor community representation -lack of direct link between BRWUA and the beneficiaries
TIST	Mitigation against climate change	Promoting tree planting	-has international funding	-not well known by the community
LWF	Environmental conservation	-creating awareness, funding CBOs	-have adequate financial resources, have expertise	-not known to the community, poor community representation
Ministry of Agriculture	Food security &facilitating agro-business	-offering extension services	-Government policy, support from the community, have expertise	-inadequate staff
Ministry of Defense	Defending the country	-tree planting, road and bridge construction -water abstraction from Rongai River	-Government policy, have adequate machinery &equipment	None
Ministry of Fisheries & Livestock	Promotion of livestock development	-offer extension services -treatment and vaccination	-have expertise -Government policy	-inadequate staff -services are expensive
Bantu Lodge	Profit making	-tourism -entertainment	-have money, support from Government, create employment	-No tree planting, no community involvement, poor security
UNDP-GEF	Environmental conservation	-establishment of tree nurseries, funding community groups, awareness creation on environmental conservation	-have funds, support from the international community, Government support through KFS and KWS	-lack of follow up project implementation activities, not well known by the community

602   Source: Gathiuru forest management plan 2010-2019

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