Information and Communications Warning System on Wildland Fire in Mozambique

A TECHNICAL PAPER PREPARED AS PART OF THE ACCESA PROJECT

Integrating Vulnerability and Adaptation to Climate Change into Sustainable Development Policy Planning and Implementation in Eastern and Southern Africa (ACCESA)

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About the Project

In 2004, the United Nations Environment Program (UNEP) initiated the regional project Integrating Vulnerability and Adaptation to Climate Change into Sustainable Development Policy Planning and Implementation in Southern and Eastern Africa (ACCESA). The goal of this project was to reduce the vulnerability of communities to the impacts of climate change, thereby improving their well-being and protecting their livelihoods. The ACCESA project also was to provide global environment benefits by contributing to the mitigation of land degradation and greenhouse gas emissions. To support the achievement of its goal, the project aimed to promote integration of vulnerability and adaptation to climate change considerations into sustainable development plans and planning processes. The regional project involved undertaking pilot projects in Kenya, Rwanda and Mozambique. Execution of this project was led by the African Centre for Technology Studies and the International Institute for Sustainable Development (IISD). Financing for the ACCESA project was provided by the Global Environment Facility (GEF) and the Governments of the Netherlands and Norway.

In Mozambique, the ACCESA pilot project sought to reduce current vulnerability to wildland fires in Sofala Province, central Mozambique, through the introduction of community-based fire management (CBFiM). The CBFiM pilot project also sought to promote the inclusion of vulnerability to climate change into relevant district- and national-level policies. Important aspects of the project included the provision of training in CBFiM at the local level, establishment of communication systems at the provincial level (including access to satellite data for fire monitoring) and efforts to influence national-level policy processes.

The CBFiM project was co-financed by German Technical Cooperation (GTZ), and built upon previous work undertaken as part of the GTZ Rural Development Program (PRODER). A rural development program for central Mozambique, PRODER included a disaster risk management component for floods and cyclones and the integration of disaster risk management into district planning. PRODER was extended as the project Institutionalization of Disaster Risk Management in Mozambique (PRO-GRC) in 2008-09. The specific goal of the co-financed component of CBFiM was to ensure that development planning in selected districts of central Mozambique contained exemplary examples of Integrated Fire Management or CBFiM. These examples were to support Mozambique's National Strategy for the Prevention and Control of Wildland Fires, and strengthen regional adaptation to climate change.

Implementation of the PRO-GRC project, including its CBFiM component, was led by AMBERO-IP Consult.

Additional copies of this publication may be downloaded from IISD's web site: http://www.iisd.org/climate/vulnerability/adaptation.asp

Cover photo: A.A. Hoffmann

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Abbreviations and Acronyms

ACCESA	Integrating Vulnerability and Adaptation to Climate Change into Sustainable Development Policy Planning and Implementation in Southern and Eastern Africa
CBFiM	Community-based fire management
CBNRM	Community-based natural resource management
CENACARTA	National Centre for Mapping and Remote Sensing / Centro Nacional de Cartografia e Teledetecção
CENOE	National Emergency Operation Center / Centro Nacional Operativo de Emergência
CIG	Geographic Information Centre / Centro de Informação Geográfica
CSIR	Center for Scientific and Industrial Research (South Africa)
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization
FIRMS	Fire Information for Resource Management System
FDRS	Fire Danger Rating System
GEF	Global Environment Facility
GIS	Geographical information systems
GTS	Global telecommunicate satellite
GTZ	German Technical Cooperation
IISD	International Institute for Sustainable Development
INAM	National Meteorology Institute / Instituto Nacional de Meteorologia
INGC	National Institute for Disaster Management / Instituto Nacional de Gestão de Calamidades
MINAG	Ministry of Agriculture / Ministério da Agricultura
MICOA	Ministry for Coordination of Environmental Affairs / Ministerio para a Coordenacao da Accao Ambiental
MODIS	Moderate Resolution Imaging Spectroradiometer
MSG	Meteosat Second Generation
NGO	Non-governmental organization
PRODER	GTZ Rural Development Program
PRO-GRC	Institutionalization of Disaster Risk Management in Mozambique
UEM	University Eduardo Mondlane / Universidade Eduardo Mondlane
UNEP	United Nations Environment Programme
WoF	Working on Fire

Executive Summary

Mozambique, like other southern African countries, is highly affected by wildland fires. It is currently estimated that nearly all of the forests in central and northern Mozambique burn at least once a year (FAO, 2005)—a considerable increase from the previous return cycle of about 12 years for all of southern Africa (Abekerli, 2001). The current perceived rise in fire frequency in Mozambique appears to be driven by two main factors: population growth and an associated increase in demand for land and income; and a breakdown in traditional land-use management systems over time due to changes in the political context in which these local institutions have existed. This situation has negative implications for people and the miombo forest ecosystem that dominates central Mozambique. Uncontrolled fires can damage and destroy critical infrastructure, cause the loss of human life, and adversely affect livelihoods and economic activities. Burning on nearly an annual basis also leaves little or no chance for tree species—even those that are fire tolerant—to regenerate and can lead to forests and woodland areas transitioning into grassy savannah.

The Government of Mozambique has increasingly recognized the need to strengthen its capacity to monitor, prevent, manage and suppress the negative consequences of wildland fires, particularly in light of the ongoing process of climate change. To support Mozambique in achieving this objective, German Technical Cooperation and the United Nations Environment Programme jointly funded a pilot project that sought to reduce current vulnerability to wildland fires in Sofala Province, central Mozambique, through the introduction of community-based fire management.

As part of this project, an assessment was undertaken in 2009 of the potential for establishing and implementing an information and communication early warning system for wildland fire at the district level in Sofala Province. The objectives of this study included: undertaking a review of existing information related to wildland fires in the study area (Buzi District); identifying relevant information sources; interviewing relevant stakeholders at the national, provincial and district levels regarding their role in fire management, current activities and possible needs; and assessing the capacity of these institutions and communities to understand and use the anticipated information in order to prevent wildland fires. This report presents the main findings and recommendations from this study.

MAIN FINDINGS

A strong policy framework and workable institutional arrangements need to be in place to effectively minimize the negative impacts and augment the beneficial consequences of fires in Mozambique. At present, however, neither the institutional arrangements for fire management, nor agreements on rules and regulations about fire prevention and responsible use, are entirely clear in Mozambique. Although several stakeholders are involved in various fire management activities, many originating from the country's national-level Action Plan for Prevention and Control of Wildfire (2007), these efforts lack systematic interagency coordination and planning, as well as effective implementation.

These weaknesses are effectively illustrated by how information regarding fire occurrence is collected and communicated at the national, provincial, district and local levels. At the national level, information regarding fire occurrences is limited to the use of the Web Fire Mapper Services and is mainly applied by the Forest Inventory Unit of the Ministry of Agriculture. A systematic process for generating and analyzing information tailored to specific needs and subsequently communicating and disseminating it to provincial- and district-level (government) organizations is not taking place. At the provincial and district levels, fire information based on satellite data (like the Web Fire Mapper) is only received by organizations such as the Catholic University in Beira, Gorongosa National Park and individual projects based in Sofala Province that are able to access the Internet through satellite connections. At the community level, a reporting system is only in place in specific areas. Moreover, as fire is used as a day-to-day land management tool, it is not perceived as a problem *per se* but as a normal part of the landscape. This perception discourages local reporting of fire occurrence.

RECOMMENDATIONS

To effectively respond to the growing occurrence of wildland fires in Mozambique, relevant institutions at all levels need to be strengthened with respect to their capacity to carry out the five elements fire management—fire analysis, prevention, preparedness, suppression and rehabilitation. As information is the glue that links each of these elements together and makes them interdependent, the establishment of an effective information and communication system is essential to Mozambique's efforts to manage wildland fires. The following recommendations therefore could be considered to increase fire management knowledge and raise political awareness of needed organizational improvements:

1. Establish and support structures to receive, analyze and disseminate active fire data from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor and Meteosat Second Generation at the national level. An appropriate institution should be given training and the transfer of skills required to receive and use active fire data and establish a system for disseminating information to relevant stakeholders.

2. Develop a Fire Danger Rating System (FDRS) at the national level tailored to the climatic and fuel conditions of Mozambique. The Meteorological Service of Mozambique acquires synoptic weather data from global telecommunicate satellites (GTS) at each of its 20 weather stations. In collaboration with the Canadian Forest Service, decoder software can be installed to decode GTS weather data and import them into a relational database from which a fire danger rating for each station could be calculated. A FDRS could serve as a first step towards Mozambique's National Institute for Disaster Management developing readiness criteria and indicating when fire might become a local or national disaster.

3. Strengthen the fire reporting system at the local level through existing local committees and other communication mechanisms. Existing committees, such as the district- and local-level disaster committees and natural resources management committees, may select members to form fire management units (brigades) responsible for carrying out fire management activities. These committees should receive training and skill transfer with regard to various fire management techniques.

4. Pilot early burning programs with selected communities and members of the local committee responsible for fire management to (re-)introduce traditional knowledge of the use of low intensity fires. "Cold" burning can simultaneously reduce wildfire hazard and improve livelihood opportunities related to grazing, production of thatch grass, etc.

These efforts should be implemented as part of a long-term program involving the country's various administrative levels and within respective government and non-governmental agencies. Coordination and cooperation needs to be improved to jointly implement the well-intended Action Plan for Prevention and Control of Wildfires. The establishment of a National Fire Forum could serve as the platform needed to achieve this objective.

At the same time, local communities should be able to use and manage fire for livelihood purposes under the guidance of traditional leaders. Traditional knowledge of fire use should be revived. Moreover, as land tenure security is a crucial incentive for communities to prevent and control fires, a community-based natural resource management approach should be considered as the framework for community-based fire management.

1. Introduction

Fire has been used by people living in southern Africa's tropical savannahs for at least 60,000 years (Zolho, 2005). These fires have been used for an array of purposes, such as to clear land for agriculture, flush out animals when hunting, stimulate the growth of grass on grazing lands, improve visibility around settlements and to produce charcoal. The resulting patchwork of burned areas has contributed to the region's ecological diversity. Although the vast majority of wildland fires in Mozambique continue to be intentionally set for various land management (and hence income generation) reasons, current research and experience suggests that fires historically may not have been as regular as they are today. While the return cycle of wildfires in southern Africa previously was about 12 years (Abakerli, 2001), today this cycle is reported to have decreased to between one and three years (Albano, 2003; Chidumayo, 1997).

Uncontrolled fires can damage and destroy critical infrastructure, cause the loss of human life, and adversely affect livelihoods and economic activities. As the frequency of fire increases, it can also reduce ecological diversity by preventing the establishment and growth of tree species, leading to forests and woodland areas transitioning into grassy savannah. Given these potential outcomes, the Government of Mozambique has increasingly recognized the need to strengthen its capacity to monitor, prevent, manage and suppress the negative consequences of wildfire.

To support achievement of this objective, an assessment was undertaken of the potential for establishing and implementing an information and communication warning system for wildland fire at the district level in Mozambique, using information supported by South Africa's Advanced Fire Information System. The location selected for assessment of this proposition was Buzi District in Sofala Province.

The study was undertaken between February and May 2009, including a field mission from February 23 to March 4.[1] The objectives of the study were to:

• Compile and analyze the contributions from the workshop on the community-based fire management[2] related to the information and communication systems required for wildland fire prevention and combat;
• Undertake and provide a review of existing information related to wildland fires in the study area, giving particular attention to anticipated changes in the fire regime due to climate change;
• Identify relevant information sources and provide a review that included experiences and methodologies on the establishment of an information and communication early warning system for wildland fires;
• Carry out interviews and meetings with relevant authorities at the national, provincial and district levels, including target communities involved in wildland fire management; and
• Assess the capacity and level of organization of these institutions and communities to understand and use the anticipated information in order to prevent wildland forest fires.

Based upon the outcomes of this analysis, a proposal was to be put forth for the most suitable approach for creating an information and communication early warning system on wildland fires that could be used and implemented at the district level, including the legal, institutional and organizational framework required. This report presents the main findings and recommendations from this study.

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[1] The detailed work program and schedule for this field mission is provided in Appendix 1.
[2] The Workshop on Community-Based Fire Management was held on February 25, 2009, in Beira, Mozambique. Hosted by INGC's office in Sofala Province, the workshop aimed to establish a provincial-level fire coordination structure.

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2. Background

Mozambique, like other southern African countries, is highly affected by wildland fires. Although estimating the spatial distribution and size of wildfires in Mozambique is currently hampered by the absence of a long-term fire monitoring program, the limited amount of existing information suggests that fire is a widespread phenomenon. According to the Food and Agriculture Organization, nearly all of the forests in central and northern Mozambique burn at least once a year (FAO, 2005), leaving little or no chance for tree species, even those that are fire tolerant, to regenerate. This change in fire frequency and intensity (particularly in late-season fires) is leading to increasingly negative impacts on the balance of composition, structure and function of Mozambique's woodlands ecosystems (Saket, 1999).

Changes in the frequency and intensity of fire also has implications for the approximately 70 per cent of Mozambique's 17 million inhabitants that live in rural areas, many near forests (Mansur & Cuco, 2003). Mozambican villagers rely upon the forest to supply shelter, construction materials, medicinal plants, energy, cultural values and other products that help satisfy their basic needs. Fire can destroy the trees and woodlands from which these timber and non-timber forest products are derived. Fire also directly affects rural livelihoods by causing damage to crops, infrastructure and buildings, in addition to the potential loss of human life. In 2008, for example, wildland fires affected a total area of over 1.6 million hectares and killed 49 people in Manica and Sofala provinces (INCG, 2009).

The current perceived rise in fire frequency and ongoing ecological transition in parts of Mozambique appears to stem predominately from increasingly unsustainable use of natural (forest) resources. This pattern appears to be driven by two main factors: population growth and an associated increase in demand for land and income; and a breakdown in traditional land-use management systems over time due to changes in the political context in which these local institutions have existed.

While sometimes harmful, fire is an integrated part of many ecosystems throughout the world, and especially the savannahs and forests of Africa. Some ecosystems need periodic fires for ecological processes or to burn off plant debris to prevent larger, hotter and more destructive fires. Additionally, fire remains even today the only economically viable management tool for impoverished people to clear land for agricultural or other land management purposes. In many places, the use of fire by local people has contributed to the diversity of the landscape by creating a mosaic of different vegetation structures and compositions, thus maintaining the biodiversity of an ecosystem. When controlled and small-scale, the intentional use of fire in land management can be beneficial. However, this tool also has the potential to be quite harmful if used unwisely. Therefore, the role of fire in the landscape needs careful assessment. As total fire suppression is often not the correct approach, a more diversified and holistic approach to fire management is needed.

2.1. HOLISTIC AND COMMUNITY-BASED FIRE MANAGEMENT

The current and future vulnerability of Mozambique's rural communities to the negative impacts of wildfires could be significantly reduced through the implementation of balanced or holistic fire management. Holistic fire management involves various stakeholders in the implementation of necessary technical, logistical, operational and social programs. It is based on five principal components (which are more thoroughly described in Appendix 2):

- Analysis – the systematic and integrated collection of data regarding the number, location, size, etc. of fires; the development of an understanding of their causes; and analysis of appropriate prevention, response, restoration and rehabilitation actions;
- Prevention – the development of a strategy for preventing and managing unwanted fires, and controlling fire for use in sustainable land management practices;

• Preparedness – the training of personnel; the installation and maintenance of required infrastructure; the monitoring of land and weather conditions; the establishment of tools such as the Fire Danger Rating System; and other activities that enable fire management on a continual basis;
• Suppression – the actions taken to contain fire and prevent it from spreading, including fire breaks and removal of fuel; and
• Restoration – the repair, replacement and rebuilding of physical and ecological assets.

Information is the glue that links each of these elements together and makes them interdependent (see Figure 1).

Figure 1: Depiction of the interrelated elements of a holistic fire management strategy (after Hoffmann et al., 2003; Moore, Haase & Hoffmann, 2002).
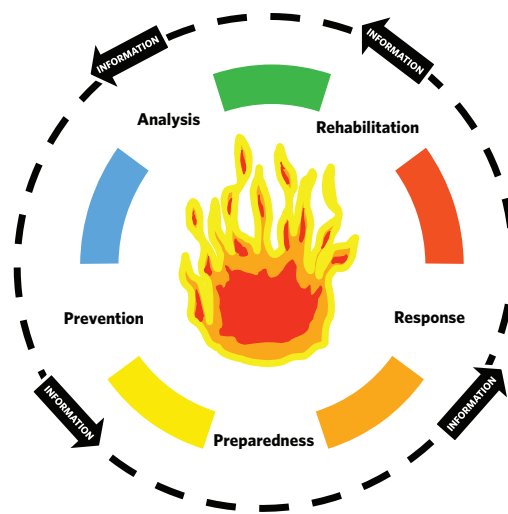
The major role of humans in determining fire frequency, intensity and distribution in Mozambique implies that local communities have an important influence on the management of fires. The importance of participation by local communities is also reinforced by the country's vastness and its limited accessibility and infrastructure. As such, the implementation of holistic fire management in Mozambique would be significantly strengthened by including a commitment to establishing community-based fire management (CBFiM).

CBFiM recognizes the potentially positive role that local communities can play in fire management. It is an approach to the management of fire in the landscape that adequately includes communities in decision-making about the role, application and control of fire. It works to:

• Create sensitivity, awareness and knowledge about fire and the use of fire to improve natural resources income;
• Enable communities to manage fire for their own benefits (as by using prescribed burning) and minimize the negative impacts of fire (such as by constructing fire breaks and engaging in low-cost maintenance); and
• Enable communities to develop, regulate and enforce village fire regulations, and to suppress unwanted fires through village fire crews (including the provision of basic fire suppression training and equipment).

By enabling local people to build upon their knowledge and expertise related to fire control and prevention, CBFiM has the potential to be an important avenue for effectively managing the wildland fires that increasingly are having a negative impact on livelihoods and ecosystems in Mozambique. However, for communities to play a positive role in fire management, they need to have control over natural resources and their management. Therefore the promotion of CBFiM should be undertaken as part of a broader commitment to increasing local control over surrounding natural resources.

It is important to note, however, that communities cannot provide the complete solution to harmful wildland fires. Communities are only one part of a holistic approach to fire management. The approach needs to involve all parties managing land, particularly the government and the private sector.

2.2. INSTITUTIONAL ARRANGEMENTS AND THE POLICY FRAMEWORK IN MOZAMBIQUE

Nowadays in Mozambique, four administrative levels—central, provincial, district and local—are responsible for fire management activities. The prevention and control of wildfires at the national level is led by the Ministry of Coordination of Environmental Affairs (MICOA), which also acts as a coordinating institution for governments and as an umbrella for local programs and projects. The Ministry of Agriculture is highly engaged in the prevention and fight against uncontrolled fires as well through its technical implementation branches at the provincial and district levels. It also is active in receiving fire satellite information at the national level.

At the provincial level, Directorates for the Coordination of Environment Affairs, Agriculture and Education (the latter under the Ministry of Education and Culture), as well as the private sector, non-governmental organizations (NGOs) and the media, are involved in the prevention and suppression of uncontrolled fires. At the district level, the main acting institutions are the District Directorates of Education, Agriculture, Coordination of Environmental Affairs, Health (the latter under the Ministry of Health), and District Administration through the National Institute for Disaster Management. The main institutions acting at the local level are local authorities, NGOs, the private sector, independent individuals and communities supported by the extension services of government agencies, mainly agriculture and forestry.

Unfortunately, there are no formal arrangements between these various institutions engaged in fire management at different jurisdictional levels. Consequently, the effectiveness and efficiency of fire management activities in Mozambique is weakened.

The policy framework within which these institutions are acting is set by the Constitution of the Republic, the Land Law, the Law of the Environment and the Law of Forests and Wildlife. Each of these laws defines basic principles and responsibilities for protection, conservation and sustainable use of natural resources. They establish measures of responsibility in decision-making on restoration and compensation for natural hazards, looking particularly at forests and wildlife as well as prejudices caused to third parties. Specific regulations on fire management are set by the Law of the Environment, the Law of Forests and Wildlife, the Penal Code and the (to be approved) Law of Crimes against the Environment. Other policies include the Environmental Strategy for Sustainable Development for Mozambique and Plano de Acção para a Redução da Pobreza Absoluta (Action Plan for Reducing Absolute Poverty), which provide guidance on the control of fires and the reduction of uncontrolled fires. Linked to the administrative measures above, at the community level, there are customary laws and regulations for fire management agreed among community members (MINAG, 2005).

2. Background | continued

The future of wildland fire management in Mozambique is likely to be strongly influenced by implementation of the Action Plan for Prevention and Control of Wildfires. Introduced in 2007, the Plan has recently started to be implemented in some provinces, including Sofala Province. Implemented through MICOA, the plan is intended to provide district governments with practical fire management guidelines that they will use to develop their own district-level fire management plans. The guidelines include six components designed to: guide district level awareness-raising; promote community-level fire management; emphasize the role of traditional authorities; and provide information on locally available, low-cost fire management techniques and tools. The Action Plan integrates, at different levels, the activities of a number of different institutions, including MICOA, the Ministry of Education and Culture, Ministry of Tourism, Ministry of Planning and Development, Ministry of Safety, Ministry of Energy, Ministry of Woman and Social Affairs, and the Ministry of Transport and Communications. However, lack of coordination and clarity regarding the roles and functions of each institution involved hampers the effectiveness of the program.

As described in Section 3 of this report, wildfire management will also likely be influenced by ongoing initiatives led by Mozambique's Ministry of Agriculture and National Institute for Disaster Management.

In conjunction with these activities, Mozambique is promoting community-based natural resource management (CBNRM) as part of its ongoing decentralization process. CBNRM allows local communities to have ownership over and derive income from natural resources. Local Natural Resource Management Committees are mainly guided by the Land Law of 1997 and the Forestry and Wildlife Law, the latter of which falls under the Forestry Regulatory Framework of MINAG. These committees (or the equivalent Disaster Management Committees) could be suitable entry points for introducing CBFiM activities.[3]

[3] For further reading on Mozambique's CBNRM policy, refer to: *Towards community-based forest management of miombo woodlands in Mozambique* by A. Salomão and F. Matose (2007); and *Building a community forestry framework in Mozambique: Local communities in sustainable forest management* by E. Mnausr and A. Cuco (2003).

3. Summary of Stakeholder Interviews

To better understand the current system of wildfire information collection and dissemination in Mozambique, stakeholder interviews were carried out at the national, provincial (in Sofala Province) and district (in Buzi District) levels. Relevant representatives of various departments were questioned with regard to their role in fire management, current activities and possible needs. A summary of each interview is given below.

3.1. DISTRICT- AND PROVINCIAL-LEVEL STAKEHOLDERS

a) Goronogsa National Park

Gorongosa National Park is situated in the centre of Sofala Province on the western escarpment that forms the southern limit of the Rift Valley. The major vegetation type in Gorongosa is dry and wet miombo forest. The area's unique physical structure and relief have contributed to it having the highest biodiversity in Mozambique. The park contains some 74 different vegetation systems, 15 geological formations and 40 soil types. Its extraordinarily rich array of flora and fauna includes: thousands of different plant species; a high diversity of reptiles, frogs and fish species; 500 or more species of avifauna; 25 wild ungulate species, including seven miniature antelope; six primate species; and three species of galagos.

Established in 1921, Gorongosa National Park was ravaged during the Mozambique civil war of 1977 to 1992. During this time, refugees invaded the park and shot animal to supply the bush-meat market in the nearest city, Beira. Along with illegal logging, this hunting pushed many of the park's large bovine species to near extinction. When peace returned to Mozambique the government appointed a dynamic young engineer, Roberto Zolho, to rebuild the park's shattered infrastructure and restore the area's once thriving tourism industry. Zolho, who studied environmental management in Australia, embarked on an ambitious scheme take pressure off the resources inside the park. He implemented plans to draw people out of the park and into a controlled buffer zone in which economic activity and development would take place (see description of Envirotrade below). Today Gorongosa National Park is co-managed by the Department of Tourism and the U.S.-based Carr Foundation, the latter of which partially funds the park's employees. Three villages with a total population of approximately 1,000 people remain located inside the park's boundaries.

Gorongosa experiences fires every year that start either inside the park (near village locations) or outside the park and spread into its boundaries. Poaching of animals is one reason why burning is initiated inside the park (for visibility and game attraction). Fires usually start in the northern part of the park due to its dryer conditions earlier in the season.

To detect fires, the park management uses the Web Fire Mapper as well as patrolling. Fire management activities include the maintenance of fire breaks around the park's 21 ranger outposts. Some early burning exercises are also carried out in June to reduce fuel loads.

Training in the use of fire—including burning breaks around camps, burning open end buffer zones and the application of the Lowveld Fire Danger Index—was carried out in 2007 by the South Africa-based Working on Fire (WoF) International. It is envisaged that a Memorandum of Understanding with WoF will be agreed upon to provide further training to more people and carry out other fire management activities. Additional plans exist to employ at least ten more people in fire management activities funded through U.S. Agency for International Development.

Besides occasional training that has been carried out in the areas surrounding the park in collaboration with other government agencies (MICOA, MINAG), it was expressed that the mandated government authorities should intensify community work towards fire management. The role of the district administration, headed by the agriculture department representative, was noted in particular. It was mentioned as well that fire is not perceived as a problem amongst community members.

b) Envirotrade – Nhambita Community Carbon Project

The Nhambita Community Carbon Project led by Envirotrade is being undertaken in the buffer zone surrounding Gorongoza National Park through a partnership involving the community of Nhambita, the Government of Sofala Province and Gorongosa National Park. Following an inherent approach based on CBNRM, the project is financing community reforestation activities by selling the resulting carbon sequestration benefits through the international voluntary market. A fuller description of the Nhabita Community Carbon project is provided on its website (www.envirotrade.com).

The project includes establishing CBFiM by creating ownership over natural resources and awareness of the use and management of fire. Fire management activities include: the construction of fire breaks around the perimeter of the project area; early burning activities in seven management units, each of which are 14,000 ha in size and guarded by 5 to 10 people who take responsibility for fire management within their respective unit; introducing an award system for "no burning fields"; and using fire prevention videos provided by MICOA. For the purpose of communicating a prevention message, in 2009, Envirotrade intends to show a video using footage captured during the 2008 fire events, in which local leaders are interviewed about the causes and impacts of fires on their natural resources.

c) Buzi District Disaster Risk Management Office

Buzi is a district of Sofala Province and its principle town is also named Buzi. A local disaster management coordinating structure is located in Buzi, within the district Disaster Risk Management Office (Gabinete de Gestão de Risco de Calamidades). (Another office is located in Machanga District, also in Sofala Province). The office was established in 2003 (in the aftermath of the 2002 floods) with the technical support of GTZ.

In the past, disaster response was regulated and enforced through local authorities and related village regulations. Local people would forecast droughts and floods through the use of indigenous knowledge, such as by observing the mass fruiting behaviour of trees and the behaviour of animals, such as armadillos.

Today, a community disaster committee has been established that follows the common sense disaster response structure to be implemented during emergency situations (i.e., early warning, evacuation, logistics, search and rescue, shelter camp, damage assessment, radio operation). Currently, the coordinator of this committee is employed through GTZ. Committee members are volunteers except the radio operator, who is paid by the district. Members of the committee read and record river levels to be informed and to be able to inform others respectively in the event of upcoming floods.

As fire and its related thick smoke-haze are not perceived as problems by local people, the committee members try to raise awareness about the negative impacts of wildfires, targeting certain groups that are believed to be the main causes of fire outbreaks—such as fishermen, hunters, rice farmers, palm liquor collectors, etc. Normally, committee members go through the respective leaders of these groups to spread their education and awareness message (e.g., fire breaks around fields, no unattended burning, timing of fire, put camping/cooking fires out) but also to increase social pressure on group members.

The committee members also received training in basic fire fighting and the Lowveld Fire Danger Rating Index through WoF in 2008. The training was perceived as useful in enhancing their knowledge and skills in fire suppression techniques. The Fire Danger Rating Index calculated has not yet been assigned to preventive and other fire messages, but the committee members intend to introduce a flag indicating the fire danger and related prevention measures during the 2009 fire season.

d) Buzi District Office of Economic Affairs

At the district level, the Ministry of Agriculture is represented by the Office of Economic Affairs, which reports to the District Administration Office. The use of fire in Buzi district is understood as having a long tradition but also as having increased in the last 20 years due to population growth, high unemployment and a related shift to generating income from forest products (mostly charcoal, wood and honey collection). Fire is used as a cheap and effective tool to establish grazing grounds for cattle, hunt rodents, control pests, open access areas for fishermen and wood collectors, collect honey and produce charcoal. Fires occur mainly between August and November.

The District Agriculture Office is implementing traditional fire prevention activities with the help of drama groups and posters, such as the one shown in Figure 2. Similar to Envirotrade's initiative, the loss of life and damages that occurred during the 2008 fire season will be used to draw attention to the need for safe and responsible use of fire.

With the support of a local NGO, the District Agriculture Office engages in participatory land-use mapping and zoning to legalize community land and resource holdings within the district. Mapping and zoning of land and resources are prerequisites for successful CBNRM that aims to empower local communities to manage and benefit from forest and woodland products. Led by a local leader, the so-called "localidade" comprises about 500 families in various villages. Each village may form a Natural Resources Committee to manage and control their natural resources within defined demarcation zones (e.g., control of wood extract, transport of wood, education and regulation of species use). Some villages have set up special task forces (community police) under this scheme to prosecute environmental crimes. For example, setting fire to someone's property can be punished with 20 days of community work. Others will reward reporting of fires partly with the money the culprit has to pay.

Figure 2: Prevention material produced by MINAG

Photo: A.A. Hoffmann

However, the lack of human resources in the District Agriculture Office (one forestry technician and eight extension workers with diploma-level education) limits the outreach and support program. They rely mostly on "promoters" (who use extension material and training provided by the government but are paid for their service by the local people) to communicate their prevention message (i.e., do not burn grass and use the slash-mulching system). The relationship to MICOA was said to be weak despite initiation of the Action Plan for Prevention and Control of Wildfires.

e) Forestry and Wildlife Service Provincial Level, Sofala

Part of Sofala Province's Directorate of Agriculture, the Provincial Forestry and Wildlife Service has three divisions—Forestry, Wildlife and Finance. The mandate of the Forestry Division is to monitor and control private timber concession on a quarterly basis, issue licenses (supported by a consultative group), and afforest depleted areas with *Eucalyptus* species. Fire poses a problem for the Forestry Division's reforestation activities. Rehabilitated areas are prone to fire, especially if they are re-planted with *Eucalyptus* species. However, it was mentioned that fire is not perceived as a problem at the community level in general. It is also not seen as a problem by responsible authorities at the provincial and national levels, which is thought to be a major (political) obstacle to effectively tackle the negative impacts of fire.

Sofala Province has 12 timber concession areas, of which eight are foreign-owned and four nationally-owned. Concessions must have a management plan that includes the management of fire. The degree to which fire is a problem in concession areas is greatly dependent on the relationship and interactions between the concession managers and the surrounding communities. For example, if concession managers have included surrounding communities in CBNRM programs and associated fire awareness measures, fewer wildfires are likely to take place.

Sofala has established a provincial Wildfire Committee under MICOA that consists of various government departments and NGOs, including local communities. In 2007, the Committee received a "Train the Trainer" basic fire fighting training program within the framework of the Action Plan for Prevention and Control of Wildfire. Originally this Train the Trainer program should have led to more training at the community level; however it has not been applied and institutionalized. The original large group of people on the committee have not continued to work together, although representatives from MINAG, MICOA and the Regional Emergency Information Centre (CENOE) are sporadically active.[4] No fire fighting equipment or radio communication system exists at the provincial level, not even a set of simple hand tools. Long-term guidance on the development of a fire management system is needed.

3.2. NATIONAL-LEVEL STAKEHOLDERS

a) Ministry of Agriculture – Forest Inventory Unit

The Forest Inventory Unit in the Ministry of Agriculture is currently the only government institution collecting and analyzing fire data on the basis of MODIS active fire data. They access the Fire Information for Resource Management System (FIRMS) Web Fire Mapper and receive daily fire e-mail alerts. (Information regarding MODIS and FIRMS is provided in Appendix 3 of this report). However, this data is not analyzed to its full extent and information according to land use and other land features is not generated. In addition, the information is disseminated only on request rather than actively. The 2008 fire disaster, however, triggered more proactive fire information dissemination activities. Cooperation and coordination of activities between MINAG and MICOA could be strengthened by jointly implementing the six-component Action Plan for Prevention and Control of Wildfires.

b) Ministry of Environmental Coordination (MICOA)

Under the National Strategic Work Program, the Action Plan for Prevention and Control of Wildfires is been carried out by MICOA together with MINAG and INGC. The Plan foresees the need to sensitize and reward communities for low fire occurrences.

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[4] These cooperative activities are also support by the GTZ-led PRO-GRC project.

At the district level, MICOA does not have its own office but is part of the Infrastructure and Planning Office. Out of this position they intend to educate government officials about environmental issues. MICOA is not participating in the CBNRM program, but wants to be involved in INGC's environmental prevention and education program.

The Center for Sustainable Development of Natural Resources based in Chimoio, Manica Province, is the only MICOA institution that is actively engaged in downloading fire data via the Web Fire Mapper. An environmental database does not exist.

c) National Disaster Management Office (INGC)

Since 2007, the Instituto Nacional de Gestão de Calamidades, or INGC, has been mandated to coordinate fire prevention and control activities carried out by MINAG and MICOA. INGC is not mandated to implement activities on the ground; rather, it carries out its mandate through its District Disaster Committee prevention activities. The District Disaster Committees include representatives from all government agencies and develop contingency plans starting from the community level to the district and provincial levels. The contingency plan, a generic plan guiding in "pre" and "during" and "post" disaster events, outlines different disaster scenarios.

CENOE is the operational branches of INGC. It is supposed to gather and generate early warning information about natural disasters and then disseminate it accordingly. However, fire is not yet an integrated part of the disaster early warning system. The establishment of a fire early warning system in cooperation with Mozambique's Meteorological Service is perceived to be an important step towards increasing fire awareness at all levels.

d) National Centre for Mapping and Remote Sensing (Cenacarta)

The main role of Cenacarta (Centro National de Cartografia e Teledetecção) is to produce maps along such themes as land use, soil, vegetation, geology and infrastructure. Mozambique has very good land use and base map data based on 1996–99 remote sensing data (Landsat, Spot, Ikonos). Cenacarta has a Memorandum of Understanding with the Center for Scientific and Industrial Research (CSIR) in South Africa for data exchange. It also has very well equipped remote sensing and geographical information systems (GIS) laboratories and reliable and fast broadband Internet access.

e) National Meteorology Institute (INAM)

INAM operates approximately 20 synoptic weather stations located throughout the country. The weather data is automatically retrieved via the global telecommunications satellite (GTS) system and distributed through the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) data stream. The data can be readily used for fire danger rating calculation if a decoder, a database and Fire Danger Rating equation is installed and implemented.

f) Universidade Catholica de Moçambique – Geographic Information Center

The private Universidade Catholica de Moçambique in Beira has a very well equipped Geographic Information Centre (CIG). It offers a variety of services, such as the production of various thematic maps, demarcation exercises, land-use mapping, spatial analysis of data, and training in GIS and remote sensing.[5] The Centre is involved in various projects, often supported by international agencies like Oxfam. For example, CIG is establishing a district information system mainly to support decentralized land-use planning in central Mozambique. It also is involved in activities such as urban planning, infrastructure facilities planning and various rural development and natural resources management activities. In the future, CIG plans to offer three year Masters programs

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[5] For example, CIG provides district officers with training in land-use planning.

in Regional Development Planning (night course) and in GIS (via e-learning). CIG has excellent training facilities that include fully computer-equipped classrooms as well as reliable internet connectivity. As well, the current Director of CIG also serves as focal point for the revived Miombo Network that is part of the Global Observation of Forest Cover and Land Cover Dynamics project (www.fao.org.gtos/gofc.gold).

g) University Eduardo Mondlane – Faculty of Agronomy and Forest Engineering

The University Eduardo Mondlane (UEM) has established a fire-related project in the Niassa Reserve through Natasha Ribero, who conducted research on fire and its effects on the Miombo forest. The Niassa Reserve is in the most northern part of Mozambique and borders on Tanzania. Major fire causes in the reserve include the carelessness of trespassers (cooking and camping fires) crossing the border with goods. The university is currently attempting to set up a fire monitoring system for the reserve based on satellite data with the support of Tourism and Rural Development Society. However, currently there are only three people employed in the field. A program is further envisioned to support school education and introduce a multiple-use zoning system within the reserve.

The UEM teaches fire ecology and management as part of forest protection (16 hours) but currently has only two Bachelor students focusing on fire-related research. Four more will be starting in the field of fire risk and threat. The university's geographical analysis of fire is currently hampered by the lack of an adequate GIS laboratory.

UEM calls for a National Fire Forum that would bring together concerned and relevant stakeholders to enhance and improve knowledge about Mozambique's fire problem and related management solutions. It was suggested that INGC should spearhead the function of providing early fire warnings.

4. Overall Conclusions

Uncontrolled wildfires have long been a feature of the ecology of Mozambique. Today, however, changes in local culture and practices have led to rise in uncontrolled fires compared to the past. This pattern is in large measure the result of historical policies and practices. During the colonial period, new fire legislation and no-burn policies modelled on those implemented in Europe were introduced and traditional, local control mechanisms were revoked. From the beginning of the twentieth century, lack of supervision and no-burn policies led to a high frequency of secretly set late-dry-season fires, particularly in remote areas. These late-season fires are more destructive to the environment, humans and their properties than early-dry-season or "cold" fires that are of low intensity. The breakdown of local management structures, loss of traditional knowledge of safe fire use and loss of land tenureship have increasingly led to indiscriminate use of fire by local populations.

The ability of Mozambique to reverse this trend—to minimize the negative impacts and augment the beneficial consequences of fires—will in part be determined by the strength of the policy framework and institutional arrangements put in place to manage the country's wildland fires. These institutional arrangements for fire management include mandates and responsibilities, roles and functions, and interactions within the politico-administrative framework and amongst key stakeholders. However, neither these institutional arrangements, nor agreements on rules and regulations about fire prevention and responsible use, are entirely clear at present. Although several stakeholders are involved in various fire management activities, many originating from the Action Plan for Prevention and Control of Wildfire, these efforts lack systematic interagency coordination and planning, as well as effective implementation.

These weaknesses are effectively illustrated by how information regarding fire occurrence is collected and communicated at the national, provincial, district and local levels. Information regarding fire occurrences is limited to the use of the Web Fire Mapper Services (http://maps.geog.umd.edu/firms/; see also Appendix 3) and is mainly applied at the national level by the Forest Inventory Unit. A systematic process for generating and analyzing information tailored to specific needs and subsequently communicating and disseminating it to provincial- and district-level (government) organizations is not taking place.

At the provincial and district levels, fire information based on satellite data (like the Web Fire Mapper) is only received by organizations such as the Catholic University in Beira, Gorongosa National Park and individual projects that are able to access the internet through satellite connections. At the community level, fire is not perceived as a problem *per se* since it is used as a day-to-day land management tool for various purposes. This perception discourages local reporting of fire occurance.

To effectively respond to the growing occurrence of wildland fires, Mozambique should strive to strengthen its overall capacities related to all five elements of fire management, namely fire analysis, prevention, preparedness, suppression and rehabilitation. It should implement a long-term program involving the country's various administrative levels and within respective government and non-governmental agencies. Fire is not a disaster *per se* and therefore criteria need to be developed to define fire disaster categories and related stages for extended action.

Local communities should be able to use and manage fire for livelihood purposes under the guidance of traditional leaders. Traditional knowledge of fire use should be revived. Additionally, as land tenure security is a crucial incentive for communities to prevent and control fires, the CBNRM approach should be considered as the framework for community-based fire management.

5. Recommendations

Various institutions at all administrative levels in Mozambique (e.g., MICOA, INGC and MINAG) need to be strengthened to enhance and establish capacities in fire information, prevention, preparedness, suppression and rehabilitation. Coordination and cooperation needs to be improved to jointly implement the well-intended Action Plan for Prevention and Control of Wildfires. The National Fire Forum proposed by the University Eduardo Mondlane could serve as the platform needed to achieve this objective.

Focusing specifically on the element of an effective fire information and communication system, the following recommendations could be considered to increase fire management knowledge and raise political awareness of needed organizational improvements:

1. Establish and support structures to receive, analyze and disseminate active fire data from the MODIS sensor and Meteosat Second Generation (MSG) at the national level. An appropriate institution (as described below) should be given training and the transfer of skills required to receive and use active fire data and establish a system for disseminating information to relevant stakeholders.

2. Develop a FDRS at the national level tailored to the climatic and fuel conditions of Mozambique. The Meteorological Service of Mozambique acquires synoptic weather data from GTS satellites at each of its 20 weather stations. In collaboration with the Canadian Forest Service, decoder software can be installed to decode GTS weather data and import them into a relational database from which a fire danger rating for each station could be calculated. For INGC, a FDRS can serve as a first step towards developing readiness criteria and indicating when fire might become a local or national disaster.

3. Strengthen the fire reporting system at the local level through existing local committees and other communication mechanisms. Existing committees, such the district- and local-level disaster committees and natural resources management committees, may select members to form fire management units (brigades) responsible for carrying out fire management activities. These committees should receive training and skill transfer with regard to various fire management techniques.

4. Pilot early burning programs with selected communities and members of the local committee responsible for fire management to (re-)introduce traditional knowledge of the use of low intensity fires. "Cold" burning can simultaneously reduce wildfire hazard and improve livelihood opportunities related to grazing, production of thatch grass, etc.

5.1. SATELLITE FIRE INFORMATION SYSTEM

The objective of a fire information system is to provide the compiled and analyzed information necessary to trigger fire management activities. The information can then be used for decision-making, fire management procedures, making recommendations regarding all fire management functions, and advising other stakeholders at all levels. Such data provides a major basis for analyzing the fire "problem" and defining important parameters of the fire regimes existing in southern African countries, including Mozambique. Furthermore, analyzing historical fire data in relation to landmark features and boundaries gives information on the origin of the fires and subsequently on current and future fire risk. It also raises the level of awareness regarding fire occurrence and its likely ecological and economic impacts. Such information can be a major stepping stone in seeking political will and funding for the necessary development of operational fire management institutions that not only focus on (ad hoc) fire suppression but equally on prevention efforts that involve community participation.

In order to achieve this objective, the data and information should be consistent, reliable, relevant and based on professional interpretation and analysis. It should be delivered on time and communicated by pre-determined and well understood procedures and standards. These processes will guarantee accountability and responsibility and ensure that relevant, open and easily accessible information is available to all stakeholders at all administrative levels.

Ideally, one leading institution should be responsible for the compilation, analysis and dissemination of satellite fire information. The existing institutional structures in Mozambique point to Cenacarta (under the Ministry of Agriculture) becoming the main remote sensing and mapping institute providing data to other relevant users, such as the Forest Inventory Unit in MINAG (see Figure 3). Alternatively, it is also technically feasible for the Forest Inventory Unit of MINAG to be directly responsible for receiving satellite fire data and information.

Figure 3: Proposed flow of fire information from the national to the local level in Mozambique
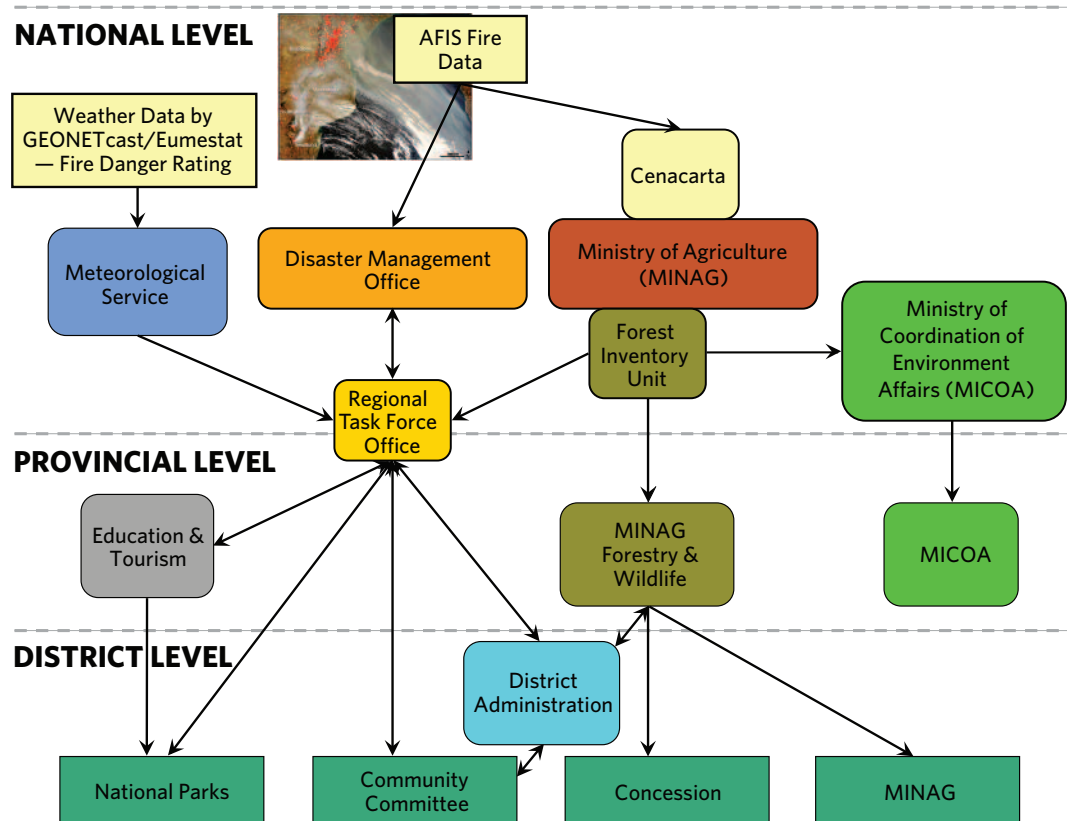
MINAG's Forest Inventory Unit would need to be tasked with the responsibility to generate end-user friendly information about fire occurrence and areas burned on a daily, monthly and quarterly basis. Existing dissemination structures and communication means (telephone, facsimile, e-mail etc.) amongst and to other stakeholders at the national, provincial and district levels and from there the community level are to be employed and improved (see Figure 3).

To achieve these outcomes, the following long-term steps are recommended:

Recommendation 1: Establishment of a File Transfer Protocol supported by MODIS and MSG that will enable active fire data to be downloaded within the structure of Cenacarta or the Forest Inventory Unit. Alternatively, explore the possibility of using an interface that is currently developed by CSIR to directly receive MODIS and MSG data through the EUMETSAT data feed.

Recommendation 2: Introduce burned area mapping on a quarterly basis within the Forest Inventory Unit.

As previously noted, Cenacarta is currently establishing a Memorandum of Understanding with CSIR to enable the exchange of data. CSIR also supports research in the field of climate change in Mozambique, which could be extended to include fire danger establishment.

5.2. FIRE DANGER RATING SYSTEM

The FDRS is the primary means of determining the daily fire prevention, preparedness and suppression activities of responsible land-management agencies. It provides indices for determining the likelihood of a land fire ignition, its extent and the difficulty in controlling fire activities. Hence, the system also supplies information for ensuring the safety of fire suppression and fighting operations. As the fire managers' day-to-day fire management tool, the FDRS serves as a tool for determining the personnel needed for fire prevention and detection activities, the readiness of prevention and suppression forces (readiness/preparedness levels), and the strength of fire control forces' initial attack on a reported fire.

To incorporate fire early warning messages into the INGC's national disaster management concept, the following long-term steps are recommended:

Recommendation 3: Establish a FDRS at INAM with the support of the Canadian Forest Service. Creating this rating system will require:
   a. Long-term research on fuel models and consequent calibration of a fire danger equation;
   b. Training of relevant institutions on the calculation and interpretation of fire danger information; and
   c. Introduction of fire danger messages and related implications for readiness, prescribed burning and suppression at the community level.

5.3. COMMUNITY-BASED FIRE MANAGEMENT

Local people will only participate in fire management activities if the values (e.g., natural resources) they protect or manage are of any benefit to them; they need to own the values to protect and manage them. If one then talks about establishing a fire information and communication system at the local level, realistically, this will only occur if people are interested in participating in community-based fire management activities or programs and have management rights over the resources.

5. Recommendations | continued

Given these considerations, it is therefore recommended that:

Recommendation 4: At the community level, the Natural Resource Management Committees established as part of CBNRM projects, as well as the local Disaster Management Committees created as part of the work of INGC, be the entry points for community-based fire management activities in Mozambique.

5.4. PILOT EARLY BURNING PROGRAMS

Fire can be used as a resource if it is applied at the right time and for the right land management objective. Early burning exercises can improve natural resources such as grazing grounds for livestock, thatching grasses and timber. Additionally, considering that fire is often used in Mozambique for pest control or access to natural resources, the problem is rather a matter of timing and placement of the fire than the actual use of fire itself. Fire tends to become destructive and uncontrollable only late in the dry season; when applied in the early dry season when air temperatures are still low and humidity is high, it can provide various benefits.

If CBFiM activities are carried out, it is advisable to tend away from purely training local people in fire suppression activities. Rather, emphasis should also be placed on educating them about the benefits of early burning as it was done in the past during pre-colonial times. Over time, people will realize the positive effects of early burning, which includes not only reducing fuels loads— and thus reducing wildfire hazard—but also benefiting their daily livelihoods.

Long-term guidance is required to introduce the concept of early burning programs. The following actions are therefore recommended:

Recommendation 5: In the Sofala Province, the Envirotrade – Nhambita Community Carbon Project in the buffer zone of the Gorongosa National Park could be regarded as a potential partner for systematically introducing early burning exercises and related education and awareness campaigns. Past and current project activities would provide for a sound entry point for community-based fire management activities.

Recommendation 6: In Buzi District, the existing Disaster Risk Management Committee or other existing natural resource management committees should pilot a fully fledged CBFiM program that focuses in the establishment of village fire management structures, village fire management regulation and education, and the implementation of early burning to improve livelihood activities and reduce wildfire hazard.

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Appendix 1: Work Program for Field Visit

Date	Activity	
February 23, 2009 (Monday)		Arrival in Beira
February 24, 2009 (Tuesday)	9:00 h 10:30 h	Forestry Department Geographic Information Center, Universidade Catholica de Moçambique
February 25, 2009 (Wednesday)	8:00 – 17:30 h	Workshop "Community base fire management"
February 26, 2009 (Thursday)	6:00 h to +/- 10:00 h 10:30 h	Trip to Gorongosa National Park Meeting with officials of Gorongoza National Park involved in wildfire management
February 27, 2009 (Friday)	8:30 h 12:00 h	Meeting with the Envirotrade Project Trip to Buzi District Meeting with Buzi District Disaster Risk Management Committee
February 28, 2009 (Saturday)	8:30 h 18:50 h	Meeting with Buzi District Office of Economic Affairs Trip to Maputo
March 1, 2009 (Sunday)		Free
March 2, 2009 (Monday)	8:30 h 10:30 h 14:00 h	Meeting with PRO-GRC, Maputo Meeting with Forest Inventory Unit, MINAG Meeting with University Eduardo Mondlane, Faculty of Agronomy and Forest Engineering
March 3, 2009 (Tuesday)	8:30 h 10:30 h 14:30 h 15:30 h	Meeting with National Centre for Mapping and Remote Sensing Meeting with Ministry for Coordination of Environmental Affairs, Department of Natural Resources, National Environmental Management Directorate Meeting with National Institute for Disaster Management Meeting with National Meteorology Institute
March 4, 2009		Return to Gaborone

Appendix 2: Elements of Fire Management

1. ANALYSIS AND INFORMATION

While fire suppression capabilities are needed, they are only effective if embedded in an integrated program with the right institutional set up and involvement of all stakeholders through educational and fire prevention/fire-use programs. Lack of available information concerning number, place, size, location, influence of weather, fuel characteristics and causes of fire contributes strongly to an incomplete understanding of fire and its causes. To prevent fires, those concerned must know who or what starts the fires and why.

Analysis is essential to defining the problem in order to clearly address it effectively and use resources most efficiently. For preparedness and suppression efforts, it is important to know where and when most fires start; this also includes fire danger information and a comprehensive knowledge about the available fire suppression resources (equipment, trained crews etc.). To ensure that these forces are used most effectively given differences in vegetation and land-use patterns, it must be clear which fires are wanted and which are not.

To undertake restoration and rehabilitation, and to integrate these measures into regional and financial planning, there is a need to know what has been damaged, to what degree, where and how much. Reported by local (fire) institutions and fire brigades, this information is also needed for assessing future prevention measures and equipment needs.

2. PREVENTION

Recognizing that prevention is the best, and in most cases the only, effective strategy for the long-term management of fires, strong emphasis should be given to designing and implementing the right prevention strategy to reduce the likelihood and impact of unwanted fires. Depending on the case, this strategy could involve education and awareness raising, fuel management (reduction, removal, or other manipulation of the fuel for fires such as prescribed burning), sound sustainable forest/land management, and law enforcement (appropriate laws and regulations, sanctions and supervision). Especially where fire is regularly used to clear land for all sorts of agricultural, fishing and cattle-raising purposes, fire cannot be eliminated from the landscape. Therefore, focus must be given not to eliminating fire but rather to introducing and providing education on the controlled and sustainable use of fire for agriculture purposes. Finally, effective law enforcement based on sound fire management policy and sanctions not only against companies but also against local people must be implemented as prevention measures.

3. PREPAREDNESS

Preparedness ensures that fires are not a surprise and that fire management is a matter dealt with not only during the dry (fire) season. The important aspects of preparedness are: the training and development of fire management and suppression personnel; the installation and maintenance of infrastructure such as access roads and tracks, firebreaks, fire detection systems; preparing assets and homes; the purchase and maintenance of firefighting equipment; and the ongoing monitoring of weather conditions, fuels and ignition sources to provide timely advice and warnings on possible fires and ensure that resources can be effectively used. As an element of preparedness (but also prevention and response) the Fire Danger Rating System is an important tool for determining the daily fire prevention, preparedness and suppression activities of the land management agencies responsible for fire management activities. The FDRS is the basis for defining readiness levels and describing the existing state of alertness and preparedness of fire management organizations. Readiness levels are the basis for recommendations to political officials, agencies and institutions. They are also a foundation for communicating standard operating procedures to local fire centres and other land management agencies.

4. SUPPRESSION/RESPONSE

Response is commonly referred to as "fire fighting" or "suppression" and involves containing a fire and preventing it from further spreading. The usual method of stopping the spread of a fire is to cut the fire from access to new fuels by creating a fire line around the perimeter of the fire. After the fire line is completed, the fire is made safe by cooling embers and hotspots along the fire line in a process known as "mopping up." All fire lines operate by the same principle: removing fuel or making it less flammable. Eventually the fire will burn all of the fuel and go out. Type of vegetation, terrain, strength of the fire and climatic conditions dictate the widths of the fire line.

5. RESTORATION/REHABILITATION

In its widest sense, restoration/rehabilitation covers the repair, replacement or rebuilding of assets damaged by fire. This includes assets such as plantations, houses and infrastructure, but also the restoration of fire-damaged ecosystems. The latter involves the re-establishment of ecosystem function, structure, productivity and natural fire regimes, all of which are part of sustainable forest and land management. Restoration can be a very important part of preventing future fires. Burnt areas may be more prone to ignition in the years following a fire due to increased fuel and debris loads from burnt, dead plants. As well, after forest/savannah vegetation is burnt, more daylight and space is available for grasses and other vegetation to grow on the forest floor. This vegetation quickly dries out and easily burns. If a forest is not properly managed and restored after a fire outbreak, this pattern can create a cycle rendering forests increasingly flammable.

Appendix 3: Fire Information for Resource Management System (FIRMS)

FIRMS integrates remote sensing and GIS technologies to deliver MODIS hotspot (or locations of forest, grassland and agricultural fires) to users around the world. MODIS stands for MODerate Resolution Imaging Spectrometer and is a sensor onboard of the TERRA (morning) and AQUA (afternoon) satellites of NASA's Earth Observation satellites. Image subsets are automatically generated in near-real time and are available as true colour, Bands 7-2-1 and NDVI. This data would allow producing cloud-free image compositions and deriving burned scar measurements from on screen delineation, thus starting to build up a more reliable database of hectares burned in Mozambique.

The MODIS image subset web site is dedicated to the daily production and distribution of near real-time data. A subset comprises images that are derived daily from MODIS-corrected reflectance products and for a fixed and limited geographic area. These images are delivered to users over the Internet, usually in compressed form, which facilitates their rapid transmission. The JPEG or GeoTIFF images are kept small to enable users with slow or limited Internet access to have access to the data.

Data delivered by the MODIS sensor are specifically designed for fire applications, and access to these MODIS images is assumed to enhance capacity to monitor fires and determine the extent of burnt areas. As described on the FIRMS web page (http://maps.geog.umd.edu/firms/), it delivers active fire information through:

- Email and cell phone text messages (Global Fire Email Alerts);
- Interactive Web GIS-Web Fire Mapper Mozambique; and
- Subsets of MODIS images in different resolutions.

The active fire locations are processed by the MODIS Rapid Response System using the standard MODIS MOD14 Fire and Thermal Anomalies Product. Each active fire location represents the centre of a $1\,km^2$ pixel that is flagged by the algorithm as containing a fire within the pixel. Subsets are typically rendered as a colour composite image with the locations of MODIS active fires highlighted. In the near future, FIRMS will also provide burned area data.

The interactive Web GIS has a specific site on Mozambique and provides topographic features and landmarks. The tool enables even non-GIS users to make their own interactive map on fires in Mozambique.