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African Forest Forum

A platform for stakeholders in African forestry

Vol 3 Issue 18 | 2017

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SUSTAINABLE FOREST MANAGEMENT IN AFRICA

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Correct citation: African Forest Forum (2017). The Status of Tree and Forest Pests and Diseases in the Eastern African Sub-region: Sustainable Forest Management in Africa. African Forest Forum Working Paper, Vol (3)18, 2017, Nairobi.

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Design & Layout: Conrad Mudibo, Ecomedia Limited

Cover photos (L-R): Cypress aphid colony, photo: K. E. Mutitu; Mangrove shoot borer damage, photo credit: Mercy Gichora; *Sorindeia madagascariensis*; *Botryosphaeria canker* on Eucalyptus species, photo: Jane Njunguna)

Acronyms

ASDS	Agricultural Sector Development Strategy
AU	African Union
AU-IAPSC	AU Inter-African Phytosanitary Council
CABI	Centre for Agriculture and Biosciences International
CIMMYT	International Maize and Wheat Improvement Centre
COMESA	Common Market for Eastern and Southern Africa
COMIFAC	Central African Forests Commission
COPE	Center for Phytosanitary Excellence
EAC	East African Community
EALA	East African Legislative Assembly
EDPRS	Economic Development and Poverty Reduction Strategy
EEFRI	Ethiopian Environmental and Forestry Research Institute
EIAR	Ethiopian Institute of Agricultural Research
EPPO	European Plant Protection Organization
FABI	Food and Agricultural Biotechnology Institute
FAO	Food and Agriculture Organization
FAO-SFE	FAO Sub-regional Office for Eastern Africa
FISNA	Forest Invasive Species Network for Africa
FNC	Forest National Corporation
FRA	Forest Resource Assessment
GDP	Gross Domestic Product
HCA	Horticultural Council of Africa
ICIPE	International Centre for Insect Physiology and Ecology
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDP	Internally Displaced Person
IGAD	Inter-Governmental Authority on Development
IPPC	International Plant Protection Convention
IUCN	International Union for Conservation of Nature

KEFRI	Kenya Forestry Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
KFS	Kenya Forest Service
KRA	Kenya Revenue Authority
MINAGRI	Ministry of Agriculture
MINIRENA	Ministry of Natural Resources
NAFA	National Forestry Authority
NISR	National Institute of Statistics
NLC	National Land Centre
NPPO	National Plant Protection Organization
NPPS	Netherlands Plant Protection Service
OGMR	Office of Geology and Mining
RAB	Rwanda Agriculture Board
RDB	Rwanda Development Board
RNRA	Rwanda Natural Resources Authority
RPPO	Regional Plant Protection Organization
SADC	Southern African Development Community
SFM	Sustainable Forest Management
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UR	University of Rwanda
WTO	World Trade Organization

Executive Summary

In this study of tree and forest pests and diseases conducted in 2015 for the Eastern African sub-region, Sudan, Ethiopia, Kenya and Rwanda were selected for detailed analysis to provide an overview of the status of forest health management in the region. Rwanda and Kenya have robust blue prints for national development based on which they formulated their forest policies. All countries in the region have prioritized expansion of forests to meet growing demands for forest goods and services. Other supplementary plans are to provide viable energy alternatives to lessen dependence of growing populations on limited forest resources. These measures are already bearing fruit in that tree cover is on the increase in the region with the best performance by Rwanda which is on course towards achieving a 30% target by 2020.

It has been realized, e.g. in Kenya, that expansion of forest cover addresses just one aspect of the complex situation of increasing the availability of tree and forest goods and services. Kenya's draft forest policy advocates for additional actions arguing that low productivity of forests can further be tackled by monitoring response to climate change, expanding the genetic base of crops and dealing effectively with emerging pests and diseases, and by attracting more investments in technology development and in the forest based processing industry. Sustainable forest management (SFM) is therefore viewed as more than just increasing forest acreage. It is regarded as an intensive management process that is informed by research and training to attain the highest volumes and quality possible of tree and forest products and services per unit area without compromising the needs of future generations.

One characteristic of forestry as practiced in this region (and in the tropics as a whole) is the heavy reliance on introduced tree species to supply forest products. Softwood timber is produced in commercial plantations of different conifers at high altitudes. Mexican cypress is the most popular species (*Cupressus lusitanica*) while, amongst pines, *Pinus radiata* and *P. patula* are the most commonly planted for wood and fiber. Several species of Eucalyptus and their hybrids are grown in woodlots to supply hardwood timber and fuel wood. *Eucalyptus globulus* is the most widely planted, being most dominant in Rwanda and Ethiopia. In Kenya, *Eucalyptus grandis* is grown in high altitude areas while *E. camaldulensis* is more suited to drier lowland areas. The hybrids suit marginal potential areas and are popular with farmers who grow them in woodlots. Other exotic species, such as *Grevillea robusta* and mangoes, have been incorporated into farming landscapes. The former is popular for supply of timber and fuel wood on farms in Kenya and the latter for fruit production in Sudan and Kenya.

Indigenous trees usually provide poles, firewood and timber and non-timber products such as medicines and fodder at subsistence level. Indigenous forests

play important ecological functions and protect vital water catchments or, in the case of mangroves, protect the shore line from wave erosion while offering breeding grounds for marine fish. Commercial plantations of *gum arabic*, featuring local acacias, are found in Sudan. Pests and diseases have been reported in all these different situations while additionally, woodlands and savannas are reported as prone to fires. These biotic and abiotic factors lower productivity of trees and forests and their interactions need to be better monitored and understood, especially under the uncertain circumstances of a gradually changing climate.

In the expansive plantations where single tree species are dominant, it is not unusual for pests and diseases to take hold and occasionally cause heavy losses. This study captures various such pest and disease situations as reported in literature for the region, giving examples of severity and spread. The most widespread regional problems to have occurred on exotic species since 1990 include the cypress aphid, *Cinara cupressivora*. There have also been reports of different pests and diseases attacking Eucalyptus species in quick succession. The blue gum chalcid, for example, is a gall forming wasp that has been reported in all the studied countries and whose different interactions with the various hosts and weather parameters have been widely studied in Kenya. Integrated pest management, including cultural, chemical and biological measures, and occasionally breeding trees for resistance, has brought many insect pest outbreaks under control and continues to be explored for all new reported cases.

The diseases of trees and forests have also been thoroughly studied in Ethiopia and Kenya. Exotic and indigenous trees are prone to damping off, mildews, leaf spots, stem cankers and root rots. Their susceptibility depends on the stage of growth of the species and location. As with pests, disease management is made easier by early detection. Spread and loss can be contained in an integrated manner using such short term options as cultural methods and chemical application, while tree breeding for pathogen resistance occasionally is used as a long term measure.

It is not only the narrow range of exotic tree species grown at national and regional levels that has trans-boundary dimensions. Of the indigenous vegetation found in Eastern Africa, e.g. miombo woodlands, span wide areas of western, central and southeastern Tanzania and spread over to other countries of southern Africa such as Zambia, Zimbabwe, Mozambique and Malawi. The vegetation is dominated by trees belonging to the family *Caesalpiniaceae*, characterized by *Brachystegia* and *Julbernardia* species, and varies in form from woodland savannas to savanna woodlands depending on land drainage. The woodlands are under increasing human population pressure and are managed using fires to destroy woody vegetation. Those outside protected areas have been converted into farmland. Another case in point is found in the upper regions of Eastern Africa, in the horn of Africa. An arid climate belt marking the edge of the Sahara Desert stretches from the Red Sea coast and cuts across Djibouti, Eritrea, Ethiopia and Sudan and continues westwards all the way to the Atlantic coast of West Africa. These countries participate in the

Great Green Wall of Sahara and Sahel Initiative, which encourages them to combat desertification in a 15 km wide band of land stretching from Senegal to Djibouti. The countries seek technical solutions, particularly long-term land and financial solutions, in order to save trees. Successful transboundary management of fires, pests and diseases thus requires joint efforts by the concerned countries since the responsible agents have no respect for boundaries.

More can be done to share experiences and information in the affected region and beyond, especially when the matter involves exotic trees and introduced pests for which the solutions are external to the region. Similarly, abiotic challenges that affect forests and spread across borders require cooperation by affected countries. This is the case for the fire-prone Nyungwe National Park, a montane forest ecosystem in Rwanda which continues across the border into Burundi where it becomes known as Kibira National Park. The Governments of Rwanda and Burundi have taken a common approach to management of the trans-boundary forest reserve by drawing up a memorandum of understanding which they jointly implement to protect the forest ecosystem that is vital for water catchment and biodiversity conservation.

Trade in trees and forest products in the East African Community (EAC) and the Common Market for Eastern and Southern Africa (COMESA) regional economic blocks is captured in statistics. IGAD is another regional economic community which brings together Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda in a treaty to oversee cooperation and aims to harmonize policies with regard to trade, customs, transport, communications, agriculture and natural resources, and promote free movement of goods, services and people, and the establishment of residence. It further seeks to initiate and promote programmes and projects for sustainable development of natural resources and environment protection.

At international level, all countries which subscribe to the International Plant Protection Convention (IPPC) adopt a number of standards in phytosanitary measures that have been developed to ease and facilitate safe exchange of plant material in a regulated environment. The application of these standards in forestry has been elaborated by FAO. The common situation in all the countries of Eastern Africa in the study is that their national plant protection organizations as recognized under the Convention are hosted by Ministries of Agriculture. Overwhelmed by the agricultural sector needs, all countries visited tended to deal less urgently with handling of pests and diseases of trees and forests. The forest sector also receives less support at national level compared to agriculture. This lack of recognition does not, however, diminish the importance of forests in supporting other sectors of national economies.

The authority to monitor and report outbreaks of pests and diseases can be delegated to research organizations but ultimately the responsibility of communication and strengthening of surveillance of forest pests and diseases lies with the NPPO. Once the relationships are better understood so that the roles of all actors are more clear and well-coordinated in fulfillment of the obligations of such agreements, then

benefits will flow better and improvements in management of pests and diseases of trees and forests can be achieved. Forestry experts are necessary to provide crucial inputs for the development of country specific and regional protocols governing movement of plant material. An EAC phytosanitary protocol was recently concluded but the process failed to engage, for example, the Kenya Forestry Research Institute, which is a cause for concern. The same mistake need not be repeated in the on-going COMESA/SADC/EAC tripartite initiative on regulation of movement of plant material.

This AFF study of tree and forest pests and diseases provided an opportunity for regional experts and staff of key organizations to reflect on the status of forest health in Eastern Africa. It was considered timely and appreciated by all who participated for the attention it drew to forest health in relation to the need to increase forest productivity, address deforestation and build carbon stocks. The reaction confirmed a need to create mechanisms for regional exchange of experiences and information which an institution like AU-IAPSC, with its regional representation of economic blocks and global linkages, is in a favorable position to do. A Center for Phytosanitary Excellence (COPE) already exists for agriculture supporting regional trade where professionals from countries with skill gaps can attend short courses and participate in tailored training to build capacity to undertake their duties more effectively. Such opportunities would serve the forest sector well if expanded to cover forest pests and diseases

1. Introduction

This study of tree and forest pests and diseases in the Eastern African sub-region identifies and discusses issues related to the key elements of improving tree performance and productivity for diverse products. In addition, it examines the actions necessary to enhance protection of forests from pests and diseases that could lower profitability of forestry. It documents the current situation in Eastern Africa including experiences from select countries, *viz.* Rwanda, Sudan, Kenya and Ethiopia.

1.1 FOREST TYPES

The African continent has different forest types among which are moist rain, montane and riverine forests, woodlands, mangroves, plantations of exotic and indigenous trees as well as trees incorporated into farming landscapes.

High elevation areas of the East African eco-region are dominated by sub-montane and montane forests, and some areas of bamboo, grassland and rocky habitats (www.eoearth.org). At yet higher altitudes the East African Montane Moorland ecoregion grades into the Afromontane heathland/moorland and Afroalpine vegetation. The northern forests of this ecoregion form the headwaters of the White Nile, and much of the western portion of the ecoregion drains to Lake Victoria, which also flows to the Nile.

In the far west of the sub-region the Nyungwe Forest Reserve is found in southwestern Rwanda. It is one of the most biologically important montane rainforests in central Africa (Plumtree *et al.*, 2002). In conjunction with the contiguous forest in Kibira National Park, Burundi, Nyungwe forms one of the largest blocks of lower montane forest in Africa (Weber, 1989). Nyungwe includes vast stretches of forest at altitudes 1 600–2 950 m ASL occupied by few other forested areas in Africa. Because it is so large and located at these altitudes, Nyungwe represents a key area for rainforest conservation in central Africa.

Another distinct type of forest found in East Africa is the mangrove forests. They occur between the sea and land and are thought to cover about a quarter of the world's tropical and subtropical intertidal zones, mostly between 5° N and 5° S latitude (UNEP, 2010). Research reveals that the forests have been declining at an alarming rate - perhaps even faster than inland tropical forests -and much of what is left is degraded. From 1980 to 2000, mangroves around the world declined by an estimated 35 per cent. Remaining mangrove forests are under immense pressure from clear cutting, especially for farming and aquaculture, encroachment, hydrological alterations, chemical spills, storms and climate change.

The total area of mangroves in the year 2000 was 137 760 km^2 in 118 countries and territories in the world's tropical and subtropical regions (Taylor *et al.*, 2003),

of which c. 20 % in Africa. In Eastern Africa, nine species of mangroves are found distributed along the Indian Ocean Coast from South Africa, Mozambique, Madagascar, Tanzania, Seychelles, Kenya to as far east as Somalia They have been well studied since 1950 with most of the studies focused on Kenya.

Woodlands in Africa, in the broadest sense, include vegetation types with a woody canopy cover exceeding 10% of the ground cover and growing under climatic conditions with a dry season of three months or more (Chidumayo, 2011). They include vegetation commonly termed woodland, shrub land, thicket, savanna, wooded grassland, as well as dry forest in its strict sense. They occur in 34 countries in Africa where they are the dominant vegetation supporting ecosystem services such as water catchment and wildlife habitat. Large areas have also been cleared for rain-fed agriculture and converted into crop land (Chidumayo, 2011).

Of the indigenous vegetation found in Eastern Africa, miombo woodlands, for example, span wide areas of western, central and southeastern Tanzania and spread over to other countries of southern Africa such as Zambia, Zimbabwe, Mozambique and Malawi. The vegetation is dominated by trees belonging to the family *Caesalpiniaceae*, characterized by the genera *Brachystegia* and *Julbernardia.* In form, they vary from woodland savannas to savanna woodlands depending on land drainage. In Tanzania, the main concentrations of this formation are wet woodlands that are found in the western zone (Tabora, Rukwa and Kigoma regions) and the southern zone (Iringa, Lindi, Mtwara and Ruvuma regions). Those outside protected areas have been converted into farmland. Miombo woodlands are central to the livelihood systems of millions of rural and urban dwellers in Tanzania (Abdallah and Monela, 2007).

Goods provided by miombo woodlands, which contribute to livelihoods of local communities, include medicines, energy, food, fibers, and construction and craft materials. Services include cultural and spiritual values, climate regulation, erosion and hydrological control. All these products and services cover basic human needs such as food, shelter, health and spiritual well-being. In East Africa, more than 50% of woodlands have been converted into agricultural use. Other threats to woodlands include frequent fires, overgrazing and over-exploitation of forest resources (Chidumayo, 2011).

Tree planting has also been widely promoted in different traditional farming systems or by introducing them in new agroforestry technologies for their added benefits on farms (Zomer *et al*., 2014). The current view of agroforestry, used in this and a previous analysis by the same authors in 2009, was not as a collection of technologies but of trees included in agricultural landscapes. Their quantification of agroforestry at global level from 2000 to 2010 led to a surprising finding that c. 46% of all agricultural land surveyed had at least 10% tree cover. Tree cover apparently is still on the increase as a common feature on agricultural land throughout the world, including East Africa. Rwanda, for example, fully embraces the definition of forests by FAO (2000) in forest sector planning - woodlots as small as 0.01ha are often

also considered as forests by smallholders, while small forests (woodlots less than 0.5 ha) and individual trees integrated with crop and animal production systems are considered as agroforestry (Republic of Rwanda, 2010). Research on incorporating trees in conservation agriculture is the latest frontier in the fight against climate change.

Mutua *et al.* (2014) summarize the purposes of having trees on farms in the following ways:

- As a source of timber;
- For provision of non-wood products;
- For meeting biomass energy needs;
- Are good for the water/hydrological cycle;
- Are good for soil conservation and fertility amelioration; and.
- Provision of air quality and environmental services (absorption of carbon dioxide).

Trees incorporated on farms in agroforestry technologies can be found growing as ornamentals, fruit trees and medicinal plants in home gardens, in woodlots, improved and rotational fallows, trees dispersed in croplands, planted as live fences or along boundaries, shelter belts and hedgerows.

1.1.1 Sustainable forest management

Sustainable forest management (SFM) addresses forest degradation and deforestation while increasing direct benefits to people and the environment. At the social level, SFM contributes to livelihoods, income generation and employment. At the environmental level, it contributes to important services such as carbon sequestration and water, soil and biodiversity conservation (www.fao.org/forestry/sfm/en/). To manage forests sustainably means increasing their benefits, including timber and food, to meet society's needs in a way that conserves and maintains forest ecosystems for the benefit of present and future generations.

Many of the world's forests and woodlands, especially in the tropics and subtropics, are still not managed sustainably. Some countries lack appropriate forest policies, legislation, institutional frameworks and incentives to promote SFM, while others may have inadequate funding and lack technical capacity. Where forest management plans exist, they are sometimes limited to ensuring the sustained production of wood, without paying attention to the many other products and services that forests offer (www.fao.org/forestry/sfm/en/).

Tenure is a broad concept which includes ownership, tenancy, rights and obligations and other arrangements for the use of land. Forest tenure determines who can use resources, for how long and under what conditions (FAO, 2008). In the case of Africa, tenure is complex and its role in sustainable development cannot be underestimated.

In situations such as in Somalia, tenure has been politically interfered with, which has led to years of civil war and become a source of prosperity and conflict (Burman *et al.*, 2014). Today, the legal framework for Somalia's land tenure system is a mix of secular, *sharia*, and customary *xeer* law. This legal pluralism has often provided a flexible structure that local actors have used to craft appropriate solutions, but it has also left grey areas within which conflicts begin. In order to reduce potential clashes and raise incentives to invest in the country's largest economic sector – agriculture – Somalia needs greater transparency and certainty in its land tenure regime. In addition, the current system largely excludes women from control over property, impoverishing them and society as a whole.

The motivation to turn this situation in Somalia around can be found in the outcome of focused, small-scale efforts that occur in areas with some minimum level of good governance. Somaliland, in this case, has achieved potentially replicable advances in land tenure formalization by issuing titles for some cultivated farmland and demarcating urban property boundaries. In Somalia's expansive rangelands, where communal ownership predominates, strengthening traditional land management practices and harmonizing their interaction with formal systems would seem to be the best strategy for boosting productivity and preventing conflict and overuse. In areas where violence is on-going, there are few options for intervention aside from documenting land-related aspects of the conflict. Throughout Somalia, empowering women to participate in decisions about land and building the capabilities of local actors will help ensure that interventions achieve sustainable, wide-spread benefits (Burman *et al.*, 2014).

A review of forest tenure in Ethiopia by Mekonnen and Bluffstone (2014) highlighted the conflicts between land uses as forest land is placed under pressure by a growing population of over 90 million who are dependent on rain-fed, low production agriculture and keep over 70 million heads of livestock. The authors suggested that for forest policy to be effectively implemented in Ethiopia, it was necessary to make changes to the existing land policy which makes land the property of government. It was their opinion that individuals and associations required improved rights to trees/forests on their land and to participation in decisions concerning use of the land. In support of SFM, they concluded that it was prudent to make clear rules and regulations regarding the legal basis and operations of different organizations involved in forest conservation and utilization. The authors presented examples of current opportunities available for exchange of experiences by different regions of

the country. There were lessons to be learnt from less forested areas, such as Amhara and Tigray, where initiatives in planting trees on farms went successfully hand in hand with establishment of community woodlots. The need to clearly demarcate and gazette the major forests and to prepare management plans was emphasized. These measures were proposed as necessary to improve Ethiopia's performance in forest management and to contain the high rates of deforestation and degradation witnessed over the last few decades.

FAO (2011) reported that 80 % of the world's forests are publicly owned, but forest ownership and management by communities, individuals and private companies is increasing – more in some countries than in others. A more diversified tenure system could provide a basis for improving forest management and local livelihoods, particularly where state capacities to manage forests are weak. An analysis of experiences in tenure and tenure reform has been carried out pointing out that the interactions among tenure, regulatory frameworks and governance are critical in determining the extent to which forest management objectives are achieved. FAO (2008) conducted several studies in Africa aimed at clarifying the relationships between forest tenure, SFM and poverty alleviation, and provides recommendations for more effective forest tenure systems. Against this background, each country needs to define its intentions in management of forests in the context of forest policy and legislation. Understanding the implications of different forest tenure arrangements is therefore essential for both government and local and other stakeholders where reforms are sometimes necessary and require support based on facts and evidence.

1.1.2 Policy setting for sustainable forest management in the Eastern Africa sub-region

The forest policies of Sudan, Ethiopia, Kenya and Rwanda were important reference documents for this study on forest and tree pests and diseases. They were taken as the bench marks against which to gauge the commitment countries have in pursuing SFM. In particular, Rwanda has already emerged as a world leader in innovative approaches to forest protection and reforestation (Rinaudo, 2014). Its forest policy dated 2010 won international recognition when Rwanda was awarded the Future Policy Award by FAO for having the world's most inspiring and innovative forest policy. Rwanda is only one of three countries in Central and Western Africa to achieve a major reversal in the trend of declining forest cover and is well on course to achieving its goal of 30% forest cover of total land area by the year 2020 as stated in its national development blue print, Vision 2020. This Vision recommends diversification of energy sources and making them accessible to the population to ease the pressure on biomass resources and targets the share of wood energy in the national energy balance to drop from 94% in 2000 to 50% by 2020.

In a national forest policy statement dated 2006, Sudan made known its intentions to regulate and control the use of the forest resources. It projected the challenges that lay ahead, *viz.* reduction of poverty, improvement of people's wellbeing,

amelioration of the physical environment, changes affecting the levels of supply and demand for forest products and obligations and commitments emanating from recently endorsed regional agreements and international conventions. Through implementation of this policy, Sudan was ready to address:

- Desertification, vital to sustainable development;
- Greening Sudan, for increasing more forest goods and better environmental services;
- Forestry industrialization, for job creation and improving the sector's economic efficiency;
- Land conflicts, where conflict resolution and land use zoning ensures safe tenure of forest land and other agricultural forms necessary for food security and the contribution to eradication of poverty;
- Energy and oil, as indicators of less reliance on wood fuels and the changing demand for other wood products;
- Biodiversity, for conservation of the country's natural heritage;
- NTFPs, for opening new opportunities in the development and sustainable use of forest resources other than wood.

Similarly, Kenya has a draft policy on forests which was reviewed as recently as 2015. It stresses the importance of forestry to the national economy. It estimates that forestry contributes 3.6% of Kenya's GDP, excluding charcoal and direct subsistence uses. Forests also support many productive and service sectors in the country, particularly agriculture, fisheries, livestock, energy, wildlife, water, tourism, trade and industry that contribute between 33% and 39 % of the country's GDP. Biomass comprises about 80% of all energy used in the country while forests also provide a variety of goods in support of subsistence livelihoods of many communities. The services provided by the water catchment forests (water towers) include local climate regulation, water regulation and purification. Other services provided include erosion control, natural hazard and disease regulation. Forest adjacent communities benefit directly through subsistence utilization of the forests (Government of Kenya, 2015).

In Ethiopia, forestry has been managed under agriculture for a long time until a recent reorganization of the public sector resulted in the formation of a Ministry of Environment and Forests (Wabulem, pers. comm., 2015). The Ethiopian Forestry Action Programme of 1994 and a strategic plan for the sustainable development, conservation and management of the woody biomass resources of 2004 have been instrumental in guiding development of forestry in Ethiopia in the absence of a specific forest policy (Bekele, 2011). A comprehensive federal policy covering either land use or forest management has yet to be officially endorsed. The forestry policy, which is at a draft stage, sets out to achieve nine objectives, among which are:

- Satisfying the demand for forest products, and,
- Ensuring that essential ecological processes and life support systems are sustained, biological diversity is preserved and renewable natural resources are used in such a way that their regenerative and productive capabilities are maintained and where possible enhanced so that the satisfaction of the needs of future generations is not compromised; where this capability is already impaired to seek, through appropriate interventions, a restoration of that capability.

The policy also encourages the development of forests by individuals, organizations and government and the designation of protected and productive forests. It also emphasizes the security of ownership of forest products to the developers and the importance of protecting the forests from both man-made and natural causes.

The expected outputs of the policy include, among others:

- Participatory forest management practices in selected priority areas in cooperation with foreign agencies.
- Privatization, devolution and decentralization, and recognition of indigenous peoples' rights to forest management which are expected to change the roles of forest administration and management (Bekele, 2001).

Bekele (2011) concluded that the status and trends of forest industries was not well documented in Ethiopia and went further to suggest that continued deforestation and forest degradation indicate that conventional approaches to managing the forests of Ethiopia have not been able to guarantee the conservation of these resources. All natural forests and the extensive industrial forest plantations remain under the overall control of the government. A separation of management and administration has affected both the industry and the forest plantation sectors causing financial problems which lead to inefficiency in management.

Measures to protect forests from pests are an integral part of sustainable forest management. Effective forest pest management (often called "integrated pest management") involves:

- Maintaining the health of forests;
- Managing native pest disturbances that threaten forests; and,
- Preventing the entry and spread of non-native species into new areas.

1.1.3 Global review of forest pests and diseases.

Pests and diseases can occur in plantations, trees on farmlands and in natural forests in both temperate and tropical zones. FAO produced a report on protecting forests from pests and diseases (FAO, 2001) which pointed out that they can damage trees in all stages of development and affect the ability of both natural forests and plantations to meet their management objectives. Some fungi and insects invade tree seedlings in nurseries while others attack older trees in a wide variety of ways.

While invasive plants compete with seedlings and animals damaging forests are also sometimes problematic, the focus was placed on insects and diseases.

Many examples were given where one or more species of either indigenous or exotic pests or diseases have caused devastating losses to forests, requiring changes in management regimes or forcing forest managers to switch to alternative tree species. In Kenya, for example, plantations of *Cupressus macrocarpa* were in the past severely damaged by *Monochaetia unicornis*, a stem canker causing rot, and commercial plantations of the species were discontinued. Another stem disease, *Sphaeropsis sapinea* (*Diplodia pini*) has also been introduced in a number of countries. This fungus was especially damaging in Kenya, where it first appeared in 1973 and proliferated on *Pinus radiata*, a species adapted to a winter rainfall regime and is especially susceptible to fungal attacks during periods of rain and warm temperatures. Well-meaning attempts to improve forest production, such as attempts to introduce new genetic material into a country, have also occasionally resulted in introductions of damaging pests. In 1968, a pine woolly aphid, *Pineus borneri* (also reported as *P. pini)*, was introduced into Kenya on *Pinus caribaea* grafts imported from Australia (FAO, 2001). The extent of damage in terms of acreage affected and the loss in yield were not explicitly documented but the consequences were of economic proportions given that these were commercial soft wood plantation species.

On farmlands, between 1985 and 1988, the Leucaena psyllid, *Heteropsylla cubana* (Homoptera: Psyllidae) is an insect that spread rapidly on *Leucaena leucocephala* wherever this South American native plant was introduced in agroforestry systems across the Asia and Pacific Region. In 1991, infestations were found on the southern Indian Ocean islands of Reunion and Mauritius and one year later in several eastern African countries, including Burundi, Kenya, Tanzania and Uganda. This insect feeds on the shoots and young foliage of Leucaena causing wilting and growth loss (FAO, 2001).

Ecosystem dynamics are such that stability increases proportionately to diversity. The greater the number of plants and animals that occupy an ecosystem, the greater are the checks and balances that prevent any one species from increasing to the point where other ecosystem components are threatened. With pests and diseases, the amount of available host material determines their population status. Plantations or agro-ecosystems that are dominated by monocultures cover large forest areas in Eastern Africa and provide a virtually unlimited amount of suitable host biomass. This can result in population explosions of organisms hosted by the plants. Furthermore, natural enemies of pests thrive in diverse ecosystems and therefore find monocultures an unsuitable habitat. For this reason, plantation forests are more susceptible to damage by pests and disease than are natural forests. While this may be generally true, it does not necessarily mean that natural forests are immune to damage from pests and diseases but the relative lack of pest outbreaks in mixed tropical forests is often cited as evidence of the importance of diversity in

stabilizing plant communities (Speight and Wainhouse, 1989). The various insect pest and abiotic challenges facing forests in the tropics are summarized by Wylie and Speight (2012) with suggestions for management systems in different stages culminating in integrated pest management (IPM).

Keeping in mind that plantations of exotic tree species are the most common forestry practice in tropical countries, management practices which make them especially susceptible to pests and diseases include:

1. To give proper attention to species/site matching.
2. Use of planting stock from a narrow genetic base.
3. Failure to maintain optimum stocking levels and tree vigor through intermediate cuttings.
4. Dependence on one or two species in a plantation programme, resulting in an unlimited supply of host material for potentially damaging organisms.

In addition, when pests and diseases begin to appear, they may come from two sources. A complex of indigenous agents may adapt to the new host or exotic pests may be accidentally introduced.

A recent analysis of the area of forest disturbed by fire, insect pests and diseases globally was done by van Lierop *et al.* (2015). They presented these agents or events as important influences which at times cause undesired impacts on forest ecosystems and affect environmental functions that have consequences on biodiversity and livelihoods. Climate change is similarly anticipated to affect vulnerability of forests to fires as well as have wide ranging detrimental effects on the distribution and severity of outbreaks of pests and diseases. The work of van Lierop *et al.* (2015) builds on previous FAO Forest Resource Assessments (FRA) dating back to the 1970s in which the precision of reporting has been shifting towards more pest specific information. By 2010, the reports had become more focused on impact but many countries could not provide the requested details because they did not consistently monitor such insect or disease related disturbances or had limited access to data. A modification of the data request in 2015, requiring countries to disclose only significant outbreaks, has resulted in more precise reports than in previous years.

In FRA 2015, national respondents were asked to report on the situation of disturbances in their countries in 1990, 2000, 2005, 2010 and 2015 but this was revised to enable them report non- systematically according to actual year disturbances were reported during that period. Fires and area burnt were reported from 2003 to 2012. Information requested fell into six categories, viz.:

- number of fires reported per year of inquiry,
- total land and forest area burnt per year,
- total area affected by insect outbreaks,

- area affected by disease outbreaks,
- area affected by severe weather events. and,
- area of forest with reduced canopy cover.

From the data analysis, it was evident that forests are exposed to severe weather, insect pests and diseases to a large extent and that these are more significant agents of disturbance than fires. To get a comprehensive understanding of the impact of biotic and abiotic factors on forest health would require complete surveys assessing the areas affected at multi-scale levels and many countries have limited capacity to do it. The quantifiable impact of insect pests and diseases on forest cover is therefore underestimated. The conservative estimate of total forest area affected globally by insect pests in 2015 is 85 million ha, with bark beetle outbreaks in North America being the major contributing factor (MacDicken, 2015). For the Eastern Africa region, data was lacking on area affected and economic value of the associated loss. Country reports that contain complete country submissions can be found in FAO/FRA (2015).

It was concluded that under changing climatic conditions, disturbances by abiotic and biotic agents will alter in intensity, frequency and quantity with consequences on the state of forests in many parts of the world. Despite the challenges faced in defining, detecting, measuring and monitoring these disturbances, an effort to do so would provide information that might assist in the quantification of forest disturbance and degradation where it is occurring. This study of the current status of pests and diseases of forests and trees in the East African sub-region attempts to synthesize general information and propose ways for integrated management under these dynamic circumstances.

1.2 OBJECTIVES

1. **Review** status of forest and tree pests and diseases in the Eastern Africa sub-region including an inventory in Ethiopia, Kenya, Rwanda and Sudan, including current trends and drivers;
2. **Review** impact of the identified pests and diseases on forest production and products at all levels (farm, natural and plantation forests, and transboundary forest areas) and their economic implications including gender considerations;
3. **Review** protocols for the surveillance of and diseases and recommend ways for their implementation at national and regional levels; and,
4. **Review** modalities (including policies, laws and institutional capacity), for facilitating the development of mechanisms and actions for surveillance of forest and trees pest and disease prevalence, including transboundary dimensions.

2. Situational analysis

All countries of the sub-region that were covered by this study are members of the African Union (AU), while two (Kenya and Rwanda) are also members of the East African Community (EAC). All are members of the Common Market for Eastern and Southern Africa (COMESA) and some belong to IGAD (Ethiopia, Kenya and Sudan). Intra-COMESA total trade grew by 5% from US$ 18.4 billion in 2011 to US$ 19.3 billion in 2012. Trade in wood and wood products was captured by the economic block under global import and export trade in agricultural raw materials.

Kenya, Uganda and Tanzania are the original partner states of EAC that was formed in November 1999, and entered into force in July 2000. Burundi and Rwanda acceded to the EAC Treaty in June 2007 and became full members from July 2007. Together, the five East African countries cover an area of 1.82 million km^2 and have a population of more than 133.5 million people who share history, language, culture and infrastructure. These advantages provide the partner states with a unique framework for regional co-operation and integration. The combined GDP of the five countries is US$74.5 billion with an average GDP per capita of $558 (2010 figures).

Cooperation in environment and natural resources management is covered in Chapter 19 of the EAC Treaty and features four articles, one of which is management of natural resources. With regard to the conservation and management of forests, the partners agree to take necessary measures through:

1. the adoption of common policies for, and the exchange of information on, the development, conservation and management of natural forests, commercial plantations and natural reserves;
2. the joint promotion of common forestry practices within the Community;
3. the joint utilization of forestry training and research facilities;
4. the adoption of common regulations for the conservation and management of all catchment forests within the Community;
5. the establishment of uniform regulations for the utilization of forestry resources in order to reduce the depletion of natural forests and avoid desertification within the Community; and,
6. the establishment of Api-Agro Forestry Systems.

It is in line with these goals that the East African Legislative Assembly (EALA) adopted the EAC Forest Management and Protection Act in 2015. It promotes the development, protection, conservation, sustainable management and use of the forests in the Community, especially trans-boundary forests ecosystems, in the interest of present and future generations. It further wants to espouse the scientific, cultural and socio-economic values of forests and harmonize national forest laws.

Protection of forests requires countries and regions to consider putting mechanisms in place for halting the spread of pests and diseases which can occur through trade in forest products. Leading this initiative is the International Plant Protection Convention (IPPC) which was established in 1952 and modified in 1997 to accommodate the World Trade Organization (WTO) Sanitary and Phytosanitary agreement. Its vision is "protecting global plant resources from pests" while its mission is to "secure cooperation among nations in protecting global plant resources from the spread and introduction of pests of plants, in order to preserve food security, biodiversity and to facilitate trade".

The founding treaty of COMESA was signed in November 1993 in Kampala, Uganda and entered into force in December 1994. It aspires to consolidate economic co-operation through the implementation of common policies and programmes aimed at achieving sustainable growth and development in member states. It contains articles on cooperation in the development and management of natural resources, environment and wildlife, specifically agreeing to take necessary measures to conserve and manage forests. Its current member States are: Burundi, the Comoros, DRC, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Sudan, Swaziland, the Seychelles, Uganda, Zambia and Zimbabwe. The total GDP for the COMESA countries is USD 657 billion.

IGAD is another regional economic community similar to COMESA and brings together Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda in a treaty to oversee cooperation and aims to harmonize policies with regard to trade, customs, transport, communications, agriculture and natural resources, and promote free movement of goods, services and people and the establishment of residence (IGAD/SUM-96/AGRE-Doc, 1996**)**. It further seeks to initiate and promote programmes and projects for sustainable development of natural resources and environment protection. The combined GDP of the seven IGAD countries was USD 167 billion in 2011. Attributable to largely oil booms in the past, the Sudanese economy was the largest in the sub-region with a GDP of USD 79 billion in 2010 followed by Kenya and Ethiopia (Abdi and Seid, 2013).

An arid climate belt marking the edge of the Sahara Desert stretches from the Red Sea coast and cuts across Djibouti, Eritrea, Ethiopia and Sudan and continues westwards all the way to the Atlantic coast. These countries participate in the Great Green Wall of Sahara and Sahel Initiative. It encourages them to act to combat desertification in a 15 km wide band of land stretching from Senegal to Djibouti. The countries seek technical solutions, particularly long-term land and financial solutions, in order to save trees. .

With 180 contracting parties by November 2013 and a Secretariat based at FAO in Rome, IPPC requires each party to have a National Plant Protection Organization (NPPO) and an official IPPC contact point. Ten Regional Plant Protection Organizations (RPPOs) have been established around the world, including the Inter African Phytosanitary Council which operates under the African Union (AU-IAPSC).

The Convention is recognized by the WTO Agreement on the Application of Sanitary and Phytosanitary Measures as the international body responsible for setting plant health standards.

The AU-IAPSC head office is based in Cameroon. Established in 1956, the Council has seven strategic objectives which include, among others, promotion of safe, efficient and sustainable plant protection techniques as well as harmonization of phytosanitary legislations and regulations in Africa. Its highest governing body is the General Assembly which is made up of plant protection organizations of AU member countries. It convenes once every two years and defines the IAPSC major guidelines for the next two years. The 25th General Assembly was held in May 2013. The council set up a Steering Committee as a resolution of its 21st General Assembly in 2004, in keeping with the Maputo Structure adopted in 2003. Permanent members of the Steering Committee are Regional Economic Communities (RECs) as recognized by AU. Permanent members can propose co-option of relevant organizations into the Steering Committee for the General Assembly to endorse. The permanent and co-opted members all have voting rights. The Steering Committee meets at least once a year.

In November 2013, for example, AU-IAPSC discussed a collaborative effort with FAO and Kenya's Ministry of Agriculture, Livestock and Fisheries to develop a Rapid Alert and Response System for Plant Pests and Diseases in Africa. The meeting was attended by experts from governments and research institutions from South Sudan, Uganda, Ethiopia, Cameroon, Kenya, AU-IAPSC, CIMMYT, ICIPE, ICRISAT and FAO. It was agreed to set up a regional network for surveillance, starting with the East Africa region before extending to the rest of the continent.

AU-IAPSC has a full programme of activities focusing on different aspects of plant protection in Africa, as follows:

- Collect, evaluate and disseminate plant protection information relevant to Africa.
- Promote integrated plant protection and production management.
- Coordinate plant protection activities at regional and sub-regional levels in collaboration with relevant institutions.
- Promote international conventions on phytosanitary measures.
- Encourage ratification of such conventions by African Governments.
- Organize meetings on training, coordination and transfer of technologies.
- Articulate the needs of African plant protection organizations at international commissions, conferences, etc.
- Advise national agricultural decision makers on plant protection.
- Liaise with public and private sectors.
- Set up sector research and agricultural production networks.

Already, the Council has established a number of regional networks on topical issues, such as management of banana and plantain disease, coffee anthracnose, seed pathology, plant micro-propagation, food and perennial crops phytovirology, and control of vegetable weevils and fruit flies. Forest protection issues are not yet well articulated in the programmes of the Council.

AU-IAPSC can liaise with other regional bodies of IPPC, such as the European Plant Protection Organization (EPPO) for bench marking. EPPO activities include:

- Setting regional standards for phytosanitary measures and plant protection products.
- Organizing Working Party and Panel meetings bringing together experts from all parts of the EPPO region.
- Participating in global activities related to phytosanitary measures coordinated by the IPPC Secretariat within FAO.
- Organizing international conferences and workshops for plant protection researchers, managers of plant protection organizations, phytosanitary inspectors.
- Publishing the journal *Bulletin OEPP/EPPO Bulletin*, the EPPO Reporting Service, providing an electronic documentation service, distributing database systems.

Another continent from which Africa can learn lessons on bio-security is Australia. To better address future biosecurity demands, the Department of Agriculture and Water Resources of Australia has brought together its biosecurity research, policy and programme areas for animal, plant, food and quarantine operations. It aims to continue to conduct its biosecurity business in line with its legislative responsibilities. Biosecurity services are delivered through five regions across Australia. At the border, through the Australian Quarantine and Inspection Service, staff continues to deliver inspection and certification services as well as facilitating the movement of people and goods in ports of entry. The Department also conducts risk analyses, including import risk analyses, and develops recommendations for biosecurity policy as well as providing biosecurity policy advice. Australia is therefore at the forefront of forest and tree pest and disease management and illustrates how much further African countries must go to safeguard their forest resources.

Given this wealth of knowledge and experience by different countries and regions of the world, this study of forest pests and diseases in the East Africa Sub region seeks to document challenges faced by four different countries in forest and tree pest and disease management and to explore how the problems could be addressed using a variety of technical, legislation and policy tools.

Box 1:Lessons from Australia concerning management of a biosecurity system

The Department of Agriculture and Water Resources of Australia has primary responsibility for managing the country's biosecurity system and maintains a very interactive website for stakeholder information and contribution (www.agriculture.gov.au/). It decides how biosecurity services are delivered to meet future challenges such as increased global movements of people and goods, and climate change. The changing global environment means there is a need for a greater emphasis on managing the whole biosecurity continuum – onshore, at the border and offshore – rather than focusing primarily on interventions at the border. Effective biosecurity management requires activities offshore to reduce risks reaching the border, and actions onshore to deal with incursions. It means allocating resources to target the areas that pose the highest biosecurity risks. Currently, it has listed several exotic pests of forestry and timber to watch out for as they can be hosted by timber, a range of horticultural and tree crops, and amenity trees. They include exotic beetles in imported timber pallets, Asian gypsy moth (*Lymantria dispar*), Asian longhorned beetle (*Anoplophora glabripennis*), Formosan subterranean termite (*Coptotermes formosanus*) and the lesser auger beetle (*Heterobostrychus aequalis*). The diseases whose movement is carefully monitored include Pine pitch canker (*Fusarium circinatum),* Plum pox or Sharka (plum pox virus) and Eucalyptus rust (*Puccinia psidii*), among others.

The Department's core priorities in managing biosecurity are to:

- manage Australia's biosecurity by effectively identifying and targeting management of risks to focus on the things that matter most
- partner with other governments, industry, clients and stakeholders to manage Australia's biosecurity
- deliver biosecurity services to support access to overseas markets and protect the economy and the environment from the impacts of unwanted pests and diseases
- support Australia's reputation as a competitive exporter of agricultural goods and products.

Source: http://www.agriculture.gov.au/

Given this wealth of knowledge and experience by different countries and regions of the world, this study of forest pests and diseases in the East Africa Sub region seeks to document challenges faced by four different countries in forest and tree pest and disease management and to explore how the problems could be addressed using a variety of technical, legislation and policy tools.

3. Methodology of study

A comprehensive ***literature review*** was undertaken for each participating country through searches of the internet for open access online publications on the subject of forest pests and diseases. All full articles available were downloaded for further review. Several publications whose abstracts were all that was freely available on-line were not considered as they could not be fully analysed. The available publications were subjected to further scrutiny to establish facts about occurrence of pests and diseases according to their identity, types of hosts and forests where infestations occurred, severity of infestation reported, control measures taken and perceived effectiveness of management action.

Several other documents such as forest policies, national development goals and strategies of the different countries were also consulted.

Brief ***visits to collect primary data*** were made to participating countries where contacts were established in advance with different stakeholders in the public and private sectors. An exception was made for Sudan where the study relied entirely on secondary information available in literature as well as consultations with experts in person or via email as there was a technical hitch with visa processing and therefore no opportunity to visit the country.

During the consultations, time was spent in focused discussions with key informants whose details are given in Appendix 7. Notes made during the discussions were useful in documenting the circumstances surrounding forest and tree pest and disease situation in the particular country. Where possible, this information was complimented with interviews of experts, based on a checklist featuring standard sets of questions. The study visits also included excursions to sites where recent pest or disease activities were reported as well as tours of facilities supporting the management of plant pests and diseases in the country that was visited. Data/ information collected from the field was summarized in back to office reports and provided the basis on which to compare the situations across different countries against criteria such as inter-sector collaboration and technical capacity for forest pest and disease management.

4. Pest and disease

4.1 SUDAN

Sudan is a member of COMESA and IGAD regional trading blocks.

4.1.1 Geography

On 9th July 2011, the former country of Sudan was divided into two, the Republic of the Sudan and the Republic of South Sudan. The Republic of the Sudan (hereafter referred to as Sudan) occupies the northern area and has a forest cover estimated at about 11% of its total surface area, or c. 193 thousand square kilometers, in 2015 (FNC, 2011).

Sudan's economy is predominantly based on natural resources, including agricultural production, livestock, forestry and fisheries, which together contribute about 48% of the GDP. Forests play a significant role in integrated land use systems in Sudan for socio-economic development and environmental protection functions, in addition to provision of livelihood needs of its people. However, of the total population (39.2 million) nearly 70.5% is rural and considered as forest dependent for livelihood, wood energy and on round timber for buildings. Contribution of the forest sector to the national economy is under-estimated where the formal national accounts attribute the forestry sector contribution to the GDP to be only c. 3%.

The most important vegetation types are, from North to South:

- desert and semi-desert trees and shrubs, particularly in areas with run-on,
- riverine areas and floodplains,
- low rainfall woodlands (e.g. in North Darfur),
- high rainfall woodlands (e.g. in southern parts of Darfur),
- montane forests, such as those found on Jebel Marra,
- gallery and floodplain forests in higher rainfall areas, and,
- plantations, including gum Arabic plantations.

Figure 1:Al Sunut Forest, Khartoum, Sudan.

The government earns money from direct sales of wood products such as fuel wood, construction timber and sawn timber. Most Sudanese households in rural areas are highly dependent on forest products for livelihood support and income generation. In rural areas, the sector employs 15% of the local population, especially in the collection, processing and marketing of NWFPs, thus providing an income for the elderly, women and children. Sudan exports about 60–80 thousand tons of *gum arabic* annually.

Sudan's National Comprehensive 25 years Strategy on agricultural development and food security aims, amongst other things, at:

- Expanding forest plantation areas in rainfed and irrigated sectors;
- Increasing forest reservation and applying criteria and indicators of SFM;
- Biodiversity conservation; and,
- Combating desertification.

Deforestation is a concern that the National Forest Policy of 2006 addressed. It listed extensive and intensive agricultural use and the overuse of pastures and rangelands among the many factors responsible for the loss of forest cover in Sudan. Agricultural expansion was considered the biggest direct cause of deforestation following the conversion of natural forests to cropland and pasture (FNC, 2011). An area of more than three million ha is on record as having already been converted to mechanized rainfed agriculture. The energy sector is also considered as an important factor of deforestation, wood extraction for fuel and charcoal. Demand for

wood fuel has increased due to rapid population growth, urbanization and shortage in supply of other forms of energy. The commercial and industrial sectors are all dependent on wood fuel. Brick kilns fired with wood, for example, are the second largest consumer of biomass energy and are driven by the recent building boom in major towns (UNEP-UNDP Project concept, 2012). Sudan consumed a total of 21 million m^3 round-wood in 2010, including wood fuel, construction, maintenance and furniture wood. Refugees and internally displaced people also contributed to the removal of forests to obtain their requirements of fuel-wood and building houses (IDPs in Darfur and refugees the Eastern, Western Sudan).

There is scattered information available about insects, diseases and other hazards impacting forests and the forest sector in Sudan. One report estimated that 102 874 km^2 of forested areas in four states – Darfur, Kordofan, Eastern and Central - were affected by insect pests and diseases. Fire, fungal and insect attacks and over-grazing are reported as the key factors that hinder natural regeneration. While fire is used as a tool for land preparation for cultivation, it also destroys the range land, killing or displacing wildlife to remote areas. It is a serious problem in nearly all forest areas in Sudan (FNC, 2011).

4.1.2 Trends of disturbance of forests in Sudan

Fire has led to abandonment of the establishment of exotic tree plantations after the failures associated with it (see Box 2).

Box 2: Fire occurrence and its impacts on forests in Sudan - Forest Plantations in Jebel Marra.

After establishing 500 ha of *Cupressus lusitanica* plantations in Golod area in 1957, fire swept through them in 1974. They were replanted in 1980 but again fire wiped them out in 1984. Another attempt to re-establish the plantations was made in 1989 but when they burned down again in 1994, efforts were shifted elsewhere. Massive planting of trees was undertaken with assistance of FAO and the Government of Netherlands to create Sudan's Gum Belt in the early 1990s. It consisted of massive *Acacia senegalensis* tree seedling production and distribution. Food was provided as a part of the project strategy but the results were not entirely satisfactory because the survival rate of planted trees was often low. Community participation in forestry projects picked up in the 1990s, mostly with eucalypts, because they interested local people more and the trees were more fire resistant. There was good uptake, but local people were less interested in community forestry than in private plantations. The El Ain Community Forestry Project is an example of one such successful venture which continued to flourish after the project had long concluded.

Source: UNEP-FNC, 2011.

Diseases and pests that attack indigenous trees and forests in Sudan include tree locusts, termites and several beetles which have indigenous or exotic tree hosts on which they damage the bark, seeds, leaves and roots (El Tahir *et al.*, 2010; FAO, 2007; El Atta, 2000). Forest and tree pests are listed in Appendix 1. Among the most serious pests of trees and forests in Sudan is *Sphenoptera chalcichroa arenosa* a cambium and wood boring beetle that is widely spread in the country. Details are found in Box 3 below. Forest and tree diseases of Sudan are listed in Appendix 2.

Box 3: Spread of wood boring beetles in Sudan.

Sunt, *Acacia nilotica*, is the most valuable timber-producing species in northern Sudan. It contributes an estimated 40-50 percent to the total sawn timber production in northern Sudan and 10-15 percent to fuel wood production. Dieback of *A. nilotica* was reported in Sudan as early as the 1930s and was attributed to infestation by *Sphenoptera chalcichroa arenosa*, a cambium and wood boring beetle. The larvae of this beetle tunnel into the cambium layer of branches and stems causing dieback and gradual tree mortality. By the early 1950s, the condition had affected most of the forests between Khartoum and Sennar and was estimated to have caused losses of up to 60 percent in the plantations along the Dinder River. It spread to the south and appeared on both banks of the Blue Nile in 1989 when it suddenly erupted reaching plague proportions. Fourteen reserves had been affected with a total area of 500 ha affected and 15 percent of the *A. nilotica* area in the reserves being killed by 1995.

Source: FAO, 2007a.

4.1.3 Capacity for forest pest and disease management in Sudan

FAO (2007a) assessed the capacity for forest protection in Sudan by reviewing land tenure, the organization of the forest sector, technical expertise available for surveillance, data and pest management. Areas of strength included having data on estimated areas affected by different pests and the impact of infestation on forest production. A range of pest and disease management options was also available and include de-husking of seed before storage to prevent infestation by beetles, application of botanical and inorganic chemicals as well as cultural methods for managing termites. More effort, however, was required in formalizing the detection and monitoring of forest pest and disease outbreaks. Concerning institutions, UNEP-FNC (2011) confirmed The Forest National Corporation (FNC) as Sudan's forest service since 1989, then under the Ministry of the Environment, Forestry and Physical Development. Other government institutions that are linked to the forest sector include the Ministry of Agriculture (with respect to agricultural expansion) and

the Ministry of Petroleum (with respect to energy alternatives). Many NGOs are also active in a range of forest activities. As reforms in the sector continue, policies and legal frameworks focus on the creation of a Sudan specific framework. Reforms also take into account emerging sector issues, e.g. climate change and carbon credits as well as woodfuel substitution by Liquified Petroleum Gas (LPG). Great emphasis has been placed on conflict resolution to contain rampant destruction of vegetation by IDPs. Biodiversity surveys that take stock of current situations have been carried out in certain regions, e.g. the one of 2008-09 in the eastern mountains of Southern Kordofan by Baldo (Forest Research Center Annual Report 2008 - 2009). More coordinated efforts are thus necessary to facilitate the development of mechanisms and actions for surveillance of forest and tree pest and disease prevalence, including transboundary dimensions.

4.2 ETHIOPIA

Ethiopia is a member of COMESA and IGAD regional trading blocks and is an active member of the Great Green Wall of the Sahara and Sahel Initiative.

4.2.1 Geography

Ethiopia is a land-locked country, occupying an area of 1.2 million km² between 3-15° N latitude and 33-48° E longitude. According to the current constitution, land is a common property of the nations, nationalities and peoples of Ethiopia and is not subject to sale or to other means of exchange. Ethiopia's economy is predominantly rural with the agricultural sector providing employment for about 85% of the population and accounting for nearly 90% of its exports (Bekele, 2011).

Forests are among the natural resources recognized in the Environmental Policy of Ethiopia that was launched in 2007. In it there is a concern that in many areas of highland Ethiopia, the present consumption of wood was in excess of unaided natural sustainable production. Estimates of deforestation, caused mainly by expansion of rainfed agriculture, varied from 80 000 to 200 000 ha/y. Natural forests of Ethiopia and commercial plantations, mainly of exotic tree species (with only a few of indigenous species), are publicly owned in some of the National Forest Priority Areas. The main plantation species are *Eucalyptus* spp. covering 56% and *Cupressus lusitanica* covering 32 % of the total area, followed by *Juniperus procera* (2%), *Pinus patula* (1.8 %), and other species (8 %) (Bekele, 2011). It is also reported that the area of natural forest available for wood production is diminishing. By 2011, natural forests and woodlands covered 12.3 million ha, down from 15.1 million ha in 1990. Of this, the remaining closed natural forests occupied 4.12 million ha or 3.37% of Ethiopia's land area. The country has thus become dependent on wood product imports, mainly of sawn wood, paper and plywood following discontinuation of a programme which established large areas of industrial forest plantations in the 1970s with donor support.

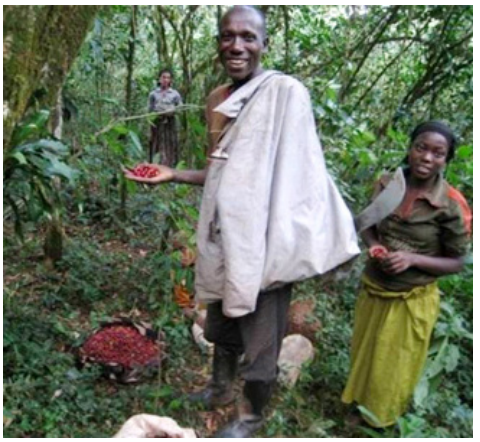

Figure 2: Harvesting coffee in the wild forests of Ethiopia.

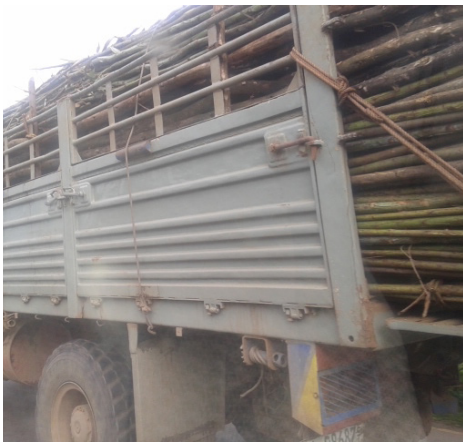

Figure 3: A truck load of tree poles on the road to Addis Ababa. The building construction industry absorbs them for scaffolding. Photo credit: Author

Ethiopia has several agro-ecological zones in which indigenous forests are dominant. They include an Afro-montane zone in which coffee grows wild in broad-leaved humid montane forests. The zone also has dry Juniper forests and Acacia woodlands found to the East and Rift Valley regions of the country. In the broad-leaved deciduous forest zone are also found Combretum and Terminalia woodlands in which indigenous bamboo zones occur, either as lowland (solid stem) or highland (hollow stem) types (Woldemariam, pers. comm., 2015).

According to Bekele (2015), among the direct drivers of deforestation and forest degradation in Ethiopia include forest clearance for both subsistence and large-scale agriculture, illegal and unsustainable extraction of wood mainly for charcoal and firewood, overgrazing and recurrent forest fires. Underlying drivers include rapid population increase and the associated growing demand for land and energy, extensive legal and institutional gaps including lack of stable and equitable forest tenure, lack of stakeholder participation in forest management and benefit-sharing schemes, and weak law enforcement. As a result, much remains to be done to make forest management sustainable in Ethiopia.

The rising demand for wood and non-wood products from forests has led to several government initiatives to involve communities in planting woodlots since the mid-1970s, mostly *Eucalyptus* spp. At the same time, focus has shifted away from centralized management of woodlot resources to community and village level. Additional efforts are required to fill the existing gap between demand and supply of

forest products and services in Ethiopia. Unsustainable harvest from natural forests and woodlands has reduced the supply of woody biomass, further widening the gap between supply and demand. The low level of industrial wood supply from in-country production is compensated by a large volume of imports. For instance, during the 2010/11 Ethiopian Fiscal Year, the import bill for wood products reached Birr 1.8 Billion (USD 115 million), creating an additional challenge for a country struggling to increase its foreign currency earnings (Lemenih and Kassa, 2014). Progress will depend on recognizing the forest sector for its immense contribution to GDP which the official figures do not reflect. The forest sector also lacks the necessary technical and financial resources to manage the forests sustainably.

4.2.2 Trends of disturbance of forests in Ethiopia

Reports on the health status of forests in Ethiopia indicate that exotic plantations have been faced with various challenges since introduction of *Eucalyptus globulus* in the 1890s. The reasons given for low performance have been poor species and site matching, inadequate management practices and climatic factors. Rarely were failures attributed to tree pests and diseases in the past (Alemu *et al.*, 2003b). These assumptions were proven wrong when several disease reports were documented in a survey conducted in southern and south western Ethiopia in 2000-2001. Root diseases, stem cankers and leaf diseases were recorded on both indigenous and exotic tree hosts. The Forestry Research Center of the Ethiopian Institute of Agricultural Research (EIAR) has conducted other studies related to a disease on *Cordia africana*, a high value and endangered indigenous tree growing in natural highland forests. It has also been reported on *Olea europaea subsp. africana.* A pest infestation of cactus has also recently caught the attention of experts. Cactus is highly valued by residents of ASALs as a food source as well as fodder for livestock. These and other challenges are receiving attention of the Directorate of Protection of the newly formed Ethiopian Environmental and Forestry Research Institute (EEFRI) in response to the pressure exerted by stakeholders. Biological control is under investigation as a potential method for managing the situation (Wabulem, pers. comm., 2015). Coffee pests are the most well studied as it is a commercial tree of agricultural importance growing in the montane forests and has a lot of cultural significance in Ethiopia. A list of pests of trees and forests in Ethiopia is given in Appendix 3.

A successful case of management of pests of trees in exotic plantations in Ethiopia is that of cypress aphid (see Box 4).

Box 4: Cypress aphid management in Ethiopia.

Cinara cupressivora (commonly referred to as cypress aphid) attacks conifer trees causing major damage to plantations and hedges. The insect was accidentally introduced to Africa from Europe in the 1980s. It was first detected in Malawi in 1986 and quickly spread to other parts of Africa, including: Tanzania, Burundi, Rwanda, Uganda, Kenya, DRC, Zimbabwe, South Africa, Libya and Morocco.

The presence of cypress aphid in Ethiopia was first detected in Addis Ababa in 2003 and by 2005 it had caused over USD 10 million worth of damage to plantations across the country. A parasitic wasp by the name *Pauesia juniperorum* that is a natural enemy of the cypress aphid was exported from Kenya to Ethiopia as a safe bio-control agent for the pest. The female wasp lays its eggs in live cypress aphids and the eggs hatch into larvae that feed on the pest's internal organs, eventually killing it. Experiments were undertaken to ensure that the release of the wasps would have no negative effects on the Ethiopian environment nor create any problems for humans, animals or beneficial insects. Within three months, the released wasps had successfully spread to most parts of the targeted plantations as well as neighboring cypress hedges and patches. In June 2009, FAO conducted a monitoring and evaluation mission which found that almost all of the target hedges and trees had since recovered and had resumed good growth.

Source: FAO SFE, undated.

The first report of *Leptocybe invasa* in Ethiopia was in 2002. It is a gall forming wasp with a relatively narrow host range, attacking only eucalypt species, clones and hybrids. Adult wasps can spread very quickly by flight and wind currents. They can also be introduced into new areas through the movement of nursery stock and international flight traffic. The eggs are laid in young shoots where they hatch into larvae protected by galls. Severe attack can lead to deformed appearance, loss of vigor, stunted growth and eventually death of the affected trees. The insect pest commonly referred to as the blue gum chalcid, was first found in the Bahardar region of North Ethiopia. By 2007 it was already reported elsewhere in Africa - in Algeria, Kenya, Morocco, Mozambique, South Africa, Tanzania, Tunisia, Uganda and Zimbabwe (FAO, 2012).

In plantations of Eucalyptus, the *Mycosphaerella* Leaf Disease (MLD) is among the most important diseases with symptoms restricted to *E. globulus* trees growing in several localities in south, south western and western Ethiopia (Alemu *et al.*, 2006). The proposed management was by tree selection as wide variation had been observed in susceptibility to MLD within families and provenances. Stem cankers are other diseases reported in *Eucalyptus* plantations in Ethiopia. Diseases reported on trees and forests in Ethiopia are listed in Appendix 4. Box 5 below describes

distribution of a stem canker disease found on *Eucalyptus camaldulensis.*

Historically, *Pinus radiata* was abandoned as a plantation species in Ethiopia after a disease outbreak caused by *Diplodia pinea* occurred. No practical management programme was developed (Roux *et al*., 2005). A comprehensive study of parasitic plants and a stem canker affecting Frankincense was undertaken in North Ethiopia as reported by Alemu *et al.* (2014). This was the first report of *Lasiodiploida theobromae* infecting *Boswellia papyrifera* in Ethiopia presenting a new constraint to the sustainable management of the tree and incense production.

Box 5: Occurrences of Coniothyrium disease in Ethiopia.

Eucalyptus camaldulensis is one of the most widely planted *Eucalyptus* spp. in Ethiopia. This species appears to be highly susceptible to *Coniothyrium* stem canker. The disease results in stunted growth and reduction of timber quality and strength. This greatly affects the use of these trees for construction purposes. Symptoms of the stem canker were first observed on *E. camaldulensis* in Ethiopia during a survey of plantation forestry diseases in 2000 and 2001. The disease is restricted to specific areas in southern and south-western Ethiopia and causes large scale damage to trees in plantations, woodlots and around homesteads. It has not been found on other species of Eucalyptus in Ethiopia. This is probably due to the fact that they are planted in cooler areas, which would not be conducive to the development of *Coniotyrium zuluense*. This is consistent with the fact that in South Africa, *Coniothyrium* stem canker is a problem only in warmer sub-tropical areas. The disease is widespread in areas growing *E. camaldulensis* between Wolkite and Sodo, and between Woliso and Jima. Near Jima, the disease was found on most E*. camaldulensis* trees in the Jiren plantation, east of Jima, whereas trees planted in a different site close by showed no signs of infection. These were attributed to different seed sources of *E. camaldulensis* which differed in their susceptibility, raising the possibility of being able to select disease tolerant planting stock in the future.

Source: Alemu *et al.*, 2005.

4.2.3 Inter-sectoral collaboration in tree and forest pest and disease management in Ethiopia

Forest health is not only a concern to public forest managers but also to those in other related sectors of the economy. Recent findings of a study on re-greening Ethiopia show that farmers and NGOs are the main players, and that the private sector has so far played only a small role (Mulegeta and Kassa, 2014). The role of the government was supportive in some cases and hindering in others. The challenges of state- and NGO-led re-greening practices were: inadequate involvement of communities; poorly defined rehabilitation objectives; lack of management plans;

unclear responsibilities and benefit-sharing arrangements; and poor silvicultural practices.

In Ethiopia, the key players with influence on forest health are different units within the Ministry of Agriculture.

A *Plant Health and Regulatory Directorate* acts as the National Plant Protection Organization under the International Plant Protection Convention (IPPC), to which Ethiopia is a signatory. Movement of all plant materials, including tree and forest products, falls under the international regulation of IPPC for countries which subscribe to it.

To contain the spread of pests and diseases of forests and trees, it is necessary to apply the same stringent measures in movement of timber and NTFPs as is applied to movement of other plant materials but this is not the case in Ethiopia. It is therefore recommended to create awareness amongst citizens and traders of the importance of such regulations in light of the potential risk of spreading pests and diseases that exists through trading in forest products. In addition, it would greatly improve the situation to also develop a reference list of quarantine pests associated with the countries from which such products are sourced or exported as is done, for example, in Australia. In principle, only clean material accompanied by phytosanitary certificates should be allowed to leave or enter Ethiopia.

The *Ethiopian Institute of Agricultural Research* (EIAR) comprises of 17 research centers with the one at Ambo having the national plant protection mandate. This centre handles all plant protection issues for all crops.

At the Center, a national pathology programme conducts its work under four projects, *viz*.: Phytobacteriology, Mycology (wheat rust disease), Virology and Nematology.

A national entomology programme addresses key pests in the following categories: Field pests, Storage pests and Migratory pests (locusts) - providing a back-up for the EA Locust Control Organization.

There is also a national Weed Science Programme under which research is conducted on: Non-parasitic common weeds, Parasitic weeds including Striga and 'Orobanke' weed on Faba bean, and, Invasive weeds in rangeland ecosystems which include *Parthenium* sp. (Asteraceae), a weed that has spread everywhere in Ethiopia.

The center facilities are organized in a way that each project has its own staff, laboratory facilities and equipment. Biological control agents are passed through quarantine for evaluation before release in pilot sites. One of the current projects when the study visit was made was on a beetle imported for control of the *Parthenium* weed in collaboration with Virginia Tech IPM CRSP. *Parthenium hysterophorus* is a species in the aster family, Asteraceae, which is native to the American tropics. Common names include Santa Maria feverfew, whitetop weed and congress weed.

It is a common invasive species in India, Australia and parts of Africa. The pilot release site is in Oromia Region, about 100 km east of Addis Ababa where release was made the year before and monitoring was under way to evaluate success of the biological control agent.

The experts who participated in this study expressed concern over the limited manpower and infrastructure for pest management available in Ethiopia. The current situation was such that specimen identification services were sourced from Europe. On trans-boundary trade in tree and NTFPs, tree seeds were reported to be informally traded or shared between Ethiopia and neighboring countries in small, undeclared quantities. This posed a potential avenue for spread across borders of seed borne pests and diseases. The same thing applied to non-timber products such as bamboo. Walking sticks made out of bamboo are popular in Ethiopia but trade is restricted. They still find their way informally across borders and inland as far as Gondar.

4.2.4 Capacity for forest pest and disease management in Ethiopia

A number of organizations with different mandates in the management of forest pests and diseases are already established in Ethiopia within the framework of the agriculture sector. In this regard, there is also adequate infrastructure to handle plant movement and related biological imports and exports. Regulations are also in place requiring personnel handling movement of biological materials do so with a great sense of responsibility. What remains is for more attention to be paid to enhancing the human resource for handling forestry pests. This will require skills development and it is advisable to train personnel in forest entomology and pathology at under-graduate and post-graduate levels as well as in phytosanitary procedures. The related field work should be based in the country to ensure that experts are familiar with the local situation. Such graduates, if hired in adequate numbers, can strengthen the research team in EEFRI where there was no trained forest entomologist posted at the time of the study. Two pathologists handled all forest health issues.

Ethiopia is a party to IPPC and already subscribes to international arrangements securing common and effective action to prevent the spread and introduction of pests of plants and plant products, and to promote appropriate measures for their control. As a contracting party, it adopts the legislative, technical and administrative measures specified under the Convention. Strengthening the relationship between the national plant protection organization under the Ministry of Agriculture and EEFRI in the Ministry of Environment and Forests is thus necessary so that surveillance of forest and tree pests and diseases can be improved. It is a requirement under the IPPC to monitor the movement of quarantine pests through tradable commodities, of which timber and NTFPs are some.

Trade is only one potential avenue of spread of pests and diseases of trees and forests. As observed by Odera (1991), heavy dependence on the same limited number of exotic tree species across East Africa itself is a recipe for rapid spread of pests and diseases across territories. It would thus be worthwhile to conduct pest risk analysis of threats faced by tree species which grow both in Ethiopia and in the wider region, especially where pests and diseases of the same species have been reported in neighboring territories. The information gathered in such a surveillance exercise could be widely distributed in the country and the region to help all concerned to do their due diligence in containing the spread of pests and diseases.

In conclusion, the different agencies of the Government of Ethiopia which currently act quite independently need closer coordination in order to improve efficiency and to avoid duplication of effort in the coverage of forest pests and diseases. This would, when translated into future action, mean that they could be detected and action taken sooner and in the most efficient manner possible.

4.3 KENYA

Kenya is a member of both the EAC and COMESA economic blocks and of IGAD.

4.3.1 Geography

Kenya has a total land area of 582 646 km^2. With an estimated population of 41.8 million people in 2014, the leading sectors in GDP performance at current prices between 2010 and 2013 were agriculture and forestry (Government of Kenya, 2014). Growth in those sectors was 2.9% in 2013 during which period it accounted for 25.4% of GDP. The sector also led in wage employment. Volume of trade was higher within the EAC region compared with other regions. Trade statistics did not specifically capture tree and forest products but stated the area under forest plantations as 129 000 ha. The Kenya National Bureau of Statistics tracked details of export or import oriented trade in such products through a partnership with the Kenya Revenue Authority (KRA).

Different forest ecosystems are represented in Kenya: montane rainforests, savannah woodlands, dry forests, coastal forests and mangroves (Peltorinne, 2004). The current forest cover of c. 7% of the land area was, however, still below the constitutional requirement of 10%. Through the new policy, the forest sector aims to explore new measures to halt and reverse the pace of deforestation and forest degradation in the country and increase forest cover by taking advantage of emerging opportunities for sustainable forest financing both at national and international level. Among the interventions proposed, some were expected to address low productivity of tree crops, low conversion efficiency and weak value addition schemes. These challenges were attributed to climate change, small genetic base of crops, emerging pests and diseases, low investments in technology development and poor investment in forest based industry. In response, it was

suggested that forestry research and development should pay more attention to basic forestry disciplines such as productivity, health, crop diversification, processing, value addition, intellectual property rights and indigenous knowledge (Government of Kenya, 2015).

The role of forests in sustainable development was also quite clearly defined in Kenya's economic blue print *Vision 2030*. Forests fell under the social pillar of the Vision in the environment, water and sanitation sectors. The target set during the Vision's time scale was to achieve at least 10% forest cover (Government of Kenya, 2007). The second Medium Term Plan of the Vision, spanning 2013-2018, featured flagship projects and programmes that focused on the ecosystem and participatory forest management as necessary to support SFM (Government of Kenya, 2013). Bamboo, commercial forestry and other nature based enterprises were to be promoted for poverty alleviation and environmental sustainability. Such programmes would be implemented both on farmlands and dry-lands in collaboration with Community Forest Associations.

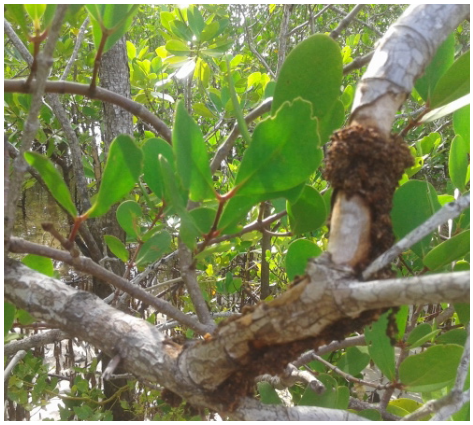

Figure 4 : Mangrove shoot borer damage in Gazi Bay, Kwale County, Kenya. Photo credit: Author

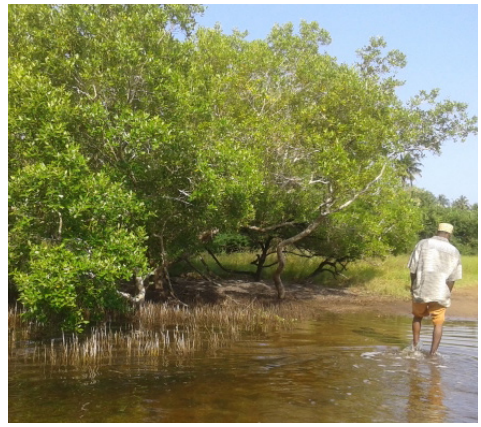

Figure 5: Mangroves enjoy community protection in Gazi Bay, Kwale County, Kenya. Photo credit: Author

Farm and dry-land areas were expected to provide the best opportunity for increasing the tree cover to 10 %. Famers would be encouraged to integrate planting of appropriate tree species on their land to increase the availability of tree products on farm and also attain the requisite forest cover. On forestry research and development, the plans as outlined were to conduct research to develop intervention measures for arresting forest degradation, providing forestry-related base line data as well as establishing a monitoring system on forests and aspects of climate change. In addition, identification and improvement of tree species for various uses and services, development and demonstration of forestry technologies and new products, and generation and dissemination of knowledge and technologies would be undertaken.

Trees also had a place in land reclamation plans whereby 50 000 ha in the counties prone to landslides, flooding, heavy soil loss that lead to gully formation and loss of landscape are earmarked for rehabilitation and reclamation. All significant water towers and water catchment areas were to receive attention while promoting and piloting green energy to reduce pressure on forests and meet increasing biomass energy needs. To achieve this would require harmonization of various sectoral policies. Efforts to intensify management, conservation, utilization and protection of forest resources for sustainable production of environmental goods and services were expected to rehabilitate water towers and spur development of tree out-grower schemes.

It was expected that reviewing the Forests Act 2005, draft Forest Policy and Timber Act, and developing the National Forest Programme, would provide the necessary instruments to achieve the set goals. This was to be done in an environment in which emerging issues and challenges included climate-related extreme weather events such as droughts, floods and landslides; degradation of water catchments due to settlements, agricultural activities and encroachment as well as increased competition and conflict over natural resources.

4.3.2 Trends of insect pests and diseases of trees and forests in Kenya

The Kenya Forestry Research Institute (KEFRI) has a mandate to conduct research in forestry and allied natural resources (KEFRI, 2013). With a history dating back to colonial times, research on forest protection has been long established in the Institute under the disciplines of forest entomology and pathology (Mugo *et al.*, 2007). Insect and mycology reference collections have been maintained and updated since the 1950s, having commenced during the era of the Institute's predecessors, the Research Conservancy of the Forest Department and the East African Agricultural and Forestry Research Organization (EAAFRO). Curated specimens in the insect collection include tree defoliators, sap suckers, borers and other insects that attack fruits and seeds. The collection also features beneficial and other insects comprising the broader biodiversity of different forest types. The accompanying records help to construct the trends of distribution, host preference of pests and type of damage caused over the sixty-five year period during which records have been maintained.

In its current strategic plan 2013-2018, which is aligned with Vision 2030 and thematic areas of the draft National Forest Programme, KEFRI is expected to continue to play a key role in SFM by providing research support for increased forest productivity and biodiversity conservation (KEFRI, 2013). KEFRI, at the time of this study, had a team of four entomologists and four pathologists, all trained up to post-graduate level. In addition, experienced technical staff, interns and undergraduate students on attachment were posted to well-equipped and managed laboratories. The Institute counts on these strengths to address forest health issues in a comprehensive manner.

KEFRI's mandate also covers partnership with institutions of higher learning and other research organizations at local and international level to ensure that research conducted remains relevant to the current challenges. Such networking and dynamism has attracted national and regional recognition of KEFRI as a center of excellence in forestry research culminating in consultations and funding for regional projects. Fruitful collaboration with stakeholders such as FABI (Food and Agricultural Biotechnology Institute) of South Africa and reliable service delivery have also kept KEFRI engaged and at the forefront of forest protection in the event of forest insect and disease outbreaks. Technical Note No. 40 of the Kenya Forest Service equips field personnel with guidelines on how to make detailed reports for action by KEFRI on pest and disease incidences they might encounter as they routinely patrol forests.

4.3.3 Tree and forest insect pests in Kenya

Pests of trees and forests occur in all forest types in Kenya, some on hosts that are indigenous, some on introduced species (FAO, 2007). Integrated pest management is the preferred approach for handling forest pests in Kenya, with an emphasis on biological control and minimum application of chemicals (only where justified), such as in tree nurseries and on ornamental plants. Box 6 has details of past management considerations based on biological control.

Box 6: Management of the *Gonometa podocarpi* moth.

G. podocarpi is a well-studied pest. It is an example of a moth whose larvae cause serious defoliation of conifers, in addition to attacking the leaves of many dicotyledons. *Acacia lahai, A. mearnsii, Cupressus benthamii, C. lusitanica, Eucalyptus regnans, Juniperus procera, Pinus halepensis, P. leiophylla, P. montezumae, P. patula, P. radiata* and *Podocarpus gracilior* are among the trees it attacks in East Africa (Kenya, Tanzania and Uganda). It was first reported as a pest in 1925 on *Podocarpus* sp. in the Mt. Kenya region and in later years caused other outbreaks in the Mt. Elgon area on *Pinus* sp. Eggs of *G. podocarpi* are parasitized by a Hymenopteron of the family Eupelmidae, belonging to the genus Anastus, the only known parasite of *G. podocarpi* eggs. Adult Anastus parasites usually emerge from the attacked eggs. Such eggs do not hatch. The larvae of *G. podocarpi* are fatally parasitized by a number of insects, the most common of which are the Hymenopterans *Meteorus trilineatus* and *Pimpla mahalensis*, and the Dipteran *Sturmia gilvoides*. Most of the parasitized larvae die; a few may go into pupal stage, but these too die and do not emerge as moths. So far, no parasites of adult moths have been found. In addition to the parasites, a non-inclusion-type virus is an important disease of *G. podocarpi* larvae in the fourth and fifth instars. These factors, of parasites and virus disease, offer options for natural biological control of the pest (Okelo, 1972).

Source: Alemu *et al.*, 2005.

Other options for pest management include the removal of infested trees which yields temporary success as experienced when the pine wooly aphid first appeared in Kenya. On the furthest extreme of the management scale is breeding for pest resistance, which Owino (1991) associated with limited success. It usually takes a long time to develop resistant strains of host trees by which time the dynamics of the target pest could have already changed.

Sporadic outbreaks of a shoot borer in indigenous mangrove forests affecting *Sonneratia alba* were reported in Kwale and Mombasa in the mid-1990s and re-occurred in Gazi Bay as recently as 2013. The caterpillar stage of *Salagena discata*, a wood moth, tunnels into the bark and wood and causes defoliation (FAO, 2007). Repeated attacks can cause tree mortality and, recently, a massive insect infestation event occurred on Pemba, Tanzania, where infested trees experienced massive defoliation of such wide scale that it caused concern in the region (Jenoh, undated). The residents of Gazi Bay who were interviewed for this study, however, regarded it as a minor pest and expressed little concern about it. This was confirmed by a site visit in 2015 when only a low population was observed. It is possible that natural control agents keep it in check whenever it reaches outbreak populations but more comprehensive studies should be done on its population dynamics. Among the most widely studied insect pests are those attacking Eucalyptus species in Kenya. A list of recent pests as reported in literature was compiled for this study and is presented in Appendix 5.

4.3.5 Diseases of trees and forests in Kenya

Most forests and trees in Kenya at high altitude are prone to disease incidences. The concern about ill health of *Eucalyptus spp.* in Kenya is captured by Mutitu *et al*. (2008), Kenya Forest Service (2009) and Mwangi (2014). Tree and forest diseases of eucalyptus and other exotic plantation species such as pines and acacias in East Africa were also covered by Roux *et al*. (2005). Many of these diseases were also mentioned in FAO (2007) where they were classified according to their origin and hosts. *Mycosphaerella pini*, for example, is a fungus with worldwide distribution. It infects and kills the needles of *Pinus* spp. The infection can lead to significant defoliation in both plantations and natural stands. In 1960, *M. pini* was discovered in Kenya where it was especially damaging to *Pinus radiata*. The tree is adapted to a winter rainfall regime and is especially susceptible to fungal infections during rain and warm weather in the tropics. The occurrence of this fungus in Kenya led to the suspension of *P. radiata* as a plantation species, creating greater dependence on *P. patula* and *Cupressus lusitanica*. A successful selection and breeding programme by KEFRI eventually produced disease resistant varieties whose trials are located near Londiani, in Rift Valley. This species can now be used again as a commercial species for fiber production (Joram Mbinga, pers. comm.).

On farms, a stem canker and die back disease of *Grevillea robusta*, a widely grown agroforestry tree, was studied and reported about in detail by Njuguna (2011). Other

diseases of trees on farms in Kenya include Phytophthora, reported by Mbaka *et al.* (2009) on two varieties of macadamia nut trees (*Macadamia tetraphylla* and *M. integrifolia*). Armillaria root rot occurs in tea plantations and is also reported on indigenous and exotic trees. Appendix 6 has details.

4.3.6 Inter-sectoral collaboration in tree and forest pest and disease management in Kenya

The Agricultural Sector Development Strategy (ASDS) is the overall national policy document for the sector ministries and all stakeholders in Kenya for the period 2009-2020 (Government of Kenya, 2009). The document is an expression of sector characteristics, challenges, opportunities, vision, mission, strategic thrusts and the various interventions that the ministries are expected to undertake to propel the sector to the future. It is good for development of agriculture as the mainstay of the Kenyan economy, which directly contributed 24 % of the GDP annually valued at KShs. 342 billion and another 27 % indirectly valued at KShs. 385 billion at the beginning of the strategic phase. The sector accounted for 65 % of Kenya's total exports and provided more than 60 % of informal employment in rural areas. Therefore, the sector was not only the driver of Kenya's economy, but also the means of livelihood for the majority of Kenyans (Government of Kenya, 2009). Currently, the agricultural sector comprises the following sub-sectors: crops, livestock, fisheries, land, water, cooperatives, environment, regional development and forestry. The sector also includes the development of arid and semi-arid lands (ASAL). Thus, there are many players and stakeholders in the sector due to its role in the economy and its rural-based nature, touching on the livelihoods of many people. The interdependence of sectors from the forest perspective is that forests provide a wide range of economic, environmental and social goods and services such as raw materials for the wood-based industries, employment, soil stabilization, carbon sinks and water catchments that protect the rate of flow and quality of water discharged by the rivers draining these catchments.

Forest health is therefore a big determinant of how productive forests can be to supply goods and ecosystem services to various sectors of the economy. The institutions most closely associated with forest health in Kenya are found in different ministries. It is advisable for them to collaborate more closely in order to ensure sustainable supply of goods and services. Some of them were drawn into this study and their perceived roles are as outlined below.

4.3.7 Kenya Plant Health Inspectorate Service (KEPHIS)

IPPC recognizes KEPHIS as the NPPO for Kenya. KEPHIS contributes to harmonization of sanitary and phytosanitary procedures at international level. At COMESA level, a process for harmonization of seed certification for trade purposes was launched in 2014 and KEPHIS became fully engaged in it. Another on-going

initiative is a tri-partite arrangement for harmonization of sanitary and phytosanitary procedures within three regional trading blocks: EAC, COMESA and SADC. The calendar of activities had already been developed and adopted at the time of this study and adoption of a common protocol was the expected outcome of the process. KEPHIS continued to provide the necessary comments on technical documents, protocols and Sanitary and Phytosanitary Standards (SPS) in such international processes.

According to a strategic plan for 2013-2017, protection of plant resources and trade facilitation are strategic themes of KEPHIS. The issues dealt with here include how to handle increased numbers of pests, weeds and invasive species as well as the need to enforce compliance with market requirements. For enhanced agricultural productivity, KEPHIS, in the same plan, also addresses seed quality, soil fertility, irrigation water quality and facilitation of international trade through food safety analyses, export certification and inspection, analysis of pesticide residues and contaminants in agricultural produce as well as undertaking import and export approvals and documentation. The organization is guided by sixteen functional mandates during the current strategic phase including ensuring trade and standards under which IPPC and WTO agreements are implemented.

On forestry issues, consultation with forestry experts during the process of the just concluded harmonization of plant protection protocols for EAC was noticeably absent. This resulted in missed opportunities by Kenyan forest protection experts to contribute to development of the protocol. This omission can be corrected when reviewing other protocols, including draft standards in the pipeline, such as the COMESA protocol on trade in seeds and tripartite initiatives that were in progress.

KEPHIS is also responsible for inspection of plant goods at ports of entry and exit, particularly airports. The Service has installed declaration desks in ports where it handles importation and export of plant materials. This huge task requires high levels of awareness amongst port staff, traders and passengers alike of the risks associated with transporting even small quantities of plant material, including seed. Port staff are expected to guide bearers of any plant material to seek advice at such declaration points in Kenyan ports.

Port inspection staff follows ISPM No. 21 guidelines for handling regulated non-quarantine pests. The procedures require passengers to declare any plant material they carry for inspection and cargo to be held in custom-bonded warehouses before it is cleared for importation. In the course of this study, it was noted with concern that staff handling such materials are guided by an outdated plant import order book published in 1971. For cargo, import permits stipulate that pre-clearance and phytosanitary certificates from the country of origin are required to support clearance of consignments. Samples of the imported plant consignment are tested for verification using visual indicators of damage or rapid result tests for viral loads. Not to be overlooked is the danger of spread of tree pests and diseases as posed by wood packaging material (pallets) for which ISPM No. 15 applies. The packaging

material is inspected and is expected to bear a stamp indicating it underwent heat and fungal treatment and carries no known pests from its origin.

KEPHIS also plays a key role in regulating the process of deliberate importation of biological control agents and serves as the Secretariat to the Kenya Standing Technical Committee on Imports and Exports (KSTCIE). In this regard, it issues permits for import or export of agents. Requests for import or export of such agents follow a process using standard dossiers which are completed and submitted to KEPHIS for scrutiny in advance. Based on them, decisions are reached to:

- approve importation with or without requirement for quarantine,
- disapprove importation, or,
- recommend further trials, where deemed necessary.

The procedure followed in clearing plant material for import is that samples are collected and processed in laboratories at KEPHIS Plant Quarantine Station where they are tested to determine the status of larger cargo consignments held in the custom bonded warehouses. A test nursery is maintained in the station for screening ornamental material. For large quantities of imports, KEPHIS has licensed open, bulk quarantine sites in biologically isolated locations for seed potato, for instance. A pest risk analysis is conducted to reveal the pests that occur in both countries and management options are tested while material is in quarantine. ISPM No. 34 is followed. It was noted that a quarantine facility was under construction in KEFRI and on completion, commissioning and becoming fully functional in the near future would operate under KEPHIS supervision to handle importation of forest pest biological control agents.

With an increasing level of trade in tree and forest products to meet Kenya's supply deficit, the most common precaution taken by port inspection staff is to ensure wooden poles are debarked and treated before importation while standard procedures are followed for inspection of cargo once it arrives at ports of entry. It was clear that making current pest alerts on forest and tree pest and disease available at ports for reference by inspection staff would serve a very useful purpose and backstop forest material inspectors with technical information.

On capacity building of staff of KEPHIS and the wider EAC/SADC/COMESA region in sanitary and phytosanitary measures, KEPHIS Headquarters hosts a Centre of Phytosanitary Excellence (COPE) with a residential, laboratory, classroom and field exercise capacity to handle pest risk analysis, pest surveillance and diagnostics, phytosanitary inspection and compliance. Training courses can be tailored for specific needs of NPPOs in Africa. COPE is managed by a secretariat at KEPHIS in collaboration through an MoU with the University of Nairobi. Its policy issues are determined by an advisory board with representatives from a range of African and International organizations, i.e.:

- Three African National Plant protection Organizations (NPPOS), including KEPHIS;

- University of Nairobi (UoN);
- Inter-African Phytosanitary Council (IAPSC) of the African Union;
- Secretariat of the International Plant Protection Convention (IPPC);
- Netherlands Plant Protection Service (NPPS);
- FAO Regional Office for Africa;
- Horticultural Council of Africa (HCA); and,
- CAB International (CABI).

Among short courses offered at COPE are:

- Updated Phytosanitary Systems Short In-service Courses;
- Certification and import verification procedures for inspectors and technicians;
- Phytosanitary systems improvement and management for phytosanitary managers and senior technical staff;
- Phytosanitary skills enhancement course for subject matter specialists and technicians; and,
- Re-orientation phytosanitary course for university lecturers and trainers in institutions of higher learning.

Kenya's capacity for tree and forest disease and pest management is thus spread across different local and international institutions.

4.4 RWANDA

Rwanda is a member of EAC and COMESA. At regional level, Rwanda also joined the COMIFAC, a regional organization in Central Africa which aims at promoting cooperation among ten country members in sound management of their forest resources.

4.4.1 Geography

Rwanda is a land locked country in Central Africa with a land area of 26 338 km^2 and a population of c. 11.3 million in 2015. Its GDP was USD 7.1 billion in 2012 with a real growth rate of 12%. Agriculture contributes 30% to the GDP (www.rdb.rw, 2016).

According to the national policy (2011), natural forests occur on 8% of the land area against 13% for manmade forests. Extractive utilization of natural forests is prohibited and forest plantations cater for all needs of Rwandans. From 2010, an average of 23 700 ha of forests would have to be created each year for achieving the target for 2020. This is an ambitious target considering that Rwanda is dominated by traditional subsistence farming and there are many competing land-based uses.

Due to a high population density (387 inhabitants/km^2 in 2009) (Republic of Rwanda, 2010) farming land per household is decreasing and most of the soils have been exhausted. As a result, cultivation is spreading into marginal areas, particularly on steep slopes, leading to widespread landslides, soil erosion and siltation of water bodies. These challenges, however, are outweighed by the importance of forests as a key component of the life-support system in view of both the products and services they provide. Forests protect watersheds, thus making agriculture viable. They were reported to contribute up to 80% of total energy needs in 2007 (Republic of Rwanda, 2010). Furthermore, forests generate direct monetary income (revenues) for households, public entities and the country in general.

Against this background, the specific objectives of Rwanda's forest policy are to:

- Encourage the participation of the private sector to invest in forestry for poverty reduction, employment creation and improvement of livelihood through sustainable use, conservation and management of forests and trees;
- Contribute to sustainable land use through soil, water and biodiversity conservation, and tree planting through the sustainable management of forests and trees;
- Strengthen the participation of communities and other stakeholders in forest management to conserve water catchment areas, forest biodiversity and ensure sustainability of the forest sector;
- Promote farm forestry to produce timber, wood fuel and to supply wood and NWFPs;
- Promote forest extension to enable farmers and other stakeholders to benefit from forest management approaches and technologies; and,
- Promote forest research, training and education to ensure a vibrant forest sector.

The current national development pathway for Rwanda is guided by Vision 2020, a blueprint for 20 years that was launched in 2000. Built on six pillars, it places greatest emphasis on good governance and addresses the cross cutting issues of gender equality, environmental conservation and natural resource management. It sets transformative goals of achieving annual per capita income of USD 900 (USD 644 in 2012), a poverty rate of 30% (64% in 2000) and an average life expectancy of 55 years (49 years in 2000). The initial state of land, water, flora and fauna and nonrenewable resources was recorded as deplorable following massive deforestation, depletion of bio-diversity, erosion and landslides, pollution of waterways and the degradation of fragile ecosystems, such as swamps and wetlands. Dependency on wood for energy was also regarded as too high, standing at 94% during the base year of the Vision (Republic of Rwanda, 2000; www.rdb.rw, 2016).

Opportunities for forest development identified in V2020 include a target to achieve at least 20% forest cover in Rwanda. Soil protection measures were set

to achieve 90% success level and reforestation targets on per ha basis were part of the indicators of achievement of the vision. The vision is being implemented through the medium term planning framework that began in 2002 with the first Poverty Reduction Strategic Plan (PRSP I). This has since been followed by the Economic Development and Poverty Reduction Strategy (EDPRS) which covered the period of 2008-2012. In line with this, the Government has embarked on the second Economic Development and Poverty Reduction Strategy (EDPRS 2) to be implemented from 2013/14 to 2017/18.

The contribution of forestry resources to economic growth and poverty reduction is expected to be attained by the increase of forest cover across the nation as well as the increase and sustainable management of ecosystems and forestry resources. Thus, Rwanda's EDPRS II retains forestry as a main focus in recognition of its prime contribution to the GDP. Targets to be achieved through increased job creation in forestry range from 0.3% to 0.5% by 2018, a reduction in the use of biomass energy through the use of improved stoves is expected and improved kilns are expected to produce 75% of charcoal by 2018. EDPRS II also supports the previous target of increasing forest cover to 23.5% by 2012 and has reset the cover indicator to reach 30% by 2018. In addition, EDPRS II recommends sustainable management of forest biodiversity and critical ecosystems through protection and maintenance of 10.25% of the land area and reduction of wood energy consumption from 86.3 % to 50% by 2020 as reflected in the 2020 Vision targets (Republic of Rwanda, 2013).

Figure 6: Nyungwe National Park, Rwanda is a reservoir of biodiversity. Here we get an aerial glimpse of the forest from the Uwinka Look Out suspended bridge. Photo credit: Amini Mutaganda.

4.4.2 Inter-sectoral collaboration in tree and forest pest and disease management in Rwanda

The forestry targets set in Vision 2020 took into account the high competition between forests and agriculture, stemming from high population pressure. Land with a 30 % slope or more is used for agricultural crop production instead of being used for forestry as provided for in the land use master plan. The misplacement of agriculture on unsuitable land that better suits forestry diminishes capacity for producing wood materials and protecting degraded land. An inherent weakness of forest research has also resulted in key issues not receiving due attention as deserved because more emphasis was previously put on food crops and livestock rather than trees. Recent re-organization of the administration of the forest sector has resulted in the creation of the Rwanda Natural Resources Authority (RNRA) after the merger of former units, *viz.* the National Land Centre (NLC), the National Forestry Authority (NAFA), the Rwanda Office of Geology and Mining (OGMR), and the department of Integrated Water Resources Management that was hosted within the Ministry of Natural Resources (MINIRENA). The new institution was established in 2011 and has four Departments:

- Forestry and Nature Conservation;
- Lands and Mapping and Office of the Registrar of Land Titles;
- Integrated Water Resources Management; and,
- Geology and Mining

4.4.3 Insect pests and diseases of trees and forests in Rwanda

Records of forest and tree pest and disease incidences and management in Rwanda are scanty in literature. A visit to the country in the course of this study confirmed that problems are indeed encountered but are not reported. This was attributed to past institutional arrangements where recognition of the forest sector took a lower ranking than agriculture when both sectors were under the same administrative structures. A recent re-organization (as just described above) has already taken effect to improve the situation.

4.4.4 Capacity for sustainable forest pest and disease management in Rwanda

A workshop took place in Kigali in July 2015 seeking to improve information gathering on forest pests and diseases and to foster better collaboration between RNRA and MINAGRI, MINIRENA, RAB, UR and FAO. The recommendations made included strengthening collaboration with the University of Rwanda in conducting research on forest pest and diseases, establishment of long term research plans in forestry (especially on eucalyptus trees) and capacity building in management

of forest pests and diseases. An important message from this workshop was that almost all forest pests and diseases were likely to be favoured by a warmer climate. It was reported at this workshop that *Eucalyptus* spp. were infested with *Thaumastocoris peregrinus* (Bronze bug) in most areas of Rwanda.

In September 2015, RNRA led a qualitative baseline survey in different agro-ecological zones to document pests and diseases of dominant tree species in Rwanda. Quantitative surveys were expected to follow in order to generate up-to-date information on forest health in Rwanda (Ntirugurirwa, pers. comm., 2015). In the meantime, Rwanda subscribes to an international pest management arrangement whereby national institutions, including the Rwanda Agriculture Board, the Ministry of Agriculture, University of Rwanda and local governments support and run plant clinics. Code named 'Plantwise', it is a CABI initiative where 33 such clinics have been established and 214 'plant doctors' trained in Rwanda, thus helping farmers to diagnose plant pests and diseases. Occurrences of forest pests and diseases are documented and the doctors rely on standard fact sheets available on an internet website, some among which cover trees growing in their localities. Information technology gives the doctors access to a wide range of plant health resources. They respond to queries via mobile phone services and send management recommendations to farmers via SMS. Data collected is submitted electronically to national data managers for wider dissemination.

4.4.5 National Institute of Statistics (NISR)

A department capturing forest statistics was recently established in NISR. Working closely with RNRA, NISR is developing an on-line software called FMIS for capturing forest data. With 22 indicators now finalized, a baseline survey was scheduled to take place by June 2016. A common analysis of the data is expected to benefit both institutions.

Monthly trade surveys are also carried out by NISR in collaboration with local governments whose responsibility is to issue permits for formal trade in commodities, including tree and wood products. Information on volume and value of forest goods traded is gathered through RNRA officers working in District environment/forest offices. Reports of cross border trade are prepared on a quarterly basis by NISR. Formal trade statistics (based on exports and imports) is sourced from the RRA Customs Department. This is a commendable arrangement for tracking movement of plant materials given that even small volumes of infested wood or tree products traded have potential to spread pests and diseases of trees and forests. Tracing the source and destination of such products can serve a useful purpose in management of pests and diseases.

4.4.6 Rwanda Agriculture Board (RAB)

A tree arboretum is managed under the Southern zone of RAB in Ruhande. In its grounds stands an old forestry research establishment which dates back to the 1930s. The arboretum comprises of many species of trees, both indigenous and

exotic. The library of the station has a record of *Cinara cuppressi* (cypress aphid) reported in Rwanda in 1990. At the time of the study visit, it was observed that eucalypt and pine stands in the arboretum were dying back in patches due to a suspected, unidentified disease. The health of other old trees of different species appeared to be declining and some were already decaying while still standing (as evident from mushroom bodies at the bases of their trunks). This was not formally reported. This situation was attributed to funding constraints as well as having no scientist specialized in forest pathology or entomology to detect and report the problems. Personnel with diverse research interests and specializations were posted to the arboretum in RAB and to the University of Rwanda arboretum in Butare, as well as in private practice but none was a forest health specialist. It was further acknowledged that monitoring and detection of pests and diseases, when occasionally done, was often informal in nature, involving observations made by foresters and forest workers while carrying out other activities in the field. The situation clearly demonstrated an urgent need for capacity building in forest pest and disease management in Rwanda, especially since eucalypts which are widely grown and are an economic backbone for the forest sector were faced with different pest and disease threats at the time.

4.4.7 Rwanda Development Board

Nyungwe National Park is a trans-boundary natural forest that is shared with Burundi (where it is known as Kibira National Park). Its management plan revolves around key ecological attributes such as primary, secondary and bamboo forests as well as wetlands. The Nyungwe ecosystem is recognized as a site of global importance for its biodiversity and endemism values, which is among the highest within the biologically rich Albertine Rift eco-region (RDB, 2011). The Park contains 20% of all African primates with 13 different species. It is also extremely rich in birdlife with 275 species, 24 of which are endemic to the region. There is also an extremely rich plant life with more than 240 species of orchids. The forest thus plays a key role in conservation and renders invaluable services to the national economy and local communities.

Forest fires and invasive plant species are regarded as threats to the Nyungwe ecosystem. In particular, the liana *Sericostachys scandens* is a widespread indigenous invasive climber that colonizes recent forest gaps, leading to large mono-dominant forest patches that can span over many hectares. The resulting decrease in biodiversity is a serious concern for park management (RDB, 2011). An outbreak of defoliators (caterpillars) in the natural forest also caused concern in 2012 but was soon after reported to be under control. The infestation started in the outlying pine forest which occupies 7 000 ha along its periphery and acts as a buffer zone, then spread to *Newtonia buchananii*, an indigenous species that is dominant in the park and to an undergrowth shrub, *Alchornea hirtella*. The last major infestation in the park by this caterpillar was in 1996 (Ndikubwimana, 2012). There were no scientific reports made concerning its identification or population dynamics.

4.4.8 New Forests Company

From 2011, RDB entered into a concessionary arrangement with New Forests Company, which took over responsibility for management of the existing Buffer Zone of Nyungwe National Park that covers 10 080 ha. The zone features exotic forest plantations with potential for replanting denuded areas using enrichment planting involving both indigenous hardwood trees as well as commercial exotic species, such as pine (RDB, 2011). Silvicultural methods are followed in mitigating pest and disease incidents in the plantations. A case in point is the current stocking of *Eucalyptus maidenii* which stands at 1 111 stems/ha and is expected to reduce water stress and give trees vigor to grow and resist pests and diseases. Care is taken that tree species are grown in sites that best match their requirements and to which they are well adapted (for example, *E. maidenii* is grown at altitudes between 1 900 and 2 900 m, with 21-23° C mean day temperature and 11-14° C mean night temperature). They are found to perform satisfactorily. Having taken such precautions, regular scouting for diseases and pests of plantations is also undertaken but nothing of concern had been reported yet.

Risks associated with monoculture planting are also mitigated by establishing tree nurseries of *E. grandis* only from certified high quality seed with guaranteed improved yield performance of 5% to12%. This is a costly undertaking at USD 3 800 – 4 000 per kg of seed but the expected fiber quality and genetic gain are considered well worth the investment. The goals and objectives of the company are for increased stock and yield per unit area under concession when compared to past performance. At the time of the study visit, planners were also busy remapping the forest blocks of which 5 have been done and 10 remained to be mapped over the next six months. When these were ready, a 5-year harvesting and replanting management plan was to be adopted for pole production based on annual growth curves.

Operations at New Forest Company are due for certification by the Forest Stewardship Council (FSC). Research, monitoring and corporate social responsibility (CSR) programmes with local communities are key requirements for certification. New roads had been opened for better access to the forest during harvesting and in the event of fire. They additionally acted as fire breaks in an area where beekeepers use traditional harvesting methods to gather honey in the adjacent natural forest and such practices pose a real danger of starting fires during the dry season (end of May until mid-September). A priority of the CSR programme was therefore to introduce safer, modern technologies of beekeeping to the local community.

A concern about lack of local forest health expertise was expressed by the New Forests Company and it was confirmed that it relied on expensive external expertise for advice when necessary.

4.4.9 Rwanda Natural Resources Authority

Several reports of insects attacking *E. maidenii* in the lower western region of Rwanda caused concern after affected trees died. The pests were suspected to be *Leptocybe invasa,* a gall wasp whose common name is the blue gum chalcid. Damage symptoms were described as initial deformation of shoots followed by drying. It was thus necessary to proceed with full identification of the pest in order to develop an appropriate management programme for it.

Other reports of diseases and pests included attacks on Eucalypts by borers in the aftermath of droughts. The agent responsible was reported to be a beetle but it was not identified by its scientific name. The RAB laboratory in Rubona received specimens but the staff there were unfamiliar with the beetle as there was no reference collection of forest pests in Rwanda. Unfortunately, the matter was not immediately pursued any further by RNRA and by the time of the study, the beetle was not fully identified and no further action taken for its management.

The above described tree health challenges in exotic plantations in Rwanda and lack of management programmes were indications that little information on tree and forest pest management trickles into Rwanda from neighboring countries. Most of the literature to which the persons concerned referred was about Australia, where eucalypts originate from, and pests or diseases that occur there. The Plantwise clinic data base in particular had fact sheets dwelling on potential invasiveness of exotic tree species and not on their economic value when grown in plantations or as trees on farms. The content thus did not match the expectations of those seeking information on management of the pests and diseases.

A regional study of the current nature was much appreciated by RNRA as it confirmed that similar problems faced by Rwanda's East African neighbors had long been contained using the classical biological control approach. The interventions had saved large areas of plantations of affected species, such as cypress, and these were still standing as commercial crops or for other use in Kenya and Ethiopia, for example. It was also encouraging for RNRA to learn that major steps had been made in Kenya towards control of the gall forming blue gum chalcid, which was reported in Rwanda in the recent past. As such, RNRA expressed keen interest to collaborate with other organizations in the study region and beyond, especially in information sharing and capacity building in tree and forest pest and disease management.

4.4.10 Ministry of Agriculture

Rwanda ratified the IPPC in 2009 as a move to increase international trade in plant products. The Ministry of Agriculture acts as the national plant protection organization. It has weak linkages with RNRA. There is need to strengthen information sharing between the two organizations with respect to pest risk analysis for quarantine and management of regulated non-quarantine pests and diseases of trees and forests in Rwanda.

4.5 CAPACITY FOR FOREST PEST AND DISEASE MANAGEMENT IN RWANDA

Forest pest and disease surveillance was undertaken through a recent baseline survey conducted by RNRA. Its results could provide information leading to identification of priority areas for follow up based on host species, causal agent, damage caused, severity of symptoms and location. Some of the pests and diseases reported might already have been encountered and studied elsewhere in the East African sub-region on tree species that grow in more than one country. As such, collaboration with neighboring countries is recommended as it would give Rwanda several tried and tested management options to consider.

Rwanda has no entomologist or pathologist currently working in the country specialized in local tree or forest insect and disease management. Additionally, the current research capacity in taxonomy of individuals and concerned institutions in Rwanda is weak. It is therefore advisable to outsource specimen identification services internationally in the short term while developing a long term strategy to strengthen local capacity in integrated pest management.

The staff responsible for forests who have a general foundation in agriculture could also be encouraged to pursue post graduate training in reputable forestry schools (preferably with examinable coursework) and, where possible, arrangements should be made for their field projects to be carried out back home in Rwanda.

5. Lessons Learnt

This study of forest and tree pests and diseases revealed that countries in the East African Sub region are individually working towards sustainable national and global development goals on the basis of ambitious blueprints on which current policies and legislation are anchored. Forests are recognized as serving both consumptive and ecological functions. One key challenge for SFM is to supply enough wood to match heavy dependence on biomass energy for domestic and industrial use. Other purposes served by trees and forests include provision of diverse wood and non-wood products.

In Rwanda, the human population density is very high and agriculture is one of the land uses competing with forests. This, however, has not been a setback to achieving increased forest cover. From 2002, Vision 2020 incorporated farm forestry development into its programmes to such an extent that the set target of 20% forest cover achievable by 2020 has recently been revised upwards as it is expected to be exceeded. All in all, Rwanda's successful reforestation has set a good example for the other countries in the region to follow, considering Ethiopia is the second most populous country in Africa and other countries also have rapidly increasing populations. Kenya can find inspiration in Rwanda's achievement as the country works towards achieving a 10% forest cover by 2030, a much softer target under the circumstances. Sudan's targets for forest cover are not explicit but the guiding strategy basically addresses combating desertification and accommodates conservation of forests on whose goods and services the population is highly dependent. From the perspective of forest health, paying more attention to the condition of forests will ensure they continue to meet a growing demand for goods and services and yield more volume within the limited area that is set aside for them.

Requirements for tree and forest pest and disease management in the region therefore include:

- Surveillance at periodic intervals to document the health status of key forest types (natural and plantation) in representative ecological zones in each country. It is important to emphasise that scientific identification of forest insect pests and diseases is absolutely essential as it forms the basis for effective management interventions. The challenges faced, whether biotic and abiotic, should be documented and changes associated with climate change noted over time. Such findings would be used locally (first to inform policy on SFM) but could also be shared widely (regionally and globally) to inform others of any precautions necessary in international plant material exchange. Such actions could curb the spread of invasive plants, pests and diseases associated with tree and forest products and prevent outbreaks, as Australia and South Africa have learnt and shared (www.biosecurity.qld.gov.au; Dittrich-Schröder et al., 2012)

- Adequate research infrastructure and funding will be required to address the pest and disease situations of concern in the countries of East Africa. This calls for recruitment and retention in adequate numbers of qualified staff and investment in their further training for skills development. Where they exist, laboratory facilities should be well maintained and where they are under-staffed or inadequately equipped, the short to medium term solution might lie in reaching out to other organizations for collaboration within and outside the countries as necessary. This has been demonstrated as a practical strategy by Ethiopia.
- More cooperation is necessary at regional level. The countries in the region depend heavily on planted forests to supply products and have several exotic tree species in common. This situation is risky given that, unless timely action is taken when a pest or disease is reported by one country, it may find its way into another. A more efficient and integrated regional pest management system can be achieved by pooling scanty resources for mutual benefit of individual countries. There have been proposals for setting up networks like the Forest Invasive Species Network for Africa (FISNA) and the Tree Pest Management Network, and about the form such regional cooperation could take but none have worked effectively so far.
- The African Phytosanitary Council, supported by AU, which bridges continental and global plant health concerns, is an existing institution that can coordinate efforts to contain spread of pests and diseases through movement of plant material as it delivers on its IPPC mandate.
- There also exists a centre of excellence in KEPHIS (COPE) where courses on phytosanitary measures are conducted for the region. Courses on forest pests and disease management are not offered yet.

6. Conclusions

Trees and forests in East Africa broadly occur in afro-montane, savanna woodland, semi-desert and mangrove zones where they grow as indigenous forests, plantations or in agroforestry configurations. In all these situations, they are subject to changes in biotic and abiotic factors that can cause significant loss in tree production or products. All the countries selected for this study have long term plans and targets to increase their forest cover and to reduce pressure on forests which supply their populations with various goods and services.

Relatively few exotic tree species have been widely planted in the region. These tend to be especially prone to pest and disease attack after an initial phase with fewer attacks following introduction of tree species in new environments. The agents responsible for damage are sometimes those with which trees are associated in their countries of origin and at other times those present in areas where they have been introduced. Losses associated with tree and forest pests and diseases have been reported to lower yields and even cause planting of high yielding species to be abandoned in the worst case scenarios. There is a need to monitor the situation more consistently and to take timely action in bringing back ecological equilibrium as soon as possible following disturbances. This balance is expected to become more fragile with climate change.

The countries included in the study have varying institutional capacities for handling pests and diseases of trees and forests. The best equipped is Kenya with its well trained personnel who can diagnose problems and prescribe integrated management for the diverse situations. There is need for infrastructure and funding to compliment the personnel which ought to be taken into account to further improve the situation. Each country faces unique circumstances and challenges which internal collaboration and better communication between local and international stakeholders can help to improve upon.

At the regional level, there is room for exchange of information and sharing resources in combating threats by fire, pests or diseases affecting trees and forests across territorial boundaries. The most appropriate manner for achieving this would be to develop common approaches for solving common problems, as is done in the East African Community by adoption of a common sanitary and phytosanitary protocol (EAC-SPS). Such cooperation has further been demonstrated by adoption of harmonized customs protocols as well as laws and regulations governing SFM in EAC. Other initiatives, like adoption of common phytosanitary measures adopted from international agreements will be even more effective when passed through regional bodies to individual countries. COMESA is the trading block to which all the countries in the study region belong and common sanitary and phytosanitary initiatives made at that level will benefit all countries in the sub-region. IGAD also

subscribes to the ideals of COMESA and covers the study region in the horn of Africa. An on-going harmonization and regulation of seed trade in a tripartite arrangement covering COMESA, SADC and EAC points the way forward in other matters related to tree and forest health in Africa as a whole. The Great Green Wall of the Sahara and Sahel Initiative provides yet another opportunity for the countries in the study region and beyond to collaborate on SFM.

In the countries covered by this study, international trade in timber and non-timber products has taken root and is an avenue through which pests and diseases can spread widely to new areas unless keen inspection is made at points of entry and only clean material is exchanged. The current situation is nearly overwhelming for the personnel available in the concerned national plant protection organizations. They barely manage to deal with agricultural commodities yet the time is right to strengthen the capacity to handle tree and forest products also in cognizance of increasing trade in wood and NWFPs. It is therefore necessary to train more personnel and post them in key ports to expand scope of surveillance.

7. Recommendations

7.1 PROMOTE ADOPTION OF INTEGRATED MANAGEMENT OPTIONS

Several options are available for management of forest and tree pests and diseases when an integrated approach is followed. Some outbreak situations, such as in seed stores and tree nurseries, are confined and under these circumstances it is appropriate to choose chemical application for management of pests and diseases. In the field, silvicultural control may begin as early as when tree species are matched with conditions prevailing in planting sites. Poorly matched trees perform badly and the resultant lack of vigour and stress make them more vulnerable to pest and disease attack. Other influential factors are the quality of germplasm available, timing of planting, initial stocking density, subsequent thinning, pruning and weeding regimes. Whether to plant trees as single or mixed species also determines their susceptibility to potential outbreaks of pests or diseases.

Biological methods also work well and depend on natural enemies that regulate pest and disease levels in natural conditions. Where classical biological control introduces a new insect or organism in a situation where an exotic pest or disease has taken hold on an exotic tree host, it is important to be sure of the identity of the pest or disease and its associated biological control agents in order to select a host-specific candidate with least impact on non-target organisms. Thorough studies of the biology of the concerned organisms are required and success is often very high and long lasting where the selection and matching is done with appropriate care. The approach is further supported by having functional quarantine facilities and following recommended procedures which FAO has developed as best practices for pest and disease management in forestry (FAO, 2011).

Each country covered by the study is therefore encouraged to conduct a self-assessment to determine which measures it can take to improve on the current pest and disease situation, using the integrated pest management approach.

7.2 POLICY IMPLEMENTATION TO COVER SURVEILLANCE AND MONITORING OF PESTS AND DISEASES

Countries where research informs policy and leads to increased productivity of trees and the products derived from them may be considered progressive. Kenya has acknowledged this need in its draft forest policy where it seeks scientific inputs in order to contend with low productivity of tree crops, low conversion efficiency and

weak value addition schemes. Forest productivity is proposed to be enhanced further by conducting regular surveillance and monitoring of incidents of forest pests and diseases. Economic threshold levels can thus be determined and action taken where necessary for timely protection of susceptible trees from further damage. This positive development in policy formulation is one that other countries can consider adopting and is achievable if gaps in research capacity and knowledge management systems are filled. In all cases, it will be of great help to capture data on area of forests affected, value of forests and volume of products traded in order to estimate level of loss of revenue and services caused by pests and diseases in the study region.

7.2.1 Coordinated regional action in response to pest and disease reports

All the countries covered in this study are signatories to the IPPC. The time has come to raise the profile of forest pests and diseases in the Eastern African subregion under this arrangement for members of the AU-IAPSC. Pest risk analysis as related to trees and forests can be given more prominence than in the past where agricultural pests and diseases overshadowed them. At country level, the designated national plant protection organizations would be best placed to coordinate action by different sectors whenever pest or disease outbreaks are reported. Channels of communication between the different stakeholders need to be enhanced and facilities and funding available utilized jointly in the most effective manner. Pest alerts and other technical information need to be shared in a coordinated fashion within and between countries to contain potential outbreaks.

Regional Economic Communities are likewise members of the AU-IAPSC, bringing together different countries at continental level. It is therefore recommended to expand the mandate of the recently launched information exchange platform of the Council (known as Rapid Alert and Response System for Plant Pests and Diseases in Africa) to include coverage of forest pests and diseases. This would serve as a regional surveillance network, starting with the Eastern Africa region as planned before extending to the rest of the continent. For immediate action, the Council can also be approached by the ***African Forest Forum*** and made aware of the findings of this study which covers EAC and COMESA countries. The two parties can then propose a joint project to organize relevant meetings on training, coordination and transfer of technologies at sub-regional level as this is within the mandate of AU-IAPSC. Any country needing further advice on plant protection can also approach the Council on its own for assistance.

The existence of a Center for Phytosanitary Excellence in KEPHIS is good for the East African sub-region. Each country covered by the study is encouraged to assess its capacities in phyto- sanitary measures and to approach COPE for in-country training tailored to meet its needs. Trainees can also attend general courses in this field. At the same time, organizers of the training can review the range of courses on offer at COPE and expand their scope or formulate new ones to adequately cover tree and forest pest and disease management for the African region.

8. References

Abdallah, J.M. and G.G. Monela, 2007. Overview of Miombo Woodlands in Tanzania. Working Papers of the Finnish Forest Research Institute 50: 9–23.

Abdi, A.I. and E.I. Seid, 2013. Assessment of Economic Integration in IGAD. The Horn Economic and Social Policy Institute (HESPI). Policy Paper No. 13/2. 32 pp.

Alemu, G., A. Yirgu and Habtemaria Kassa, 2014. First report of *Lasiodiplodia theobromae* causing canker on tapped *Boswellia papyrifera* trees in Ethiopia. New Disease Reports 29, 11 pp.

Alemu, G., J. Roux and M.J. Wingfield, 2003a. Diseases of Exotic Eucalyptus and Pinus species in Ethiopian Plantations. *South African Journal of Science* 99: 29-33.

Alemu, G., J. Roux and M.J. Wingfield, 2003b. First report of pink disease on *Eucalyptus camaldulensis* in Ethiopia. *Plant Pathology* 52: 402.

Alemu, G., J. Roux, G.C. Hunter and M.J. Wingfield, 2006. Mycosphaerella species associated with leaf disease of *Eucalyptus globulus* in Ethiopia. *Forest Pathology* 36:253–263.

Alemu, G., M-N, Cortinas, M.J. Wingfield and J. Roux, 2005. Characterizaton of the coniothyrium stem canker pathogen on *Eucalyptus camaldulensis* in Ethiopia. *Australasian Plant Pathology* 34:85-90.

Baldo, N.H., 2009. Survey of forest pests and diseases in eastern mountains of southern Kordofan. Forestry Research Centre, Sudan. Annual Report 2008 - 2009. 3 pp.

Bekele, M., 2011. Forest Plantations and Woodlots in Ethiopia, African Forest Forum Working Paper Series. Vol. 1 Issue 12. 52 pp.

Bekele, M., 2001. The forest revenue system and government expenditure on forestry in Ethiopia. FAO Working Paper FSFM/WP/04. 50pp.

Bekele, M., 2015. The context of REDD+ in Ethiopia: Drivers, agents and institutions. CIFOR Occasional Paper No. 127.

Burman J., A. Bowden and A. Gole, 2014. Land Tenure in Somalia: A Potential Foundation for Security and Prosperity.

Chidumayo, E., 2011. Climate change and the woodlands of Africa. In: E. Chidumayo, D. Okali, G. Kowero and M. Larwanou (Eds.): Climate Change and African Forest and Wildlife Resources. African Forest Forum. p 85-101.

Dittrich-Schröder, G., M.J. Wingfield, B.P. Hurley and B. Slippers, 2012. Diversity in Eucalyptus susceptibility to the gall-forming wasp *Leptocybe invasa*. *Agricultural and Forest Entomology* 14:419–42.

East African Community Protocol on SPS. 11 pp.

El Atta, H.A., 2000. Effect of diet and seed pretreatment on the biology of *Bruchidius uberatus* (Coleoptera, Bruchidae). *Silva Fennica* 34(4):431–435.

El Tahir, B.A., K.E.M. Fadl and A.G.D. Fadlalmula, 2010. Forest biodiversity in Kordofan Region, Sudan: Effects of climate change, pests, disease and human activities. *Biodiversity*

11(3-4):34-43.

Environmental Policy of Ethiopia. 2007. 29 pp.

FAO Sub-regional Office for East Africa, undated. Cypress aphid pest control in Ethiopia. 5 pp.

FAO, 1997. International Plant Protection Convention (IPPC).

FAO, 2000. FRA 2000. On definitions of forests and forest change. Forest Resources Assessment Programme. Working Paper 33. 15 pp.

FAO, 2001. Protecting plantations from pests and diseases. Report based on the work of W.M. Ciesla. Forest Plantation Thematic Papers, Working Paper 10. Forest Resources Division. FAO, Rome (unpublished).

FAO, 2006. Sudan National Forest Policy statement. TCP/SUD/2903 (A).

FAO, 2007a. Overview of forest pests of Sudan. Working Paper FBS/31E. 14 pp.

FAO, 2007b. Overview of forest pests of Kenya. Working Paper FBS/20E. 22 pp.

FAO, 2008. Understanding forest tenure in Africa: Opportunities and challenges for forest tenure diversification. Forestry Policy and Institutions Working Paper 19. FAO, Rome, 393 pp.

FAO, 2011. Guide to implementation of phytosanitary standards in forestry. FAO Forestry Paper 164.

FAO, 2012. Forest Pest Species Profiles. *Leptocybe invasa*. Blue Gum chalcid (Hymenoptera: Eupholidae).

FAO, 2015. Global Forest Resources Assessment 2015. How are the world's forests changing? FAO, Rome.

FNC, 2011. Supplement to Expression of Interest in Joining the Forest Carbon Partnership Facility (FCPF). 6 pp.

Government of Kenya, 2007. Kenya Vision 2030.The Popular Version.

Government of Kenya, 2009. Agricultural Sector Development Strategy 2009-2020. 160 pp.

Government of Kenya, 2013. V2030 Second Medium Term Plan (2013-2017). Ministry of Devolution and Planning.

Government of Kenya, 2014. Statistical Abstract. Kenya National Bureau of Statistics.

Government of Kenya, 2015. Draft National Forest Policy. Ministry of Environment, Water and Natural Resources.

Government of Kenya, 2015. Forest Conservation and Management Bill.

Government of Rwanda, 2011. National Forest Policy of Rwanda.

Jenoh, E.M., undated. Insect pest infestation on mangrove forests of Kenya: Identification, threats and impacts. PhD study proposal for 2011-2015. Kenya Marine and Fisheries Research Institute.

KEFRI, 2013. Kenya Forestry Research Institute Strategic Plan 2013-2018.

Kenya Forest Service, 2009, A Guide to On-Farm Eucalyptus Growing in Kenya. 36 pp.

Kenya Forest Service. Technical Note No. 40.

KEPHIS, 2013. Strategic Plan 2013-2018.

Lemenih M. and H. Kassa, 2014. Re-Greening Ethiopia: History, Challenges and Lessons. *Forests* vol. 5.

Lierop, P. van., E. Lindquist, S. Sathyapala and G. Franceschini, 2015. Global forest area disturbance from fire, insect pests, diseases and severe weather events. *Forest Ecology and Management* 352:78- 88.

MacDicken, K.G., 2015. Global Forest Resources Assessment 2015. What, why and how? *Forest Ecology and Management* 7:3–8.

IGAD, 1996. Agreement establishing The Inter-Governmental Authority on Development (IGAD), Assembly of Heads of State and Government. Nairobi, 21 March 1996.

Mbaka, J.N., L.S. Wamocho, L. Turoop and Waiganjo, 2009. *Journal of Animal & Plant Sciences* 4(1):289-297.

Mbinga, J., pers. comm., 2015.

Mekonnen, A. and R.A. Bluffstone, 2014. Forest tenure and reform in Ethiopia. In: Bluffsone, R.A. and E.J.Z. Robison (eds): Forest Tenure Reform in Asia and Africa: Local Control for Improved Livelihoods, Forest Management, and Carbon Sequestration. 304 pp.

Mugo, E., C. Nyandiga and M. Gachanja, 2010. Development of forestry in Kenya (1900-2007): challenges and lessons learnt. Kenya Forests Working Group, Nairobi, Kenya.

Mutitu, K.E., L. Mwangi, B. Otieno and M. Minjire, 2008. Pests and Diseases Associated with Eucalyptus in Kenya. KEFRI Research Note No. 7.

Mutua, J., J. Muriuki,, P. Gachie, M. Bourne and J. Capis, 2014. Technical Manual No. 21. ICRAF, Nairobi. 93 pp.

Mwangi, L., 2014. Pests and diseases of Eucalyptus and their management. KEFRI Brochure.

Ndikubwimana, I., 2012. Update on insects damaging Nyungwe Forest. Research & Monitoring Warden, Nyungwe National Park. 3 pp.

Njuguna, J.W., 2011. Stem canker and Dieback disease of *Grevillea robusta* Cunn ex R. Br. Doctoral thesis. Swedish University of Agricultural Sciences, Uppsala. 57 pp.

Ntirugurirwa, B., pers.comm., 2015. Research scientist, Ruhande Arboretum, Butare, Rwanda.

Odera, J., 1991. Pernicious Exotic Pests Affecting Forests and Forest Products in Eastern, Central and Southern Africa. Corporate Document Repository. FAO, Rome.

Okelo, O., 1972. Life History Studies of *Gonometa podocarpi aurivillius* (Lepidoptera: Lasiocampidae) in East Africa. *Ohio Journal of Science* 72(5):301-303.

Owino, F., 1991. Silvicultural methods of exotic aphid pest control: use of resistant strains of host trees. Corporate Document Repository. FAO, Rome.

Peltorinne, P., 2004. The forest types of Kenya. In: Pellikka, P., J. Ylhäisi and B. Clark (eds.): Taita Hills and Kenya – seminar, reports and journal of a field excursion to Kenya. Expedition reports, Department of Geography, University of Helsinki 40:8-13. 148 pp.

Plumtree, A.J., M. Masozera, P.J. Fashing, A. McNeilage, C. Ewango, B.A. Kaplin and I. Liengola., 2002. Biodiversity surveys of the Nyungwe Forest Reserve in S.W. Rwanda. WCS Working Paper No. 19. 95 pp.

Republic of Rwanda, 2000. Vision 2020. Vision 2020 Ministry of Finance and Economic Planning.

Republic of Rwanda, 2010. Strategic Plan for the Forest Sector 2009–2012. National Forestry Authority (NAFA).

Republic of Rwanda, 2010. Rwanda National Forest Policy. Ministry of Forestry and Mines.

Republic of Rwanda, 2013. Five year strategic plan for the environment and natural resources sector 2014–2018. Ministry of Natural Resources. 94 pp.

Republic of Rwanda, undated. Second Economic Development and Poverty Reduction Strategy (EDPRS 2).

Rinaudo, T., 2014. Rwanda Natural Resources. Technical Notes. World Vision Australia. 23 pp.

Roux, J., G. Meke, B. Kanyi, L. Mwangi, A. Mbaga, G.C. Hunter, G. Nakabonge, R.N. Heath and M.J. Wingfield, 2005. Diseases of plantation forestry trees in eastern and southern Africa. *South African Journal of Science* 101:409-413.

Rwanda Development Board, 2011. Management plan for the Nyungwe National Park, 2012-2021.

Speight, M.R. and D. Wainhouse, 1989. Ecology and management of forest insects. Clarendon Press, Oxford, UK, 374 pp.

Taylor, M., C. Ravilious and E.P. Green, 2003. Mangroves of East Africa. UNEP World Conservation Monitoring Centre. 24 pp.

Tree Pest Management Network, 2002. Newsletter No. 1. 5pp.

UNEP, 2010. Global Mangrove Extent Much Smaller than Previously Estimated. Global Environmental Alert Service. Thematic Focus: Ecosystem Management, Disaster and Conflicts, and Climate Change. 2 pp.

UNEP-FNC, 2011. Forestry and Woodfuel Project. Concept Note for a Joint Project by The Forests National Corporation and UNEP.

UNEP-UNDP, 2012. Alternative Energy and Green Economy Project Concept Note. Ministry of Environment, Forestry and Physical Development of Sudan.

Wabulem, T., pers. comm., 2015. Director General, Ethiopian Environment and Forestry Research Institute.

Weber, W., 1989. Conservation and Development on the Zaire-Nile Divide. An Analysis of Value Conflicts and Convergence in the Management of Afromontane Forests in Rwanda. PhD Thesis, University of Wisconsin, Madison.

Woldemariam, G.T., pers. comm., 2015. Director, Ethiopian Coffee and Forest Forum.

Wylie F.R. and M.R. Speight, 2012. Insect pests in tropical forestry. CABI, UK. 365pp.

Zomer R.J., A. Trabucco, R. Coe, F. Place, M, van Noordwijk and J.C. Xu, 2014. Trees on farms: an update and reanalysis of agroforestry's global extent and socio-ecological characteristics. Working Paper 179. ICRAF Southeast Asia Regional Program. Bogor, Indonesia.

Some internet homepages from which information, statistics and pictures have been collected:

www.agriculture.gov.au/

www.au-iapsc.org

www.biosecurity.qld.gov.au

www.edprs.rw/

www.en.wikipedia.org/wiki/IPM_CRSP

www.env.go.jp/nature/shinrin/fpp/database/partnership_case/jica.html

www.eoearth.org/

www.fao.org/forestry/fisna/en/

www.fao.org/forestry/FRA2015/CountryReports/

www.fao.org/forestry/sfm/en/

www.fao.org/sustainable-forest-management/toolbox/modules/forest-pests/basic-knowledge/en/

www.indexmundi.com

www.pinterest.com/.../4828000225270

www.plantwise.org

www.rdb.rw.2014

www.uneca.org/oria/pages/comesa-

APPENDIX 1: FOREST AND TREE PESTS OF SUDAN

Pest	Scientific name	Order/Family	Indigenous or exotic	Forest type	Host tree
Sahelian tree locust	*Anacredium melanorhoden*	Orthoptera/Acrididae	Indigenous	Semi-desert	*Acacia senegal, Balanites aegyptica, Zizyphus spina-christi*
Silver tree borer	*Sphenoptera chalcichroa* subsp. *arenosa*	Coleoptera/Buprestidae	Indigenous	Plantation	*Acaciaa nilotica. A. arabica, Betula allegheniensis*
Root-boring beetle	*Sphenoptera fulgens*	Coleoptera/Buprestidae	Indigenous	Semi-desert	Brodleaf species
Seed beetle	*Bruchidius uberatus*	Coleoptera/Bruchidae	Indigenous	Plantation, Seed in storage	*Acacia* spp., *A. nilotica, A. tortilis, A, mellifera, A. burkei, A. erioloba, A. robusta*
Tamarind seed weevil	*Caryedon serratus*	Coleoptera/Bruchidae	Indigenous	Plantation, Seed in storage	*Acacia* spp., *Cassia* spp., *Tamarindus* spp., *Bauhinia* spp.
Jewel beetle	*Chrysobothris dorsata*	Coleoptera/Buprestidae	Introduced	On farm	Mangifera spp.
Bag worm	*Anchmophila kordofensis*	Lepidoptera/Psychidae		Semi-desert	*Acacia nubica, A. tortilis, Grewia tenax*
Bark borers		Unspecified bark borers		Semi-desert	*Sclerocarya birrea*
Seed borers		Unspecified seed borers		Semi-desert	*Faidherbia albida, Acacia spp., Khaya senegalensis, Adansonia digitata*
Termites	*Odototermes sudanensis, Microtermes sudanensis, Ancistrotermes crucifer*	Isoptera/Termitidae	Indigenous	Plantation	*Cupressus lusitanica, Eucalyptus camaldulensis, E. citriodora, E. tereticornis, Acacia senegal, A. nilotica*
Leucaena psyllid	*Heteropsylla cobana*	Hemiptera/Psyllidae	Introduced	Om farm	*Leucaena* spp. *L leucocephala, Albizzia* spp. *A. saman, Mimosa* spp.
Gall wasp	*Leptocybe invasa*	Hymenoptera/Eulophidae	Introduced	Plantation	*Eucalyptus* spp.

APPENDIX 2: FOREST AND TREE DISEASES OF SUDAN

Disease	Scientific name	Indigenous or exotic	Causal agent	Forest type	Host tree
Leaf spot	*Xanthomonas axonopodis* p.v. *khayabe*	Indigenous	Bacteria	Savanna woodland	*Khaya senegalensis*
Armillaria root disease	*Armillaria mellea*	Introduced	Fungus	Savanna woodland	*Tectona grandis*
Leaf blight disease	*Endophragmiella theobromae*		Fungus		*Jatropha curcas*
Arbutus canker	*Nattrassia mangiferae*	Introduced	Fungus	On farm	*Ficus carica, Juglans regia, Malus domestica, Citrus* spp., *Morus alba*, *Prunus* spp., *Mangifera* spp., *Arbutus* spp., *Eucalyptus* spp.

APPENDIX 3: INSECT PESTS OF TREES AND FORESTS IN ETHIOPIA

Pest	Scientific name	Order/Family	Indigenous or exotic	Forest type	Host tree
Cypress aphid	*Cinara cupressivora*	Hemiptera/Aphididae	Introduced	Plantation	*Cupressus* spp.
Coffee leaf skeletonizer	*Leucoplema dohertyi*	Lepidoptera/Epiplemidae		On farm, plantation	*Coffea arabica*
Serpentine leaf miner	*Cryphiomystis aletreuta*	Lepidoptera/Gracillariidae		On farm, plantation	*Coffea arabica*
Coffee giant looper	*Boarmia (Ascotis) selenaria*	Lepidoptera/Geometridae		On farm, plantation	*Coffea arabica*
Coffee leaf miner	*Leucoptera* spp.	Lepidoptera/Lyonetiidae		On farm, plantation	*Coffea arabica*
Termites	*Macrotermes* spp.	Isoptera/Termitidae		On farm, plantation	Exotic trees

APPENDIX 4: FOREST AND TREE DISEASES OF ETHIOPIA

Disease	Scientific name	Indigenous or exotic	Causal agent	Forest type	Host tree
Coffee berry disease	*Colletotrichun kahawae*	Indigenous	Fungus	Plantation	*Coffea arabica*
Coffee Wilt disease	*Gibberella xylarioides*	Indigenous	Fungus	Plantation	*Coffea arabica*
Sten canker disease	*Coniothyrium zuluense*	Indigenous	Fungus	Plantation	*Eucalyptus camaldulensis*
Armillaria root rot	*Armillaria mellea*	Indigenous	Fungus	Plantation	*Pinus patula*
Mycosphaerella leaf blotch		Indigenous	Fungus	Plantation	*Eucalyptus globulus*
Pink disease	*Erythricium salmonicolor*	Indigenous	Fungus	Plantation	*Eucalyptus camaldulensis*
Botryoshaeria stem canker		Indigenous	Fungus	Plantation	*Eucalyptus camaldulensis, E. saligna, E, grandis, Pinus patula*
Canker on tapped trees	*Lasiodiplodia theobromae*	Indigenous	Fungus	Indigenous	*Boswellia papyrifera*

APPENDIX 5: FOREST INSECT PESTS OF KENYA

Pest	Scientific name	Order/Family	Indigenous or exotic	Forest type	Host tree
	Amyna punctum	Lepidoptera	Indigenous	Natural	*Croton megalocarpus*
Emperor moth	*Gonometa podocarpi*	Lepidoptera	Indigenous	Natural	*Podacarpus* spp
Longhorn beetle	*Oemida gahani*	Coleoptera	Indigenous	Natural	*Podocarpus gracilior; Juniperus procera*
Wood moth	*Salagena discata*	Lepidoptera	Indigenous	Natural	*Sonneratia alba*
False powder post beetle; shot hole borer	*Apate indistincta*	Coleoptera	Indigenous	Plantation	*Eucalyptus* spp.
Pineapple mealybug	*Dysmicoccus brevipes* Other scientific names: *Dactylopius ananssae*; *D. brevipes*; *D.bromeliae*; *Dysmicoccus cannae; D. pseudobrevipes; Pseudoccus ananassae; P. brevipes; P. bromeliae; P. cannae*	Hemiptera	Indigenous	Plantation	*Casuarina equisetifolia*; *Ananas comosus*; *Elaeis guineensis*; *Glycine max*; *Mangifera indica*; *Saccharum officinarum*; *Musa* spp.; *Phoenix dactylifera*; *Coffea robusta*
Giant cypress aphid; cypress aphid	*Cinara cupressivora*	Hemiptera	Introduced	Plantation	*Chamaecyparis* spp.; *Juniperus* spp.; *Thuja* spp.; *Cupressocyparis* spp. *; Cupressus* spp.
Giant conifer aphid	*Cinara pinivora*	Hemiptera	Introduced	Plantation	*Pinus* spp.
Pine needle aphid	*Eulachnus rileyi* (syn: *Lachnus rileyi)*	Hemiptera	Introduced	Plantation	*Pinus* spp.
Eucalyptus weevil; eucalyptus snout beetle; gum tree weevil	*Gonipterus scutellatus*	Coleoptera	Introduced	Plantation	*Eucalyptus grandis x camaldulensis clones, E. grandis x urophylla clones, E. saligna, E. urophylla, E. camaldulensis, E. tereticornis,*
Leucaena psyllid	*Heteropsylla cubana* (syn: *H. incisa*)	Hemiptera/ Homoptera	Introduced	Plantation	*Leucaena* spp.; *Leucaena leucocephala*; *Albizia* spp.; *Mimosa* spp.; *Samanea saman*, *Azadirachta indica*
Blue gum chalcid	*Leptocybe invasa*	Hymenoptera	Introduced	Plantation	*Eucalyptus saligna; E. grandis; E. deanei; E. globulus; E. nitens; E. botryoides; E. camaldulensis; E. tereticornis, E. gunii; E. urophylla, E. robusta; E. bridgesiana; E. viminalis, E. grandis x camaldulensis* clones, *E. grandis x urophylla* clones,

Pest	Scientific name	Order/Family	Indigenous or exotic	Forest type	Host tree
Pine woolly aphid; red pine adelgid	*Pineus pini* (syn: *P. laevis, P. sylvestris, P. havrylenkoi, P. simmondsi, P. boerneri, Aphis pini, Kermes pini, Anisophleba pini, Kermaphis pini* var. *laevis*	Hemiptera	Introduced	Plantation	*Pinus* spp.
Mites	*Phyllocoptes* sp.	Eriophyidae		Plantation	*Azadirachta indica*
Greenhouse thrips	*Heliothrips haemorrhoidalis*	Thysanoptera/ Thripidae		Plantation	*Azadirachta indica*
South African citrus thrips	*Scirtothrips aurantii*	Thysanoptera/ Thripidae			
Florida wax scale	*Ceroplastes floridensis*	Hemiptera/ Coccoidea		Plantation	*Azadirachta indica*
Nigra scale, black scale, hibiscus scale	*Parasaissetia nigra*	Hemiptera: Coccidae		Plantation	*Azadirachta indica*
Oriental Scale	*Aonidiella orientalis*	Hemiptera: Diaspididae		Plantation	*Azadirachta indica*
Florida red scale, circular black scale	*Chrysomphalus aonidum*	Hemiptera : Diaspididae		Plantation	*Azadirachta indica*
Greedy Scale and Latania Scale	*Hemiberlesia lataniae*	Hemiptera/ Diaspididae		Plantation	*Azadirachta indica*
Cotton white scale	*Pinnaspis strachani*	Hemiptera/ Sternorrhyncha		Plantation	*Azadirachta indica*
Guava long scale	*Lepidosaphes tapleyi*	Hemiptera/ Diaspididae		Plantation	*Azadirachta indica*
	Loboschiza koeniginiana (syn: *Laspeyresia koeniginiana*)	Lepidoptera		Plantation	*Azadirachta indica*
Prunus africana psyllid	*Diclidophlebia xuani*	Hemiptera/ Psylloidea		Plantation, natural forest	*Prunus africana*

Pest	Scientific name	Order/Family	Indigenous or exotic	Forest type	Host tree
Crotalaria defoliator	*Amphicallia pactolicus*	Lepidoptera/ Arctiidae		Farm	*Crotalaria grahamiana*
The leaf-eating beetle	*Mesoplatys ochroptera*	Coleoptera/ Chrysomelidae		Farm	*Sesbania sesban*
Root- knot nematodes	*Meloidogyne* spp	Tylenchida/ Heteroderidae		Farm	*Sesbania sesban, Tephrosia vogelii*
Coreid bugs, coconut bugs	*Pseudotheraptus wayi*	Heteroptera/ Geocorisae		Farm	Cashewnuts, Coconut
Holopetlis bugs	*Helopeltis anacardi*	Hemiptera/ Miridae		Farm	Cashewnuts
Cashew mealybugs, The long-tailed mealybug	*Pseudococcus longispinus*	Hemiptera/ Pseudococcidae		Farm	Cashewnuts
Redbanded thrips	*Selenothrips rubrocinctus*	Thysanoptera: Thripidae		Farm	Cashewnuts

APPENDIX 6: FOREST AND TREE DISEASES OF KENYA

Disease	Scientific name	Indigenous or exotic	Forest type	Host tree
Armillaria	*Armillaria* spp	Indigenous	Natural	*Ocotea usambarensis; Cassipourea spp.*
Armillaria root rot	*Armillaria mellea*	Introduced	Plantation	*Pinus patula, P. elliottii, Acacia mearnsii*
Armillaria root rot	*Armillaria heimii* (syn: *A. elegans, Clitocybe elegans)*	Introduced	Plantation	*Pinus patula, Eucalyptus grandis*
Twig canker	*Lepteutypa cupressi* (syn: *Cryptostictis cupressi*; *Monochaetia unicornis*; *Pestalotia unicornis*; *Rhynchosphaeria cupressi*; *Seiridium cupressi*; *S. unicorne*	Indigenous	Plantation, natural conifer stands	*Chamaecyparis* spp.*; Cupressus* spp.*; Juniperus spp.; Thuja* spp.*; Cupressocyparis* spp.*; Cupressus macrocarpa*
Botryosphaeria canker	*Botryosphaeria* spp.	Introduced	Plantation, farm	*Eucalyptus grandis; E. camaldulensis, E. nitens, E. urophylla; E. grandis x camaldulensis* hybrids, *Grevillea robusta*
Wattle wilt	*Ceratocystis* spp.	Introduced	Plantation	*Eucalyptus grandis, Acacia mearnsii*
Mycosphaerella leaf spot	*Mycosphaerella pini* (syn: *Cytosporina septospora*; *Dothistroma pini; D. pini* var. *keniense, D. pini* var. *lineare*; *D. septosporum, D. septosporum* var. *keniense*; *D. septosporum* var. *lineare*; *D. septosporum* var. *septosporum*; *Eruptio pini*; *Mycosphaerella pini*; *Septoria septospora)*	Introduced	Plantation, farm and natural	*Pinus radiata, Eucalyptus grandis, E. nitens, E. tereticornis, E. camaldulensis, E. saligna, E. urophylla, E. globulus, E. grandis, clones*
Leader dieback, crown wilt, and whorl canker	*Sphaeropsis sapinea* (syn: *Botryodiplodia pinea*; *Diplodia conigena*; *D. pinastri*; *D. pinea*; *D. sapinea*; *Granulodiplodia pinea*; *G. sapinea*; *Macrophoma pinea*; *M. sapinea*; *Phoma pinastri*; *Sphaeria pinea*; *S. sapinea*; *Sphaeropsis ellissi*; *S. ellisii* var. *ellisii*; *S. pinastri)*	Introduced	Plantation	*Pinus radiata*

Disease	Scientific name	Indigenous or exotic	Forest type	Host tree
Anthracnose	*Colletotrichum gloeosporioides*		Farm	Cashewnut, *Mangifera indica*
Powdery Mildew	*Oidium mangiferae*		Farm	*Mangifera indica*
Powdery Mildew	*Oidium anacardii*		Farm	Cashewnut
Powdery Mildew	*Oidium* spp		Plantation	*Eucalyptus* spp, *Eucalyptus grandis x camaldulensis* clones
Phytophthora root rot	*Phytophthora cinnamoni*		Farm, Plantation	Avocado, peach, pineapple, chestnut, macadamia, *Acacia mearnsii, Eucalyptus* spp.
Cylindrocladium shoot blight, leaf spot blight and damping-off	*Cylindrocladium* spp.		Plantation, farm	Most *Eucalyptus* spp, *Eucalyptus grandis, E. grandis x camaldulensis* clones
Phytoplasma disease			Farm	*Eucalyptus tereticornis, E. globulus*
Eucalyptus rust;	*Puccina psidii*		Farm	Most *Eucalyptus* spp.
Cryphonectria canker	*Cryphonetria cubansis*		Farm	*Eucalyptus grandis, E. saligna, E. urophylla, E. camaldulensis, E. tereticornis,*
Edothia canker	*Endothia gyrosa*		Farm	*Eucalyptus grandis, E. saligna, E. urophylla, E. camaldulensis, E. tereticornis,*
Coniothyrium canker	*Teratosphaeria zuluense* (syn: *Coniothyrium zuluense)*		Farm	Most *Eucalyptus* spp.
Chrysoporthe canker	*Chrysoporthe* spp.		Plantation	*Eucalyptus grandis, E. urophylla*
Charcoal leaf disease	*Phaeophleospora epicoccoides* (syn: *Teretosphaeria epicoccoides*, *Kirramyces epicoccoides)*		Plantation	*Eucalyptus grandis, E. camaldulensis, E. urophylla* and hybrids
Corky Leaf Spot	*Aulographina eucalypti*		Plantation	*Eucalyptus botryoides, E. delegatensis, E. dendromorpha, E. diversicolor, E. fastigata, E. ficifolia, E. fraxinoides, E. globulus ssp. globulus, E. globulus ssp. maidenii, E. nitens, E. obliqua, E. pilularis, E. regnans, E. saligna, E. tasmanica.*
Grevillea canker and die-back			Farm	*Grevillea robusta*
Cashewnut dieback	*Phomopsis anacardii*		Farm	Cashewnut

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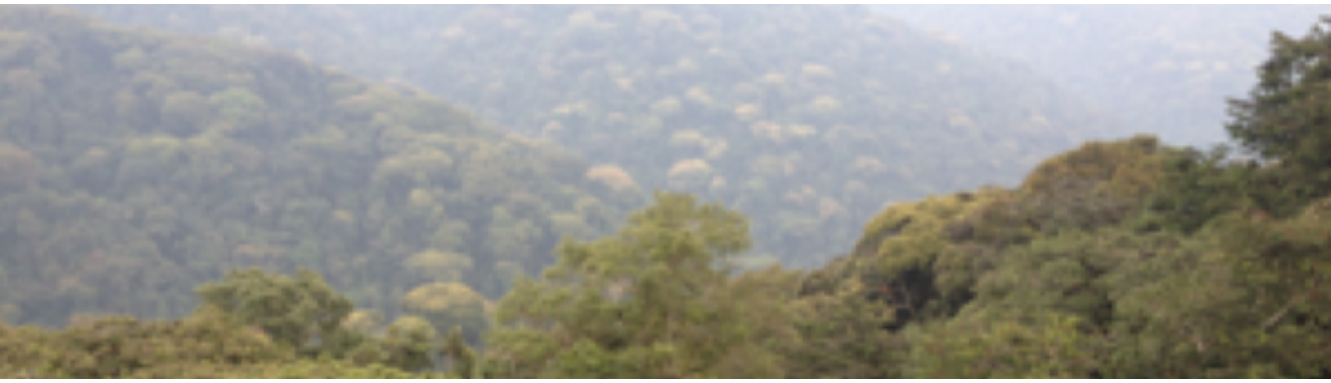

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