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STATUS, IMPACT AND MANAGEMENT OF INVASIVE ALIEN SPECIES IN TANZANIA

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ABSTRACT

Invasive alien species (IAS) are among the significant drivers of environmental change worldwide and important causes of biodiversity losses. They contribute to economic hardship and social instability, placing constraints on sustainable development, economic growth, and ecological problems in various parts of the world, including Tanzania. This study was undertaken to provide information on the status of invasive species and their management needs in Tanzania. The study used three methodological approaches including documentary search, interviews with relevant stakeholders and limited field visits. Findings from the study have indicated that the awareness, trends, distribution and impacts of the invasive alien species in Tanzania are variable, and similarly are the management and control requirements and practices for these species. Among the major impacts associated with the IAS in the country include loss of biodiversity, where in some cases has caused disappearance of certain species of fauna and flora, social and economic distress to human being due to the disappearance of plants and animal species that are regarded as important sources of livelihoods. The study shows that currently there is limited demonstrated capacity in terms of human and financial resources to address the issue of IAS, except for a few cases such as the water hyacinth (*Eichhornia crassipes*) in Lake Victoria. In addition, there are no clearly defined long term strategies to address the issue of invasive species in many institutions. Experience shows that many of the legislations and policies dealing with biodiversity and/or resource management in the country do not directly address invasive alien species. This shortfall may be responsible for the inadequate attention being accorded to the management of invasive species. Thus for effective management of invasive alien species, policies and legislations should be encouraged to directly deal with invasive species. Such situation calls for integrated efforts including various institutional frameworks and collaborations.

Key words: Invasive alien species, biodiversity loss, management of IAS, sustainable development, Tanzania.

INTRODUCTION

Invasive alien species (IAS) are among the drivers of environmental change and important causes of biodiversity losses in many ecosystems (IUCN, 2000). According to Convention on Biological Diversity, IAS are those species whose introduction in a new environment threatens the local biological diversity. The IAS may be plants, diseases, insects, or animals introduced intentionally or unintentionally into a new environment without their natural controls. Most of the invasive alien species established in natural or semi-natural

ecosystems or habitats become an agent of change, and threaten native biological diversity. Globally, IAS threatens biodiversity, agricultural yields, trade, development plans and even health. An example of the impacts of IAS on biodiversity regards the extinction of some bird species in various parts of the world. The 2000 IUCN Red List reported invasive alien species as being a significant threat, affecting 30% of all threatened birds, and 15% of threatened plant species. In terms of costs associated with invasive alien species, the IUCN estimates that the global cost of invasive species is about US$ 400 billion per year in damage, lost yields and control methods (CABI, 2007).

Invasive alien species have significantly contributed to various social, economic and ecological problems in various parts of the world, including Tanzania. The IAS have contributed to loss of biodiversity, in some cases by causing disappearance of certain species of fauna and flora which are important sources of livelihoods and biodiversity. For example, the introduction of Nile perch (fish) in Lake Victoria is believed to have caused the disappearance of some fish species that used to be found in the lake. The introduction of Black Indian Crows (Kunguru weusi in Swahili) in Tanzania mainland from Zanzibar has contributed to loss of many bird species in both Tanzania mainland and Zanzibar Islands. This has been due to their aggressive nature of colonising their niches and predation over other species. This paper aimed at assessing the status of invasive alien species, and their management aspects in Tanzania with a view to identify gaps and needs for the management of Invasive alien species. The study contributes towards raising awareness on invasive alien species prevention and management in the country.

METHODOLOGY

Three methodological approaches were used in this study, including documentary search, consultations with relevant institutions and limited field visits. Documentary search involved review and assessment of available information on invasive alien species. Relevant literature including published and unpublished reports from various sources was reviewed. Such review provided background information on IAS in the country including extent of the problem, awareness, reasons for introductions and spread of the IAS, and their implication on the community livelihoods and the environment. The information collected also included existing capacity to manage the problem of IAS by various stakeholders, and the cost implication for the prevention and management of IAS.

Consultative meetings and interviews were also held with relevant government ministries, agencies and institutions concerned with the management of invasive alien species. These included the Division of Environment in the Vice President's Office, Ministry of Agriculture, Food Security and Cooperatives, Universities, the Tanzania National Parks, the Tanzania Wildlife Research Institute, Tanzania Forest Research Organisation, The Eastern Arc Mountains Conservation Fund and the Morogoro Regional Catchments Forest Office. Consultations with these institutions involved a checklist of issues to guide the discussions.

Documentary search and key informant interviews were complemented by visits to selected sites including Kimboza Catchment Forest located in the Uluguru Mountains in Morogoro Region. The aim of the visit was to get some insights on the extent of invasive alien species and associated management problems.

Status of Invasive Alien Species in Tanzania

Tanzania has had its share of socio-economic and environmental problems arising out of invasive alien species. There are various invasive alien species identified in Tanzania, some examples are given in Table 1. However, awareness, trends, distribution and impacts of the invasive alien species in Tanzania are variable, and similarly are the management and control requirements and practices for these species. A vivid example is the water hyacinth (*Eichhornia crassipes*) in Lake Victoria, which has costed Tanzania and other countries that are riparian to the lake, millions of dollars to control. The weed dominated the lake surface such that fish and other aquatic life were hampered. It resulted into the disappearance of some fish species in the lake, the blockage of landing sites at the lake-shore, and the proliferation of some undesirable species. Other affected water bodies included Pangani River and Lake Jipe. Another example is the Cassava mealy bug (*Phenacoccus manihot*) that drastically reduced the country's cassava crop in the 1980s.

Consultation with various stakeholders revealed that there is considerable awareness and knowledge on the invasive alien species in some of institutions especially those dealing with research such as Universities (e.g. Sokoine University of Agriculture and University of Dar es Salaam), the Tanzania National Parks, and the Tanzania Forestry Research Institute. However, there is limited or little demonstrated capacity in terms of human and financial resources to address the issue of IAS, except for a few cases such as that of water hyacinth in Lake Victoria. Generally there are no clearly defined long term strategies to address the issue of invasive species in many institutions. Much of the little effort done is largely on ad-hoc basis particularly when there are serious identified problems with significant negative impacts on the community, the way it happened to the control of water hyacinth in Lake Victoria.

Primary pathways of IAS

A pathway is broadly defined as the means (e.g. aircraft, vessel or person), purpose or activity (e.g. farming, shipping or pet trade), or a commodity (e.g. fisheries) by which an alien species may be transported to a new location, either intentionally or unintentionally. This differs from between vectors, and the physical means, agent or mechanisms that facilitate the transfer of organisms or their propagules from one place to another.

Species introductions, intentional or unintentional, occur through a long list of pathways (Table 2). These pathways are also applicable in Tanzania. Knowledge and understanding of invasion pathways will enable countries such as Tanzania to take appropriate actions to prevent them from delivering harmful species to their doorsteps.

Over the past millennia, species have dispersed throughout the world by natural means. The major barriers to their spread have been their own poor dispersal abilities (for example, small mammals cannot travel great distances, whereas many birds can), natural and biological obstacles (such as rivers, mountains and oceans) and environmental factors (such as temperature, altitude, disease and natural predators). Human activities have aided the process of species dispersal, by carrying them around the world. Humans have created many vectors, and have created new pathways such as aeroplanes and ship voyages. As a result, many species have been able to establish new populations outside their native range. These incursions have shown a dramatic increase in frequency, extent and damage over the last half a century and there are indications of this trend continuing, and

is largely facilitated by the increased trade, tourism and transportation.

The rates of introductions and spread of IAS are inherently variable but they have increased substantially since the 1960s. There are many cases where species have probably been translocated for many decades, but did not establish until recent times. One probable cause is related to the concept of increased 'propagule pressure'. Propagule pressure increases whenever improvements to the pathway cause the founding population to be introduced more frequently. Other factors explaining the rise in introduction and spread rates are the anthropogenic changes that have made many receiving environments more 'invader friendly'. Local selection pressures operating on IAS founder populations may also help their offspring become better at spreading further than their native counterparts.

Such situations may have negative effects on the habitat of insects and animals that used to depend on the native species. Similarly, suppression of indigenous species may have considerable impacts to the livelihoods of local communities which depended on the local biodiversity for various uses, such as obtaining wild foods. Invasion by this species in Kimboza has caused a big threat to various species (Lovett and Clarke, 1998a&b). Already there is a local concern in Kimboza village that they should discourage planting of *Cedrella odorata*. However, the fact that this tree species is locally considered as a source of good quality timber, and due to its fast growth, makes it difficult to eradicate it in the short term. The uncontrolled *Cedrela odorata* invasion of Kimboza poses a threat of invasion to the other Eastern Arc forests if sufficient efforts are not undertaken to control it. *Cedrella odorata* invasions are also reported in the East Usambara forests. Details of various invasive species in East Usambara Mountain forests are given by FORCONSULT (2006). *Cedrela odorata* is also known to be invasive in other parts of the world, including the Galapagos Islands and in South Africa (Hagen et al., 2006). Other species include *Arenga pinnata*, *Rubus pinnatus* and R. *albata* (the Bramble), and *Maesopsis eminii* (Bracebridge et al., 2005).). The spread of Rubus is known to hinder forest regeneration as the seedlings of canopy and sub-canopy trees were missing in areas where Rubus was observed (Bracebridge et al., 2005:35). This indicates that the Rubus canopy suppresses growth of other species and it favours disturbed areas with gaps. Only a few individual trees have been recorded for *Maesopsis eminii* in the Uluguru South Forest reserve, but the species is considered as a major threat in other parts of the Eastern Arc forests, especially in Usambara Mountains, and it is an aggressive invader of disturbed forests, as seen in Amani Nature Reserve (Bracebridge et al., 2005:62). Another invasive alien species that favours disturbed areas is *Lantana camara*. *Lantana camara* is reported to quickly colonise gaps created by felling of whole trees while harvesting *Catha edulis* in the West Usambara Mountains (Msuya and Madofe, 1998). *Acacia polycantha* and *Acacia nigrescens* are a serious threat to the Miombo woodlands that cover almost one half of Tanzania (Elfadl, 2003).

Distribution and Impacts of Priority Invasive Species

Forestry sector

In the forestry sector there are various IAS with impacts on the environment. *Cedrela odorata* is an example of such species. In Kimboza catchment forest it was introduced in more than 40 years ago (Hagen et al., 2006). *Cedrela odorata* has colonized a large part of the forest, crowding out native species and almost replacing the indigenous tree species (Figure 1).

Agricultural sector

Discussions with Experts in the Ministry of Agriculture, Food Security and Cooperatives revealed that the problem of invasive alien species was first recorded in Tanzania in 1945, and occurred in sisal and later in groundnuts and bananas. However, since then the public was not much aware of IAS until the mid-1980s to 1990s when there was much public concern about Cassava mealy bugs (1985/1990), water hyacinth (1990s), and the Large Grain Borer (LGB) - *Prostephanus truncatus*, in the 1980s that was noted for the first time in Tabora, and later spread to other parts of Tanzania.

Invasion by cassava mealy bugs is associated with importation of planting materials (cuttings) from various parts of the world. The large grain borer was introduced through imported relief foods and attacked mainly cereal, particularly maize. Several other species are now considered invasive in the agricultural sector, for example plant pathogens like Grey Leaf spot of maize and banana wilt. The latter is commonly found in Kagera region. Other IAS affecting the agricultural sector include weed species like *Lantana camara*, *Datura stramonium* and *Argemone mexican*). Among the felt impacts of IAS in the agricultural sector are reduced cash income from crop production, reduced food security, increased livelihood insecurity and increased public expenditure e.g. on food relief and breeding of disease resistant varieties.

The Wildlife Sector

Considerable effort has been made to document and mitigate the threats of invasive alien species in the national parks of Tanzania. Among the documented works was undertaken in the Ngorongoro Conservation Area (NCA) and the Serengeti National Parks (SNP) by Foxcroft et al. (2006). In Ngorognogoro the recorded dominant invasive species are *Datura* stramonium, *Argemone mexicana*, *Acacia mearnsii, Cylindropuntia exalta, Opuntia stricta* var. dillennii, *Opuntia monocantha* and *Pistia stratiotes*. In Serengeti, the dominant invasive species is *Opuntia stricta* var. dillennii. In the Ngorongoro Conservation Area, reported alien species (particularly *Datura stramonium* and *Argemone mexicana*) are believed to have been introduced through the importation of construction materials especially sand from Karatu. This could be ascertained because in the Ngorongoro Conservation Area alien species are frequently observed at construction sites, such as buildings and curvets (Foxcroft et al., 2006). Possibly similar ways could have introduced the invasives in the Serengeti National park.

The invasion of alien species in the Ngorongoro Conservation area and Serengeti National Park has not yet reached a level where control and/or eradication are impossible. However, the need to control invasive alien species in conservation areas has been demonstrated by the conservator of Ngorongoro conservation area. Although there has been no significant increase in the invasive species in Ngorongoro Conservation Area the abundance of some IAS had increased considerably and necessitate need to initiate, control measures, to reduce the infestations of all priority species of alien plants identified in the area.

Invasive alien species are also found in other conservation areas. For example, *Senna spectabilis,* a tree native to South and Central America has become invasive in the Mahale Mountains National Park, where it presently covers about 225 ha (Wakibara and Mnaya, 2002). *Senna spectabilis* appears to suppress the recruitment of native trees in the Park, and its removal can encourage regeneration of the degraded forest without the need for artificial seeding..

Table 1: Examples of identified invasive alien species in Tanzania

Type	**Name of Invasive alien species**
Plant Pathogens:	*Cercospora zeae-maydis* (grey leaf spot) *Colletotrichum coffeanum* (coffee berry disease) *Mycosphaerella figiensis* (Black Sigatoka)
Invertebrate (Insect) pests:	*Prostesphanus truncates* (larger grain borer) *Phenacoccus manihot* (cassava mealy bug) *Mononychellus tanajoa* (cassava green mite) *Aleurothrixus floccosus* (citrus woolly white fly) *Colletotrichum sp.* (coffee wilt disease) *Cosmopolite sp.* (banana weevil) *Chilo partellus* (stem borer) *Phyllophaga smithi* (Sugarcane white grab) *Heteropsylla cubana* (Leaucaena psyllid) *Plutella maculipennis* (diamond backmoth) *Cinara cupressivora (cypress aphid)* *Bactrocella spp* (Fruit fly) *Aleurodicus disperses* (spiralling white fly)
Vertebrate pests	*Corvus splendens* (Indian house crow) *Rattus rattus* (Black roofrat) *Passer domesticus* (House sparrow
Weeds-Aquatic	*Eichhornia crassipes* (Water hyacinth) *Pistia stratiotes* (Water lettuce)
Weeds- terrestrial	*Lantana camara* (Lantana) *Typha domingensis* (Cat-tail) *Argemone mexicana* (Mexican poppy) *Oryza spp* (Wild rice) *Nicandra physaloides* (Apple of Peru) *Oxalis latifolia* (Oxalis)
Aquatic animals	*Lates niloticus* (Nile perch) *Oreochromis niloticus* *Oreochromis leucostictus* (Tilapiine spp.)
Tree/shrub species	*Maesopsis eminii* (Maesopsis) *Cedrela odorata* (Cedrela) *Eucalyptus spp* (Eucalyptus) *Delonix regia* (Jacaranda) *Acacia mearnsii* *Cylindropuntia exalta* *Opuntia stricta* var. dillennii, *Opuntia monocantha stratiotes* *Datura stramonium* (Common thorn apple) *Senna spectabilis* *Leucaena sp.*

Table 2: Some pathways for the different types of introductions

Intentional Introductions		**Unintentional Introductions**
Direct Introductions into the Environment	**Introductions into Captivity/Containment**	
Agriculture	Botanical and private gardens	Vessels/ aircrafts /vehicles/trains, etc.
Forestry	Zoos	Sea cargo
Soil improvements	Farmed animals	Sea containers
Horticulture (ornamentals, nursery stock, house plants, etc.)	Aquaculture	Personal baggage/equipment
Conservation	Pet trade	Agricultural produce
Fishery releases	Aquarium and horticultural pond trade	Seed contaminants
Hunting and fishing	Research	Soil, gravel, sand, etc.
Biological control		Packaging material
Aid trade		Dirty equipment, machinery, vehicles - including military
Smuggling		Aquaculture (*hitchhiker parasites and diseases*)
Aesthetics		Cut flowers
Medicinal		Nursery trade

Figure 1: Kimboza Forest Reserve invaded by Cedrela odorata. All the trees found along the roadside at Kimboza Mission area are Cedrela. Here almost all the native species have completely been suppressed by the large canopy of Cedrela trees.

The Fisheries Sector (aquatic)

The fisheries sector has also been impacted by IAS. The introduction of the Nile Perch (*Lates niloticus*) a piscivorous species in Lake Victoria is believed to have led to the disappearance of several indigenous cichlid species mainly of haplochromines. The Nile perch was introduced in the lake in the 1950's as a management measure, to utilize Haplochromis species which were in abundance, commercially unimportant and almost regarded as "trash fish'' (Witte et al., 1992). The introduced tilapiine species particularly *Oreochromis niloticus* and *O. leucostictus* eliminated the native tilapiine species as a result of trophic interactions (Fryer and Iles, 1972). The replaced species include *O. esculentus* and O. variabilis, which have taken refuge in Satellite lakes (Small lakes) (Katunzi, 2001)Water hyacinth is one of the invasive aquatic weed affecting the environment of Lake Victoria and the overall fisheries in the lake. Water hyacinth (*Eichhornia crassipes*), a member of the pickerelweed family (Pontederiaceae), is native to tropical America. Water hyacinth has been in Africa, especially in the River Nile, since the 1870's but was not reported in Lake Victoria until 1989 although it is believed to have been present since at least the early 1980s (Williams, 2005). The problems associated with water hyacinth however, did not become apparent in Lake Victoria until the early 1990's (Williams, undated). By 1995 90% of the Ugandan coastline was covered by the plant (ISSG, 2006). Both the introduction of Nile perch and the invasion by water hyacinth in the lake have had impacts on the lake biodiversity and on the local community livelihoods, especially those whose main livelihood activity is fishing.

Assessment of the Status and Knowledge of Alien Invasive Species

Early detection of alien invasive species is very important in order to establish control measures before the problem gets out of hand. Early detection and identification of IAS is considered to be of great importance to ensure successful management of the invasive species (Goodland et al., 1998). However, experience has shown that in many institutions attention to IAS is normally drawn where and when there is a problem otherwise there is very minimum effort taken prior to such situations. Good examples are water hyacinth, Cedrela, Maesopsis, and Eucalyptus.

The detection and identification of IAS may include establishing a list of IAS in areas with similar climatic and ecological characteristics and documenting which among them are present in protected and surrounding areas while ensuring regular update of newly introduced species. In addition, assessment of dispersal vectors of IAS is critical to raising awareness of such species among various stakeholders.

Existing Government IAS Management Activities in Tanzania

The vulnerability for invasion is subject to factors such as climate, disturbances, Species interactions and land management practices. The Eastern Arc Mountains are subject to some of these factors, for example, disturbance, species interaction (e.g. arboretum species interacting with native ones) and land use changes (e.g. plantation forests, experimental plots, road construction). The extent and severity of the problems are more or less linearly related to these factors. It is documented that where the factors are overlapping, the problems are more severe than where a single factor or two prevail (FORCONSULT, 2006). The presence of multiple factors leading to the variable vulnerability and severity of the

invasive species poses a management challenge. Such situation calls for integrated efforts including various approaches in controlling the IAS, institutional frameworks and collaborations, as discussed in the following sections.

Policies and Legal Aspects Related to IAS

Some national policies in Tanzania address the issue of invasive alien species. For example the National Fisheries Policy and Strategy Statement of 1998 underscores the importance of protecting fisheries resources and aquatic environment by discouraging the introduction and translocation of exotic species between water systems unless sound scientific evidence guarantees safety of genetic integrity of the water ecosystems. Further, the Fisheries Act No 22 of 2003 section 22 (1) (d) prohibits importing or exporting of fish, fish products, aquatic flora or products of aquatic flora unless one applies for, and granted by the Director or any other authorized officer a license in respect of such activity (URT, 2003:20). Controlling the importation of fish and fishery products or the introduction of exotic species is among the ways to control and manage the biological diversity in the fisheries sector.

Article 69 of Forest Act No 14 of 2002 recognizes the importance of ensuring the sovereignty over biological resources in forests (URT, 2002:98). The issue of invasive alien species has not been directly addressed by this Act. However, there are some provisions in this Act that indirectly implies the issue of invasive alien species and environmental impact assessment before any development within the area. The provision regarding developments include various ranges of development which aim to improve or change the characteristic of the native species in any area of the land, and this move may include the introduction of the new species in order to develop the desired types of the forest, which in turn will lead to the out break of invasive alien species. Although the cited Forest Act do not directly mention "invasive species", the requirement to maintain the sovereignty of biological resources may be interpreted to also include proper management of invasive alien species.

The Ministry of Agriculture, Food Security and Cooperatives is in the process of reviewing the Plant Protection Act of 1997. One of the considerations is to include clauses/articles that address the issues of invasive alien species (cf. Kangalawe et al., 2007). Also the consulted official in the ministry reported that in recognition of the importance of the invasive alien species, the ministry allocated in the 2006/2007 a budget to deal with invasive species. However, the areas of focus could not be immediately ascertained. The Plant Protection Act No. 13 of 1997 focused on prevention of introduction of exotic pests and their spread and to manage outbreak pests (URT, 1997). the Ministry of Agriculture, Food Security and Cooperatives also maintains the regulatory control of imported plants and plant materials through crop inspections at all points of entry i.e. harbours and ports, border outstations and airports. All plant and plant products imported and exported from Tanzania are also subjected to inspection for pests at all border points around the country (MAFS, undated). An exception in The Plant Protection Act regards importations that may be permitted for the purposes of essential scientific research or experiment (see Article No 9(2)). Such materials may be permitted if there is satisfying evidence that the importation will not present significant threat to the agriculture or natural environment of Tanzania (URT, 1997).

The National Environment Research Agenda (NERA) currently under preparation by the National Environment Management Council (NEMC) also has provisions for

addressing invasive species. The Agenda for Environmental Research is an intended contribution towards efforts aimed at conservation and sustainable development. Among priority research areas that will be addressed in the NERA are Invasive species in both aquatic and terrestrial ecosystems. The National Environment Research Agenda is being prepared to fulfil some of the requirements of The Environmental Management Act[1], No 20 of 2004 (URT, 2004b), which underscores the need for researched information on the state of the environment, actual and future threats to the environment, including addressing invasive alien species.

Articles 10 (a & f) of the Marine Parks and Reserves Act, No 29 of 1994 addresses some of the purposes of designation of a marine park or reserves (URT, 1994). Purposes with relevance to the invasive species concerns include Article 10(a), which aims to protect, conserve, and restore the species and genetic diversity of living and non-living marine resources and the ecosystem processes of marine and coastal areas; and Article 10(f) which aims to facilitate research and to monitor resource conditions and uses within the marine park and reserves. As with the Forest Act, 2002, which does not directly address invasive species, it is also implied in the Marine Parks and Reserves Act, 1994 that proper management of marine biodiversity would include issues related to invasive species.

Very few other national documents address the issue of invasive alien species in a systematic manner. However, the above initiatives are a move in the right direction as they will provide more for a holistic approach and legal underpinnings related to IAS. It is anticipated that other relevant sectors will have similar initiatives in the future.

Methods of Control of Invasive Alien Species

There are a number of ways used to control invasive species in Tanzania. These measures range from physical, chemical and biological. Such measures have been applied by various institutions in different ways. However, experience from different countries show that each has its own advantages and disadvantages with various implications to the environment. Consequently Tanzania has of the recent past been focusing on integrated pest control mechanism (IPM), which integrates all the different methods. IPM has been the cause for the successful control of invasive species like water hyacinth and large grain borers. Except for the control of the water hyacinth in the Lake Victoria in which the Ministry of Agriculture, Livestock Development and Cooperatives by then (involved through LVEMP), there are only scattered attempt to control other invasive alien species.

Among the measures used are: (i) Mechanical/physical control of invasive trees species such as eucalyptus that are cut and uprooted to control regeneration (e.g. in Kilimanjaro and Arusha National Parks); Physical methods such as stripping off all the bark off trees, either the basal portion or below cutting height that has been found to be effective in killing *Maesopsis eminii* in Tanzania. Sometimes, alien species have been removed mechanically. This method can be effective in some areas but it can not be recommended more widely because of the risk of re-invasion of alien plants, as well as other environmental damage, particularly soil erosion. (ii) Chemical methods: Invasive trees are cut and smeared with chemicals. However, caution need to be taken on the environmental implications of such measures. (iii) Biological methods e.g. in the control of water hyacinth using wasps. In Tanzania, biological control

[1] See EMA No 20 of 2004, Sections 18(2)(C)172-177

agents known as *Neochetina eirchhorniae* (also locally known in Kiswahili as mbawakavu), have been reported to be successful by 82% in controlling water hyacinth in the Lake Victoria (MAFS, 2004). Although biological control has been considered a more ecologically acceptable method of control of invasive organisms than chemical methods, the biological control of a number of animals has resulted in disasters including the extinction of a number of endemic taxa (Simberoloff and Stiling, 1996a, 1996b).

The presence of multiple factors leading to the variable vulnerability and severity of the invasive species poses a management challenge. However, more concerted effort is needed including enforcement of legislations and sectoral policies which address directly the issues of IAS. More cooperation and capacity building is required to effectively manage the problem of invasive species countrywide.

Economic Costs of Invasive Alien Species

Invasive species are, by definition, an international problem. Their movement and spread across borders incurs billions of dollars in prevention, control, and damage costs annually. Worldwide we need to encourage and enable scientific experts on invasive species to become actively involved in policy making and implementation processes. A critical challenge is how to strengthen the interface between the scientific and policy making communities with respect to invasive species issues. Control of invasive species in Tanzania has various cost implication. For example in the Budget Speech of 2004 it was acknowledged that every year the IAS causes loss of over 30% of crop yield (MAFS budget Speech 2004/05). Also losses of stored grains are reported to be as high as 30% weight loss with an average of 8.7% during 3 to 6 months storage period. This has been largely been attributed to the outbreak of Large Grain Borer (*Prostephanus truncatus*) (Golop and Hodges, 1982). The Plant Health Service Department in the Ministry of Agriculture has targeted to minimize crop losses caused by outbreak of pests from 100% to 10%, and other invasive species including pests and diseases from 30% to 20% by year 2010 (MAFS budget Speech 2004/05).

Assessment of Capacity to Manage Invasive Alien Species

Management capacity

Training of staff has been undertaken in some institutions to create more awareness and enhance the management capacity. However, such effort has not been adequate to meet increasing requirements. For example training of staff has been undertaken to make officers of the Ministry of Agriculture aware of contemporary phytosanitary issues and ensure that they effectively implement phytosanitary measures such as pest risk analysis and identification of pests of quarantine importance. Further training is still needed to meet new and emerging challenges. Additionally, efforts should be made within the country to strengthen phytosanitary activities, such as strengthening border control by establishing more inspection points at entry points to prevent introduction of invasive species; setting up laboratory facilities at the major entry points to ensure quick identification of intercepted species; and recruitment of more technical staff to undertake such tasks.

Database Development and Management

There are several institutions that are custodians of the knowledge and information on invasive species that are relevant to specific fields. Examples of such institutions are Tanzania National Parks (TANAPA), Ministry of Agriculture Food Security and Cooperatives, The Eastern Arc Mountains Project, Tanzania Forestry

Research Institute, the University of Dar es Salaam and Sokoine University of Agriculture. However, the major institutions managing information on environmental data and biodiversity issues, including invasive species, are the Division of Environment in the Vice President's Office. Experience shows however that the various databases are hardly linked or coordinated. Thus, for effective database development and management, efforts should be made at national level to link and coordinate the sector specific databases.

Research Capacity on Invasive Alien Species

Research on invasive species has often been reactive, quantifying the ecological and economic costs of established invaders. To avoid permanent ecological change or recurring economic costs, research on earlier invasion stages is needed. In particular, increasing research on pathways that transport invasive species is essential to inform prevention. Such research is necessarily interdisciplinary because it is guided by knowledge of trading routes, transportation methods, mathematical modelling and economic analysis. For effective control of invasive alien species an interdisciplinary risk assessments should include considerations of pathways, predictions of the identity of future invaders, and estimates of future ecological and economic impacts. To achieve this increasing the research capacity among the relevant institutions should be a priority. Furthermore, effective prevention of invasions calls for the need for greater collaboration among scientists, communities, policy makers, relevant industries and regulatory agencies at local, national and international levels.

Challenges in Managing Invasive Alien Species in Tanzania

By their very nature, invasive species challenge traditional disciplinary and geographic boundaries in the way we study and manage them. Progress in recognising and mitigating invasive species problems has often been retarded by traditional thinking in terms of countries, sectors/disciplines and habitats. Invasive species do not recognize national boundaries or sectoral/disciplinary divides. Good example is water hyacinth in Lake Victoria which covers Kenya, Uganda and Tanzania, and Large Grain Borer (*Prostephanus truncatus*) which is also found in Tanzania and neighbouring countries such as Kenya. Thus invasive species issues require cooperation among sectors, such as agriculture, forestry, environment, health, and wildlife conservation agencies, as well as academia and the business community. The same species can be vectors or weeds, for example, and can as well be pests of agriculture, livestock and of conservation importance. Hence, we must recognize a continuum of habitats, rather than separating agriculture from conservation. It can therefore be appreciated that efforts to stop invasive species will be greatly enhanced by bringing together various stakeholders, knowledge, tools, and approaches from a range of relevant disciplines. In particular, integrating various databases (including, for example, those specifically for invasive species, those for biodiversity, and those for agricultural pests) and extending them to take advantage of each other (Miller, 2007).

The Key stakeholders

In many instances the impact of invasive alien species are felt by the local communities whose livelihoods depend on particular ecosystem in their respective locations. The decreased fish stocks in Lake Jipe due to invasion by typha, and the disappearance of several fish species due to

introduction of the invasive Nile perch and water hyacinth in Lake Victoria are among the few examples.

Although there are several stakeholders involved in the management of invasive alien species, or who may have interest in this theme, to a large extent there have been isolated individual efforts to address IAS issues, possibly because some of the IAS are sector specific and requires specific attention. For effective management of the IAS it would be encouraged to have concerted and harmonised efforts by the different stakeholders.

Stakeholder Awareness on IAS

All the institutions consulted during this assignment reported to be aware, but the awareness has mainly been since the 1990s. The types of invasive species that these different institutions indicated to be of concern vary depending on the sectoral orientation of the respective institution. Generally however, issues of invasive alien species do not seem to be a priority, except in the national parks where once the problem becomes a threat it is dealt with. In addition, studies undertaken on invasive species to a large extent are based on individual species. Regarding the sources of invasive species, several explanations were articulated, including importation of food staffs (for crop pest and diseases), introduction of research/experimental material (e.g. invasive tree species such as Cedrela). In some national parks the problem of IAS has been due to the expansion of national parks into previously forested areas and farm lands or formerly settled areas with a lot of exotic plants species.

CONCLUSIONS

Tanzania is faced with the problem Invasive Alien Species whose management requires concerted effort among different sectors within the country as well as regional collaboration. Some of the IAS has been introduced with good intention in different ways such as food importation, experimentation, trade transactions and import of ornamentals and food aids. However, there are several IAS some of these species have negative impact on biodiversity, agriculture, people's livelihood and human development. IAS problems have been found in different sectors including agriculture, wildlife, fisheries and forests. Some of the problems are transboundary in nature, and the government has taken various measures for the prevention of the introduction, control or eradication of IAS. These include establishment of National Biological Control Centres, phytosanitary inspection in most of the entry ports, implementation of Plant Protection Act of 1997 section 37, and inclusion of section on IAS in Environmental Management Act (EMA 2004).

The variable priorities accorded to invasive alien species by various stakeholders have been found to contribute to inefficiency in the management of these species. For example while some species e.g. Cedrela are invasive and regarded by conservationists that they should be eradicated, some communities prefer them as fast growing timber trees. Other factors include the limited resources and the lack of specific national institutions that deal with invasive alien species. These poses a management challenge to IAS, as there is limited coordination of actions taken against the invasive alien species. Generally, it can further be concluded that currently there is limited capacity to address the invasive alien species, calling for more cooperation, capacity building for effective management of the invasive alien species.

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