CHAPTER 10
INVASIVE ALIEN SPECIES

Lead Authors: Munyaradzi Chenje, Jennifer Mohamed-Katerere

"Invasive alien species are emerging as one of the major threats to sustainable development, on a par with global warming and the destruction of life-support systems. These aliens come in the form of plants, animals and microbes that have been introduced into an area from other parts of the world, and have been able to displace indigenous species."

PRESTON AND WILLIAMS, WORKING FOR WATER PROGRAMME/SOUTH AFRICA 2003

INTRODUCTION

Alien – that is non-native – species have been introduced both accidentally and intentionally. Intentional introductions are, and have been, motivated by economic, environmental and social considerations. In the forest sector, for example, *Pinus*, *Eucalyptus* and *Acacia* species are important sources of pulp, timber and fuelwood, yet at the same time they have placed tremendous strain on water resources. In Southern and Eastern Africa, these species are the backbone of plantation forestry, bringing in valuable foreign currency, yet at the same time decimating land and water resources. In South Africa, for example, they consume 7 per cent of available water (Preston and Williams 2003). Many introductions, however, are unintentionally coming into countries with other goods and, in the case of marine IAS, in the ballast water of ships.

Although only a small percentage of these alien species will become invasive, when they do their impacts are immense, insidious and usually irreversible, and they may be as damaging to native species and ecosystems on a global scale as the loss and degradation of habitats (IUCN/SSG/ISSG 2000). In Africa some important ecosystems are under threat, consequently undermining development and livelihood opportunities, increasing human vulnerability and threatening human well-being. Thus, IAS have a direct bearing on Africa's ability to meet the Millennium Development Goals (MDGs) and their targets. (These goals and targets, and progress towards meeting them, are set out in Annex 1).

Although not all alien species will become invasive or threaten the environment, this is an area in which a clear policy approach is necessary because of its potentially wide-ranging impacts when they do become invasive, and because of the difficulties, including financial costs, in reversing its impacts. One experience which illustrates this dilemma is the introduction of *Lates niloticus* (Nile perch) into Eastern Africa. The Nile perch has had immense economic value in the countries where it has been introduced, but it has also wreaked havoc in the ecosystems, resulting in the loss of endemic species and altered ecosystems with knock-on effects for livelihoods. Alien species, such as *Bufo marinus* (cane toad) and *Chromolaena odorata* (bitter bush) (IUCN/SSG/ISSG 2004) have been used for biological control and as an ornamental, and then subsequently become invasive.

Increased mobility and human interaction have been key drivers in the spread of IAS. On the one hand, increasing global connectedness – through trade, travel and tourism – has enriched the lives of people all over the world, through increased opportunities for sharing information and knowledge as well as improved access to a range of biodiversity (McNeely and others 2001).

Box 1: Invasive alien species

IAS are also commonly referred to as invasives, aliens, exotics or non-indigenous species.

IAS are species, native to one area or region, that have been introduced into an area outside their normal distribution, either by accident or on purpose, and which have colonized or invaded their new home, threatening biological diversity, ecosystems and habitats, and human well-being.

The extent to which introduced species may proliferate and spread is affected by the state of the receiving ecosystem. An alien species may find a vacant niche and spread, or it may compete for one already occupied by a native species. Some IAS proliferate because they find no natural enemies in their new habitat.

Although some species have invaded habitats on their own, human activity such as exploration, colonization, trade and tourism has dramatically increased the diversity and scale of invasions by alien species.

Sources: CBD 1992, Shrine and others 2000, ESA 1998

Increased access to biodiversity has created new opportunities for forestry, agriculture, aquaculture, horticulture, and biodiversity-based industries including the pharmaceutical sector. However, this increasing interaction has had its costs too:

> "It has broken down the natural barriers of oceans, mountains, rivers and deserts which for millennia provided the isolation essential for unique species and ecosystems to evolve. In just a few hundred years these barriers have been rendered ineffective by major global forces that combined to help alien species travel vast distances to new habitats and become alien invasive species" (IUCN/SSG/ISSG 2000).

The challenge facing Africa is how to respond – to known IAS and to new introductions of alien species that could potentially become invasive. First, Africa needs to develop systems for evaluating the risks and benefits associated with alien species, and for deciding when to use them and when to prevent their introduction or eradicate them. This entails considering the economic, development, environment and human well-being costs-and-benefits, and recognizing the close relationship between these sectors. Second, Africa faces the challenges of how to translate its policy objectives into effective management practice. When species are identified as a threat, appropriate responses may include establishing systems for their eradication, as well as for controlling and monitoring their introduction. When alien species are used, developing early warning and assessment systems regarding their behaviour as well as effective response systems is essential.

• The impacts of IAS are immense, insidious, and usually irreversible and they may be as damaging to native species and ecosystems on a global scale as the loss and degradation of habitats. •

IUCN/SSG/ISSG 2000

STATE-AND-TRENDS

Africa is home to hundreds of IAS – both plant and animal – but the magnitude of the problem varies from country to country, and from ecosystem to ecosystem. In many parts, freshwater ecosystems are particularly at risk – with IAS surpassing habitat loss as the number one cause of biodiversity loss.

Invasive alien species are a problem in diverse ecosystems in Northern, Western, Central, Eastern and Southern Africa and in the Western Indian Ocean (WIO) islands: they affect both savannahs and tropical forests and they are found on land, in freshwater systems, along the coast, and in the ocean. (UNEP 2004).

Virtually all countries in the region are affected by IAS. In 2004, IUCN – the World Conservation Union (IUCN) identified 81 IAS in South Africa, 49 in Mauritius, 44 in Swaziland, 37 in Algeria and Madagascar, 35 in Kenya, 28 in Egypt, 26 in Ghana and Zimbabwe, and 22 in Ethiopia (IUCN/SSC/ISSG 2004). (See Figure 1). In some countries there may be under-reporting of the incidence of IAS.

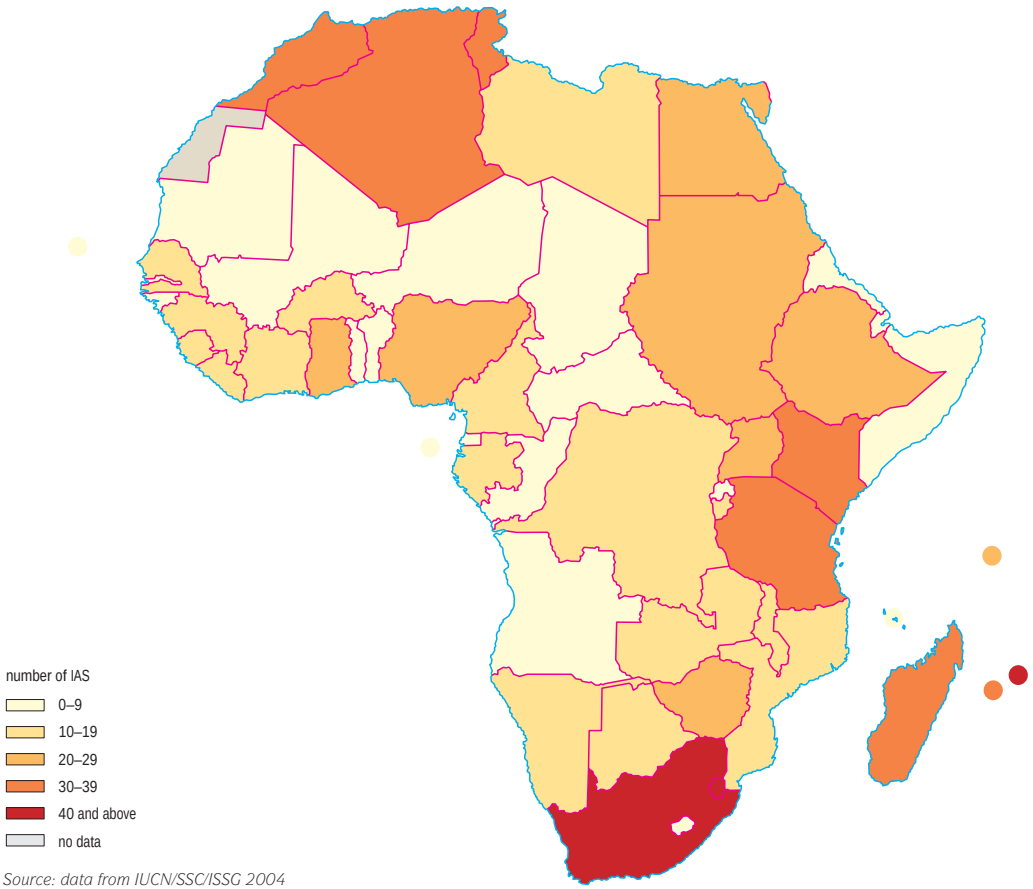
Many IAS found in Africa are included on a global list of the 100 worst IAS (IUCN/SSG/ISSG 2004). These include the infamous, *Eichhornia crassipes* (water hyacinth) (see Box 5); economically important species including the Nile perch, *Oreochromis mossambicus* (Mozambique tilapia) and *Acacia mearnsi* (black wattle) (see Box 6); species introduced for biological control, such as *Acridotheres tristis* (Indian myna) (see Box 3) and *Bufo marinus* (cane toad); and ornamentals such as *Lantana camara*. There are many other IAS which present serious challenges to regional efforts to conserve the environment and to meet development objectives – the foundation of social, economic and environmental sustainability in Africa.

In some countries, IAS have become a major ecological, social and economic problem despite the existence of legal measures and substantial funding to control them. The extent of this is discussed further in this chapter in the section *Challenges faced in realizing development opportunities*.

POTENTIAL GROWTH

With increasing globalization, the threat posed by IAS is likely to increase through both intentional and accidental introductions. Human movement and the

Figure 1: The incidence of IAS in Africa



Source: data from IUCN/SSC/ISSG 2004

movement of goods are key drivers in the spread of IAS. With improvements in communications and infrastructure, this is likely to increase. Historically, IAS have been spread through colonization and exploration. Today, mobility through tourism, business travel and migration continues to be an important factor. Many IAS have been introduced to Africa in, for example, soil, plants, luggage, vehicles and aeroplanes (Kirby 2003).

Trade – both legal and illegal – particularly in, but not limited to, plants and animals, is particularly important. Many species have been introduced through trade in manufactured goods contaminated with seeds or insects. Trade has contributed not only to the introduction of species that colonize and fundamentally alter receiving ecosystems but that are also a factor in the growing incidence of disease. *Aedes albopictus* (Asian tiger mosquito), for example, is associated with the transmission of dengue fever and is believed to have been first introduced through a shipment of tyres from Japan to South Africa in 1989. By 1999 these mosquioes were found to be present in Douala, Cameroon's main commercial harbour (Fontennille and Toto 2001).

Invasive alien species have also been spread through the provision of humanitarian emergency food aid. For example, the weed *Parthenium hysterophorus* is a recent introduction to Africa through grain shipments for famine relief to Ethiopia (McNeely and others 2001). The weed was first seen in 1988 near food-aid distribution centres in Ethiopia. Buried seeds of the weed can lie dormant for as long as 20 years before germinating (GISP 2004).

Research activities and agricultural extension have also been a factor, as shown in Box 10.

Disturbed ecosystems are particularly vulnerable to invasion by alien species. In Tanzania, for example, *Maesopsis eminii* has become dominant in logged forests. It is also capable of regenerating in natural forests, particularly where there are large gaps caused by tree-falls (Bingelli and others 1998). In both Eastern Africa and WIO islands, the woody shrub *Clidemia hirta* is also increasingly common in natural forest gaps (Bingelli and others 1998). With high levels of environmental change, such as deforestation and growing extractive timber use, IAS are likely to be a growing problem. Climate change – through its impact on ecosystems – may also favour the spread of IAS. Section 2: *Environmental State-and-Trends: 20-Year Retrospective* considers the major environmental changes occurring in land, freshwater, coastal and marine environments, and biodiversity.

Box 2: IAS, the biotic integrity of communities and the functioning of ecosystems

The Millennium Ecosystem Assessment (MA) found that trends in species introductions, as well as modelling predictions, strongly suggest that biological invasions will continue to increase in number and impact. A further concern is that multiple human impacts on biodiversity and ecosystems will decrease the natural biotic resistance to invasions and, therefore, the number of biotic communities dominated by invasive species will increase. However, research suggests that maintaining native species assemblages may diminish the ability of exotic species to become invasive.

A further important finding is that there is a positive correlation between the richness of native and exotic species across habitats – as the factors that promote the richness and coexistence of native species, such as benign climate, intermediate levels of disturbance, and habitat heterogeneity, also promote the richness and coexistence of exotic species. This suggests that hotspots for diversity are particularly at risk of invasion by introduced species, and that the loss of native species (from communities of low or high native species richness) is expected to increase.

Source: MA 2006

Increased trade is also associated with increased transportation. As already noted, ballast water, and its associated sediment, has been identified as an important route for the introduction of marine IAS: 14 billion tonnes of ballast water are transferred globally each year and more than 7 000 species of marine organisms may be present in ballast water at any given time (GISP 2004).

Even if these human drivers are more effectively dealt with, the problem of IAS is likely to continue as natural processes, such as cyclones and water currents, may also be a factor in their distribution. The Swaziland National History Society, for example, notes that an IAS known locally as demonia weed was blown into Swaziland by a cyclone in 1984; this has subsequently rendered large areas of formerly productive agricultural land useless (IRIN 2002).

IMPACTS ON BIODIVERSITY AND ECOSYSTEMS

Although IAS come from diverse taxonomic groups they share some similar impacts. Tree species such as the black wattle from Australia, *Prosopis spp.* (mesquite tree) from Mexico, and *Leucaena leucocephala* (the conflict tree) behave in a similar way to invasive alien fish species, such as *Cyprinus carpio* (the common carp), *Micropterus salmoides* (American black bass), *Oreochromis nilotica* (Nile tilapia) and Mozambique tilapia, and out-compete native species and convert receiving ecosystems.

Invasive alien species may threaten native species as direct predators or competitors, as vectors of disease, or by modifying the habitat or altering native species dynamics (MA 2006). The threat posed to biodiversity by IAS is considered second only to that of habitat loss (CBD 2005). On small islands, it is now comparable with habitat loss as the lead cause of biodiversity loss (Baillie and others 2004).

Invasive species may out-compete native species, repressing or excluding them and, therefore, fundamentally change the ecosystem. They may indirectly transform the structure and species composition of the ecosystem by changing the way in which nutrients are cycled through the ecosystem (McNeely and others 2001). Entire ecosystems may be placed at risk through knock-on effects. Given the critical role biodiversity places in the maintenance of essential ecosystem functions, IAS may cause changes in environmental services, such as flood control and water supply, water assimilation, nutrient recycling, conservation and regeneration of soils (GISP 2004, Levine and others 2003). Chapter 7: *Biodiversity* discusses the complex relationship between biodiversity and the maintenance of essential ecosystem functions.

Invasives may also affect native species by introducing pathogens or parasites that cause disease or kill native species.

Among other things, both old and newly established IAS contribute to land degradation through soil erosion and the drawing down of water resources, reducing resources available to people and indigenous plants. Others produce leaf litter which poisons the soil, suppressing the growth of other plants, and in particular that of the understorey (UNEP 2004). They may alter the environment in directions that are more favourable for them but less favourable to native species. This could include altering geomorphic processes (soil erosion rates, for instance, or sediment accretion), biogeochemical cycling, hydrological cycles, or fire or light regimes (MA 2006; Levine and others 2003). For example, invading trees in the fynbos of the Cape Floral Kingdom reduce stream-flow from mountain catchment areas and change the overall hydrological regime of the entire area, which in turn prevents the germination and growth of native species (MA 2006).

Wattle trees and mesquite can sink their roots deeper into the soil than indigenous trees, sucking out massive volumes of water and out-competing

Box 3: Invasive bird species

Over the last 500 years, IAS have been partly or wholly responsible for the extinction of at least 65 bird species, making this the most common contributory factor in recent losses to the world's avifauna (BirdLife International 2006).

Invasive bird species include: *Passer domesticus*, (house sparrow) which out-competes many small, native African birds, and Corvus splendens,(Indian house crow) which has spread from the Tanzanian coast inland over the last 20 years, and *Acridotheres tristis* (common or Indian myna).

The Indian house crow destroys the habitat of many other birds and as a result in the Tanzanian capital, Dar es Salaam, there are now only a few other common bird species (Howard 2003). The house crow came with ships from India – probably as early as the late 1800s. It now extends to Cape Town and has been recorded in Port Sudan and even in Cairo. This bird kills other species, destroys nests, and steals eggs and chicks of the domestic chicken. It also spreads disease and is generally a serious pest in towns along the coast of Eastern Africa (Howard 2003).

Indian mynas were introduced to reduce the insect population in agricultural areas. Mynas inflict damage to grape and other fruit crops like apricots, apples, pears, strawberries and gooseberries (IUCN/SSC/ISSG 2004). They also reduce biodiversity by competing for nesting hollows, destroying chicks and eggs and evicting small mammals.

Indian house crow feasting on a small mammal, Kenya.

Source: J. Chenje

Source: Birdlife 2006, GISP 2004, Howard 2003, IUCN/SSC/ISSG 2004, UNEP 2004

indigenous plants for nourishment (Preston and Williams 2003). In some environments, invasive trees, like the black wattle, increase rainfall interception and transpiration, which causes a decrease in stream-flow (IUCN/SSC/ISSG 2004).The leaves and branches of the black wattle are believed to have allelopathic properties – that is the chemical inhibition of growth and seed germination of other plants. Highly combustible, fire-tolerant alien plants may also alter the fire regime, and combined with competition for light, nutrients, water and space, this is believed to be an important factor in extinctions (Richardson and van Wilgen 2004).

Marine IAS are a growing problem in Africa's coastal waters, estuaries and lagoons. Many of these introductions are related to sea vessels and aquaculture. *Hypnea musciformis* (hypnea) is red algae, originally from Trieste in Italy, and is now distributed throughout the world. It occurs in coastland, estuaries and marine habitats where it attaches to coral, stones or shells on sheltered tropical reef flats. Its success is related to its rapid growth rate, ability to epiphytize other algae and easy fragmentation (IUCN/SSC/ISSG 2004). In Africa, it is present in the coastal waters of Morocco, Namibia, Angola, Congo, Gabon, São Tomé, Cameroon, Nigeria, Togo, Ghana, Côte d'Ivoire, Liberia, Sierra Leone, Guinea-Bissau, Gambia, north Senegal, the Cape Verde Islands, Mauritania, Ethiopia, Egypt (Red Sea), Djibouti, Kenya, Tanzania, Mozambique, South Africa, Madagascar, the Seychelles, Mauritius and Réunion. Invasion pathways include aquaculture and dispersal by boats and other vessels (IUCN/SSC/ISSG 2004).

Box 4: Aliens from Planet Earth

- IAS, especially predators, directly threaten more than 300 bird species.
- One of the most notorious plant IAS in Africa is the water hyacinth. It costs some countries tens of millions of dollars annually to control. The water hyacinth grows quickly and harms wetland ecosystems by blocking sunlight and oxygen, altering water-flows and increasing evapotranspiration.
- The water fern enhances the breeding of mosquitoes and snails that carry bilharzia, which infects about 300 million people annually in the tropics.

Source: BirdLife International 2004, GISP 2004

CHALLENGES FOR REALIZING DEVELOPMENT OPPORTUNITIES

Many alien species, including some that are invasive, have had tremendous economic value for Africa. However, overall their impact on the sustainability of the resources, upon which livelihoods and development are often based, has been adverse, undercutting opportunities, human well-being and contributing to increased human vulnerability. Invasive alien species are a serious impediment to the sustainable use of global, regional and local biodiversity (CBD 2005); this has implications for freshwater and marine resources, tourism, and forest and woodlands.

Invasive alien species may affect livelihood and other economic opportunities in multiple ways. In addition to their impact on the supply of environmental goods, they also affect the integrity of ecosystems, undercutting essential environmental services. The various chapters of Section 2: *Environmental State-and-Trends: 20-Year Retrospective* considers the environmental goods-and-services provided by the atmosphere, land resources, freshwater systems, coastal and marine environments, forests and woodlands, and biodiversity and the opportunities these resources present for development. Thus IAS, through their impact on the environment, contribute indirectly to poverty, food insecurity, ill health and poor water quality (UNEP 2004, NEPAD 2003). They have multiple level and complex impacts on human well-being and the ability to achieve development targets, such as those set out in the MDGs.

Food security, land degradation, agriculture and livestock production

Invasive alien species impact on land resources, and agriculture and livestock production systems, in multiple ways, potentially threatening food security.

Weeds may affect the productive capacity of the land and increase agricultural labour time, affecting human well-being by threatening the availability of food as well as reducing the time people have for recreation and other non-work activities, such as participation in community events. Most often the responsibility for weeding falls on women and children. In many societies women are the last to eat in times of food shortages.

Some IAS transform grasslands that support grazing. For example, *Lantana camara* poisons cattle and destroys understorey species (IUCN/SSC/ISSG 2004). The conflict tree, which is seedy and thornless, can form dense monospecific thickets. It is difficult to eradicate once established, making extensive areas unusable and inaccessible, and threatening native plants. *Chromolaena odorata* – first introduced to Côte d'Ivoire as a biological control – also forms dense thickets. It is particularly virulent in disturbed ecosystems, and thus can be associated with agriculture, and in particular slash-and-burn activities (IUCN/SSC/ISSG 2004). When it is dry it is highly combustible, promoting flash fires. In Africa, it is known to be a problem in Benin, CAR,

Water hyacinth (*Eichhornia crassipes*) is a major invasive alien species in Africa, clogging many water bodies.

Source: M. Chenje

Congo, Côte d'Ivoire, DRC, Liberia, Mauritius, Nigeria, Senegal, South Africa, Swaziland and Togo. Some tree species, such as the black wattle, also affect the viability of grass species.

Many IAS grow faster than native plants and reproduce quickly, and thus replace indigenous plants and completely alter the composition of the area they have colonized. It has been reported that agricultural and grazing land, as well as protected areas, are threatened by rapidly growing species of plants that were introduced during colonialism as garden plants and windbreaks (Hall 2003).

Parthenium hysterophorus (congress weed) invades disturbed land, including overgrazed and recently cleared or ploughed land. Once present, it is easily spread through seed dispersal – its seeds can remain viable for up to two years and buried seeds can stay dormant for up to 20 years – and as a result of its allelopathic character (GISP 2004). Because it is unpalatable to livestock its colonization of rangelands results in grazing shortages, placing livestock production at risk. In some countries, such as Ethiopia, where it was originally introduced through contaminated food imports, it has had devastating impacts on agriculture – earning it the local name, "no crop" (GISP 2004). It is also a problem in subtropical areas, affecting sugar cane and banana plantations in South Africa, Mozambique, Swaziland, Zimbabwe and Madagascar.

Viruses, such as Rinderpest and Avian Influenza Virus, can become invasive, seriously placing livestock production and livelihoods at risk. The spread of Avian Influenza Virus is closely associated with the live bird, and in particular the poultry, trade. Outbreaks of Avian Influenza in Nigeria were probably the result of illegal poultry trade with China and Turkey (BirdLife International 2006).

Freshwater and livelihoods

As discussed in Chapter 4: *Freshwater*, these systems have a central role in local livelihoods, providing food and water, water for agriculture, tourism, recreation and hydrological power. The introduction of IAS has placed these opportunities under threat. Non-native species of fish and plants have been introduced into freshwater systems to enhance food production, control pests such as mosquitoes, and to promote water purification. However, in many cases they have had adverse effects.

Although the use of alien species in aquaculture has had many positive effects, when these species escape or become invasive they can cause significant ecosystem

Table 1. Effects of some characteristic aquaculture-related introductions in Africa

Aquaculture Introduction	Environmental Impact
Oreochromis niloticus to Kenya	Displaced endemic *Oreochromis esculentus* in Lake Victoria
Tilapia zillii to Uganda	Displaced *Oreochromis variabilis* in Lake Victoria
Osphronemus goramy to Mauritius	Naturalized, minimal
Oreochromis macrochir and *Tilapia rendalli* to Cameroon	Naturalized, unknown
Cyprinus carpio to Kenya	Displacement of local species
Cyprinus carpio to Zambia	Not established
Cyprinus carpio to Malawi	Not established
Cyprinus carpio to Zimbabwe	Naturalized
Oreochromis niloticus to Zimbabwe	Introgression and reduced catches of indigenous tilapias
Clarias gariepinus to Cameroon	Naturalized
Carassius auratus to Madagascar	May have introduced parasites
Chinese carps to Ethiopia	Reportedly naturalized
Ctenopharyngodon idella to South Africa	Introduced fish tapeworm
Cyprinus carpio to Madagascar	Naturalized
Cyprinus carpio to South Africa	Reduced catches of local species; introduced 7 exotic parasites
Heterotis niloticus to Côte d'Ivoire, Cameroon, CAR, Gambia, Congo	Naturalized, unknown Naturalized
Oncorhynchus mykiss to Morocco	Unknown
Salmo trutta to South Africa	Eradication of local species
Oreochromis niloticus to Madagascar	Genetic introgression and replacement of local species

Source: Brummet 2002

damage. The Mozambique tilapia is an invasive in Northern Africa and has spread worldwide through introductions for aquaculture, as well as into the coastal waters of several WIO countries (IUCN/SSC/ISSG). Established populations in the wild are the result of intentional releases as well as escapes from fish farms. The same is true of the Nile tilapia, from Northern Africa, which has become an IAS in Southern Africa. This species can hybridize with the Mozambique tilapia, threatening its very existence in its native habitat (van der Vaal 2002).

Procambarus clarkii (Louisiana crayfish) has been introduced for aquaculture as well as a biological control agent for snail hosts of bilharzia. It escaped from aquaculture sites and is responsible for the disappearance of water lilies and submerged vegetation, as well as many species of snails, in the wetlands of Eastern and Southern Africa (Howard and Matindi 2003). It threatens the existence of smaller fish, and its habit of burrowing can result in damage to dams and reservoirs. It tolerates a wide range of salinities, oxygen-poor conditions, high pollution and fluctuating water levels. These factors, along with the ability of adult crayfish to travel long distances across land, have made it an effective invasive species (GISP 2004). In Kenya, it was introduced into Lake Naivasha where it has supported a lucrative export industry to Europe. The crayfish has become a keystone species in the lake, resulting in a cyclical boom-or-bust scenario with plants and other fish disappearing and then recovering (GISP 2004).

Services, infrastructure and shelter

The changes IAS cause in the environment may threaten human settlements. Not only do IAS reduce the availability of environmental goods-and-services, but they may also increase the physical threats to human habitat. For example, many invasives enhance the frequency and intensity of fires. Numerous invasive grasses produce a great deal of flammable standing dead material and many resprout quickly after fires, giving them a competitive advantage over native species. This may threaten homes and other infrastructure.

Aquatic IAS may clog waterways used for transportation and enter hydropower facilities, threatening the provision of electricity.

Box 5: Water hyacinth wreaks havoc

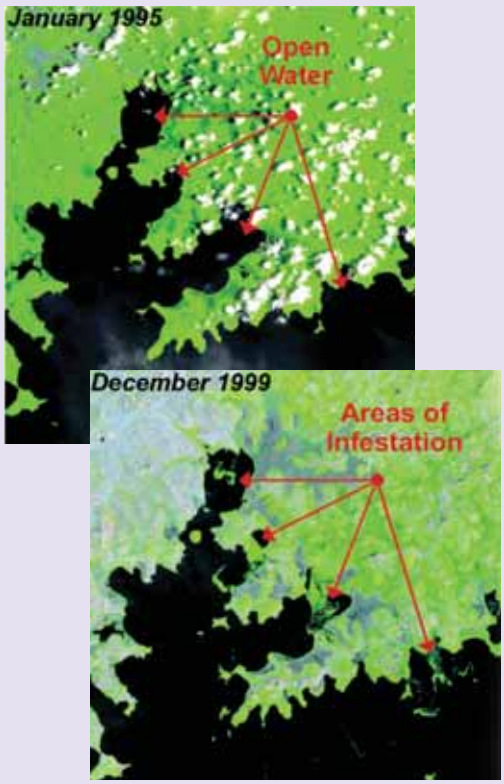
The water hyacinth (*Eichhornia crassipes*), imported into Africa from the Amazon River Basin in South America, is exploding into large infestations and is causing serious disruption to environments, economies and societies. Rivers, dams, lakes and other water bodies have become infested.

Lake Victoria is one of the most affected lakes. Although it is not known when or how the plant first entered the lake, reports suggest that it has been present in the lake since the 1980s. By 1998 it covered about 20 000 ha and huge mats paralysed activities in ports, villages and bays. At times it has even prevented large and small boats from leaving their harbours. Through biological control methods the water hyacinth has been effectively brought under control, and now only covers 2 000 ha of the lake surface.

In West Africa, the water hyacinth is a major problem, affecting more than 550 km along the Niger River. Countries such as Niger, Mali, Côte d'Ivoire, Nigeria and Senegal use various approaches to control its spread. The measures include chemical, biological and mechanical control.

The economic impacts of the water hyacinth, in seven African countries, have been estimated at between US$20-50 million every year. Across Africa costs may be as much as US$100 million annually.

Sources: UNEP 2003a, McNeely and others 2001, GISP 2004



Extent of water hyacinth coverage in Murchison Bay, Lake Victoria, Uganda (1995, 1999).

Source: UNEP/GRID and USGS EROS Data Centre in UNEP 2004

Invasive termites damage homes and other infrastructure. *Coptotermes formosanus* ((Formosan subterranean termite) lives in damp, woody conditions. It is native to China, but has spread around the world, including to many African countries. It not only feeds on timber in buildings but may also nest in homes and other structures (IUCN/SSC/ISSG 2004). The species is very aggressive and out-competes native termite species. The Louisiana crayfish, through its burrowing habits, can cause extensive damage to dams and reservoirs (GISP 2004).

Tourism

The conversion of native biotic communities to invasive-dominated communities also has aesthetic and cultural impacts and this directly affects tourism. Some IAS directly threaten the habitat of species that are key to the tourism industry. *Chromolaena odorata*, for example, affects the nesting sites of crocodiles, directly placing these populations at risk. Water hyacinth, by clogging waterways, affects water-based recreational activities. Species loss also has adverse impacts on tourism. For example on the Seychelles' Bird Island, where *Anoplolepis gracilipes* (crazy ant) displaced about 60 000 pairs of *Sterna fuscata* (sooty terns), tourism was adversely affected (CBD 2003).

Health

The relationship between human health and IAS is complex, with patterns of human settlement, economic activities, environmental change and disease virulence, as well as the interactions between these, being crucial (GISP 2004). Where IAS pose human health threats it may place added strain on already fragile health systems.

International trade introduced the Asian tiger mosquito, which carries dengue fever, to the Americas and to Africa. First introduced in South Africa, it is now present in Cameroon, Madagascar, Nigeria, Réunion, the Seychelles, Kenya, Mozambique, Djibouti and Somalia. Increased exposure to vector diseases such as malaria, dengue fever, *schistosomiasis* (bilharzia) and *trypansomiasis* (African sleeping sickness) is associated with large development projects, environmental change such as forest loss, and human settlement. Forest loss, for example, has widened the transmission of some diseases previously restricted to wild animal hosts (GISP 2004). Trade has also spread the life-threatening bacteria E. coli in meat exports (CBD 2005).

Vibrio cholerae (Asiatic cholera) is the bacteria that causes cholera and is an IAS. Cholera is endemic or epidemic in areas with poor sanitation. Although cholera may cause mild or unapparent infections, in its extreme manifestation cholera is one of the most rapidly fatal illnesses known. It occurs in both marine and freshwater habitats including lagoons, estuaries, lakes and wetlands in association with aquatic animals. In coastal regions it may persist in shellfish and plankton. It may also be associated with algal blooms (plankton), which are influenced by the temperature of the water. Rising water temperature, through for example climate change, may increase the potential risk of this. Cholera is spread through the live food trade, and the contamination of water sources.

IAS (*Pinus spp.*) encroach on Zimbabwe's Nyanga National Park, potentially threatening biodiversity and tourism.

Source: J.C. Mohamed-Katerere

HIGH COSTS

Many countries face high costs – economical, environmental and social – due to the presence of IAS. The financial and management costs associated with their eradication are astronomical and their proliferation affects the potential of countries to meet their development and environmental objectives. Resources spent on trying to control IAS could be redirected to other development initiatives, such as the implementation of the MDGs. This is an important reason to adopt approaches which control and prevent introductions.

Invasive alien species cost millions of US dollars annually in terms of lost revenue and expenditure on control measures. While the actual costs of IAS are unknown, they are believed to be substantial. The global economic costs of IAS are estimated by IUCN to be about US$400 000 million annually (UNEP 2003); IUCN also finds that IAS threaten the success of current and planned World Bank projects to the value of more than US$13 000 million (UNEP 2004).

Currently, Africa spends an estimated US$60 million annually on the control of IAS (CBD 2005). The African Ministerial Conference on the Environment (AMCEN) plans to raise a further US$265 million to fund various projects related to IAS in Africa over the next three to five years (UNEP 2004).

In South Africa, alien plant species now cover more than 10.1 million ha, threatening indigenous plants

Box 6: Black wattle: weighing the costs-and-benefits

The black wattle tree has been used in Africa as a commercial plantation species for many years. It has a variety of important uses (IUCN/SSC/ISSG 2004):

- Tannin compounds extracted from the bark are used in the production of soft leather.
- Resins, thinners and adhesives, can be made from bark extracts.
- The timber is used for building materials.
- Charcoal produced from wood is used for fuel.
- The pulp and woodchips are used to produce paper.

It also has some well known medical applications, including its use as an astringent. Plantings of wattle tress have also been used as a soil stabilizer to decrease erosion. The agroforestry industry promotes the use of the species (among other similar species) as a potential "soil improver."

It is nevertheless a highly invasive species – it produces large amounts of long-lived seeds – and it competes with and replaces indigenous vegetation. It may replace grass communities, reducing the carrying capacity of the land (IUCN/SSC/ISSG 2004). By causing an increase in the height and biomass of vegetation, black wattle infestations increase rainfall interception and transpiration, which causes a decrease in stream-flow. The soil underneath becomes desiccated more quickly than it does under grass. Black wattle stands also destabilize stream banks and support a lower diversity of species.

In South Africa, authorities are fighting to combat black wattle, which was introduced about 150 years ago to provide bark products. The black wattle is one of about 110 IAS of almost 750 tree species and 8 000 shrubby and herbaceous species that were imported into South Africa from countries in North America, South and Central America, Australia, Europe, Oceania and Asia (Sweet 1999). It has been described as "the number one threat to biodiversity in the Cape Floral Kingdom" (de Bakker 2003). Of the remaining natural areas of the Cape region, 17-24 per cent have been invaded by acacias (Musil 1993). The Cape Floral Kingdom, a biodiversity hotspot at Africa's south-westernmost tip, is of huge importance because it contains 1 per cent of the world's total plant species as endemics (de Bakker 2003).

Cape Fynbos.

Source: M. Chenje

Efforts to eradicate black wattle have come at tremendous cost:

- Since 1995, the financial cost of control comes to US$70 million (Preston 2004) and about 40 000 workers have been involved in removing the black wattle together with other invasives.
- More than 5 000 million invasive alien trees, of which many are black wattle, have been removed since 1995 (de Bakker 2003).
- It costs the South African government an estimated US$40 million annually for manual and chemical control of IAS in the Cape Floral Kingdom (IUCN 2001).

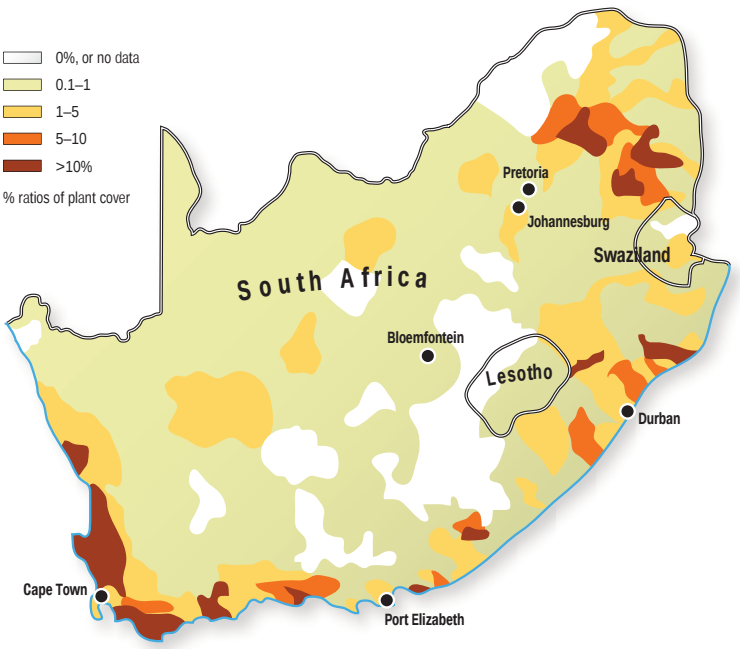
Sources: de Bakker 2003, IUCN 2001, IUCN/SSC/ISSG 2004, Musil 1993, Preston 2004

(ITC undated). (See Figure 2). Freshwater systems and the Cape Floral Kingdom (a global centre of biodiversity) are particularly at threat and the South African government therefore established the "Working for Water" programme. This programme seeks to remove IAS infestations from water catchment, and at the same time provide poverty relief (van Wilgen and others 1998). In South Africa, in addition to altering water-flow, IAS have had other important impacts on endemic biodiversity and ecosystem services. Nitrogen-fixing plants such as *Acacia saligna* alter the nitrogen cycle, impacting on native plants adapted to low nutrient conditions, such as, for example, many of the fynbos species. The costs associated with eradicating IAS, as shown in Box 6, have exceeded US 100 million.

In the Western Indian Ocean (WIO) countries, IAS pose a serious threat to forests and thus place biodiversity, including many endemics, at risk. Among these invasive woody species are *Paraserianthes falcataria* (Albizia), *Adenanthera pavonia* (Agati), *Clidemia hirta* (Creole name: *Faux Watouk*), *Cinnamomum verum*, *Chrysobalanus icaco (Prune de France)*, *Psidium cattleianum* (wild guava), *Syzygium jambos*, *Astonia macrophylla (Bois jaune)* and *Tabebuia pallida* (Calice du pape) (IUCN/SSG/ISSG). In addition to the costs to biodiversity, governments incur substantial financial and management costs. In the Seychelles, for example, the Ministry of Environment is involved in a programme for the eradication of IAS, including those listed below, and the replanting of indigenous species; public education is seen as an important aspect of this (Ministry of Environment Seychelles, undated):

- *Clidemia hirta* grows quickly, particularly in disturbed areas, and displaces native plants. It competes effectively for light and soil nutrients and is therefore a successful invasive.
- *Cinnamomum verum*, introduced in the 1970s for economic reasons, has spread so rapidly that today it is the most widely distributed and probably the most numerous plant in the Seychelles.
- *Chrysobalanus icaco* was originally introduced to prevent erosion on steep slopes. Dense thickets of this species have now become established on many steep erosion slopes. It is difficult to get rid of this species once it has become established. It also invades areas where the indigenous forest had been cleared.
- *Syzygium jambos* (Jambrosa) tends to replace the naturally occurring vegetation, including forests in river ravines. Jambrosa is native to Indo-Malaysia and was recorded as being well established in the Seychelles as early as the 1870s. It is still planted by many people for its edible fruits.

Figure 2: Estimated percentage invasion per tertiary catchment



Source: Versfeld and others 1998

Across Africa, IAS in the genus *Striga* have a direct impact on local livelihoods, affecting more than 100 million people and as much as 40 per cent of arable land in the savannahs. The cost of eradicating it is reportedly between US$7-13 000 million annually (UNEP 2004). These invasives stunt maize plant growth by attacking the roots and sucking nutrients and water (Ithula 2004) and thus in addition to the direct financial costs have implications for food security.

Small Island Developing States

While islands may not be more susceptible to invasions by alien species than continental landmasses, they are, however, considered to be particularly vulnerable to the impacts of such invasions (CBD 2003 and IUCN/SSC/ISSG 2001). On islands, IAS are now on a par with habitat loss as the lead driver of species extinctions over the last 20 years (Baillie and others 2004).

Important opportunities exist for effective control for terrestrial IAS. These can be effectively controlled through customs and border monitoring; these measures have greater potential for success on islands than in countries that share boundaries (IUCN/SSC/ISSG 2001 and Wittenberg and Cock 2001). In terms of responses on islands, research shows that the experience of one island country can be invaluable in managing IAS on another island even where there are major differences in climate and ecological systems. Key similarities such as the role and nature of trade may be significant. Areas where a cooperative initiative

on island IAS may be especially valuable include (IUCN/SSG/ISSG 2001):

- Undertaking the eradication of IAS;
- Undertaking the management of IAS where eradication is not currently feasible, to low levels that allow recovery of biodiversity values;
- Training and other capacity enhancement activities; and
- Undertaking quarantine and contingency response activities to prevent the establishment of new populations of IAS that might threaten ecosystems or species (including the control of movement in the country).

DEVELOPING EFFECTIVE RESPONSES

Although Africa has recognized the problems associated with IAS for several decades, a comprehensive approach to IAS is still to be developed. However, as discussed in Box 8, considerable progress has been made towards this with the adoption of the New Partnership for Africa's Development (NEPAD) Environmental Action Plan (NEPAD-EAP).

Understanding the factors driving the spread of IAS and their impacts is essential to developing effective responses. Where species have become invasive they are an important factor in environmental change, contributing to or exacerbating human vulnerability, and in some cases foreclosing livelihood and development options (UNEP 2004). Globalization – with its expanding trade and increased human movement – is likely to increase the risk of IAS. The inadvertent ending of millions of years of biological isolation has created major ongoing problems that affect both developed and developing countries (IUCN/SSC/ISSG 2004). Given that the threat posed by IAS stems from transnational processes, responses need to be based on collaborative measures. Further, the potential severity of IAS needs to be acknowledged; this includes its impacts on socioeconomic systems as well as the costs of eradication. On the basis of a global assessment, the MA found that climate change and the introduction of IAS are the two drivers of environmental change that are the most difficult to reverse (MA 2006).

The threats of IAS cannot be treated in isolation. They are part of a complex set of pressures and drivers of biodiversity loss and environmental change. As discussed in Chapter 1: *The Human Dimension*, social, political and economic drivers are growing in both scale and scope. The underlying causes are a complex tangle, rooted both in our expanding demands on the planet and the unfair ways that we share our resources (BirdLife International 2004). Rising individual consumption and material expectations, especially in rich nations, are driving agricultural intensification, habitat destruction and overexploitation elsewhere (BirdLife International 2004). Poverty, along with inequity, particularly in trade, access to technology, and the distribution of benefits from the use of biodiversity, make sustainable use and development particularly challenging for developing countries (WRI and others 2005). Therefore, responses need to go beyond short-term crisis-focused approaches. They need to be at multiple levels, and in many incidences an interlinkages approach – which takes into account the horizontal linkages between environmental sectors as well as the links between development and social objectives – will need to be adopted. Policies across different sectors as well as at different scales, including the national and regional, will need to be harmonized. Chapter 8: *Interlinkages: The Environment and Policy Web* considers this approach to decision making and responses more fully.

Traditionally, environmental law has focused on protected areas and species protection, and it has failed to take into account the multiple drivers affecting the environment, and consequently environmental protection has been insufficient. Developing an effective legal framework demands adopting appropriate measures at multiple scales: in the case of IAS this may include, among others, having more effective customs controls, appropriate trade measures, and sanitary and phytosanitary provisions for imports and transportation vessels. Legal and policy

Box 7: Key facts

- Invasive alien species threaten all sub-regions in Africa.
- Invasive alien species occur in all major taxonomic groups. They include viruses, fungi, algae, plants, fish, amphibians, reptiles, birds and mammals.
- Numerous species – including as high as 10 per cent of the world's 300 000 vascular plants – have the potential to invade other ecosystems.
- IAS affect wetlands, forests, drylands, marine and coastal and other ecosystems, contributing to biodiversity loss and ecosystem degradation.
- IUCN has estimated that, worldwide, the total economic cost of invasives is US$400 000 million annually.
- The CBD estimated that Africa spends as much as US$60 000 million annually to control IAS.
- Invasive alien species flourish in areas disturbed by human activities.

Sources: IUCN/SSG/ISSG 2004, Howard and Matindi 2003, McNeely and others 2001, MA 2006

Box 8: NEPAD makes IAS a priority

The NEPAD-EAP has prioritized IAS. The reasons are simple:

- Alien species are second only to habitat loss as a cause in endangering species and their extinction (IUCN/SSC/ISSG 2004).
- IAS affect Africa's forestry, horticulture, trade and tourism industries, as well as other sectors of the economy.
- IAS affect human well-being by indirectly contributing to poverty, food insecurity and ill-health.

The control of IAS is an important aspect of biodiversity conservation. A NEPAD thematic workshop on prevention, control and management of IAS which was held in Pretoria in January 2003, identified 14 project proposals for the implementation of this programme area. The sub-programme areas include: prevention of IAS; awareness-raising and provision of information; training and capacity-building; aquatic IAS; terrestrial IAS; ballast water; and African islands.

Sources: NEPAD 2003

approaches to IAS need to be at multiple levels, from the local, to national, to regional, to global, and law at these different levels needs to be harmonized. Policies and laws across different sectors, such as trade and environment, need to reinforce overall social priorities and not pull in different directions.

IAS are a constant and potential threat, and thus require strategic policy responses and action.

Making choices

It is important that an informed approach be taken to new introductions of IAS as well as to decisions related to existing ones. Policy and decision-making processes that evaluate the various benefits and risks associated with IAS need to be adopted. (Box 6, for example, looks at the benefits and costs of the black wattle tree). Chapter 8: *Interlinkages: The Environment and Policy Web* considers the opportunities offered by interlinking policies as well as the use of management tools that integrate development and environmental considerations. Among these are environmental impact assessments (EIAs) and valuation techniques. Chapter 9: *Genetically Modified Crops* assesses the value of risk assessment processes that effectively link uncertainty, scientific knowledge, and social and economic objectives. It considers the opportunities of inclusive policy processes that draw on a wide range of expertise and values. Given the central role that the general public, and in particular the business sector, plays in the proliferation of IAS, this is perhaps an important tool for decision making related to IAS.

Building partnerships

Managing and controlling IAS presents special challenges. The public are particularly important partners because of their role in introducing and maintaining IAS. Many introductions occur because the importer or user is unaware of the environmental, social and economic costs of a given species and thus information and its effective communication are critical. Even where there is an appreciation of these costs, many IAS are maintained because the public do not identify them as such or see them as a threat. This is particularly true of ornamental plants, exotic pets and economically valuable species which have been used over long periods. Bringing in the public and the business sector as partners must be a cornerstone of any effective IAS policy.

Investing in research and capacity

It is widely acknowledged that good information and understanding is the basis for sound policy and management. While considerable knowledge exists about IAS, there are still many gaps. Some of these gaps relate to the impacts of specific species on other species and ecosystems, while others relate to management strategies. For example, while we know that *Suncus murinus* (the Asian musk shrew or house shrew) is a rapid colonizer and a growing ecological threat, preying on or competing with many animal species and that it has a large and expanding range in Africa, very little research has been carried out on how to effectively manage the species.

It is critical for Africa to invest in and to cooperate in building better understanding and capacity to deal with these and other management challenges. This involves, as discussed in Chapter 8: *Interlinkages: The Environment and Policy Web*, empowering institutions and people. Direct investment in research and technical agencies is an important aspect of this, as is the development of good institutional and governance systems.

Investment in management is essential – and this too needs to be at multiple levels. Different management techniques are needed for new and established IAS. Techniques that focus on the eradication of specific species need to be complemented by more integrated approaches to ecosystem management. For example,

• Climate change and the introduction of invasive alien species are the two drivers of environmental change that are most difficult to reverse. •

MA 2006

integrated water resource management (IWRM) can complement chemical, biological and manual eradication. Management needs to be closely linked to monitoring and evaluation and adapted accordingly.

Regional and global cooperation

Given that IAS are essentially related to trade and human mobility, it is essential to improve regional and global cooperation. The NEPAD-EAP sets the basis for such cooperation in Africa. The opportunities it presents are complemented by the development of sub-regional organizations throughout Africa which focus on harmonizing trade, customs and immigration policies and practices. These institutional arrangements are discussed in Chapter 1: *The Human Dimension*.

These specific African initiatives are complemented by various global responses, in which Africa and other developing regions have played an important role. There is a gamut of different agreements dealing with different aspects of IAS that are relevant in terms of controlling their movement and possible invasive nature. These range from the multidimensional CBD, to the conservation framework of MEAs concerned with migratory species and the aquatic environment, to biosafety laws, to sanitary and phytosanitary measures, to transport, and to trade.

Since 1992, the CBD along with Agenda 21 has set the general global framework for addressing the problems associated with IAS. The CBD recognizes the need for conservation and development as well as the close relation between them. The approach of the CBD is based on Article 8(h) of the Convention (see Box 9), and encompasses all IAS which threaten biodiversity, whether or not they remain under human control. Under this broad definition, alien plantations may also be considered to fall within the ambit of the Convention (Shrine and others 2000). The CBD provides the basis for taking preventative and mitigation measures to address the full range of threats posed by IAS to genetic diversity, species diversity, ecosystems and habitats.

Through the CBD Conference of the Parties (COP), a comprehensive framework for addressing these problems has been developed. The CBD has developed a sequenced approach to managing IAS (Shrine and others 2000). At the 2000 Conference of the Parties (COP), parties agreed:

- To give priority to preventing entry of IAS within and between states; and
- Where entry has already taken place to prevent the establishment and spread of such species.

The COP identified the eradication of such invasives as the preferred response and, where this is not feasible, the adoption of cost-effective, containment and control measures. This approach is echoed in MEAs for protecting migratory species, as well as those concerned with coastal and marine environments, the United Nations Convention on the Law of the Sea, the Ramsar Convention and the Convention on the Law of Non-Navigational Uses of International Watercourses.

A woman holds a huge Nile perch skeleton, Kisumu, Lake Victoria, Kenya.

Source: T. Bolstad/ Still Pictures

Box 9: Convention on Biological Diversity

Article 8(h) of the CBD calls on Parties as part of *in situ* conservation measures and as appropriate to:

> "Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species."

Source: UN 1992

Aquatic environments may be extremely vulnerable to IAS and eradication of such species more difficult than in terrestrial habitats. Consequently, there has been a strong focus in multilateral law on preventative measures for marine and coastal environments.

In the management of IAS, partnerships between different sectors and disciplines, as well as between the public and private sectors, is acknowledged as important. The Global Invasive Species Programme (GISP) is an initiative closely linked to the CBD and is a partnership which seeks to build global cooperation. It brings together several international non-governmental organizations (NGOs), such as IUCN and the Nature Conservancy, scientists including those from IUCN's Invasive Species Specialist Group, DIVERSITAS and its International Programme of Biodiversity Science, Australia's Commonwealth Scientific and Industrial Research Organization, South Africa's National Botanical Institute, local projects involved in IAS eradication and control such as Working for Water in South Africa, and the United Nations Environment Programme.

The GISP has proposed 10 strategic responses to control IAS; these are (IUCN 2001):

- Building management capacity at national and international levels;
- Building research capacity using cross-sectoral and multidisciplinary approaches;
- Sharing information to, among other reasons, alert management agencies to potential dangers of new introductions;
- Developing economic policies and tools;
- Strengthening national, regional and international legal and institutional frameworks;
- Instituting a system of environmental risk analysis;
- Building public awareness and engagement;
- Preparing national strategies and plans;
- Building IAS issues into global change initiatives; and
- Promoting international cooperation.

Biosafety, sanitary and phytosanitary measures

Africa has, over a long period, recognized the importance of controlling the introduction of alien species that can be potentially damaging to ecosystem:

- The African Convention on the Conservation of Nature and Natural Resources, adopted in 1968,

FAO staff providing technical advice on IAS Tilapia management near Bouak, Côte d'Ivoire.

Source: M. Pickstock/FAO

requires Parties to prohibit the entry of "zoological or biological specimens, whether indigenous or imported, wild or domestic" that may cause harm to protected areas.

- The Protocol concerning Protected Areas and Wild Fauna and Flora in the East Africa Region (1985) calls for the adoption of appropriate measures to prohibit the intentional or accidental introduction of alien or new species which may cause significant or harmful changes to the sub-region.
- Other protocols developed by sub-regional bodies also address some aspects of controlling IAS. Examples include the treaty for the Establishment of the Eastern African Community (EAC), the treaty of the Southern African Development Community (SADC) and the treaty establishing the Common Market for Eastern and Southern Africa (COMESA).

The African Convention on the Conservation of Nature and Natural Resources (ACCNNR) – which revised the 1968 convention and was adopted in 2003 – requires parties to strictly control the intentional and accidental introduction of alien species, including modified organisms and to endeavour to eradicate those already introduced where their consequences are detrimental to native species or to the environment in general (AU 2003).

Sanitary and phytosanitary measures focus primarily on import and export regimes and provide for quarantine periods to ascertain safety as well as for the destruction of specimens. Relevant instruments and institutions include:

- The World Health Organization's (WHO) International Health Regulations;
- The International Plant Protection Convention (IPPC);
- The World Trade Organization's (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures; and
- The Inter-African Phytosanitary Council, which was established in 1954.

Under the IPPC, special measures have been adopted for the importation and release of alien biological control agents. However, with globalization, and the legal dominance of the WTO, managing these threats in a way that is compatible with environmental concerns, national interests and unfettered or free global trade is an increasingly complex challenge. The WTO has 148 members and creates a binding, and enforceable, set of rules designed to ensure that governments extend free market access to each others' products and services (Shrine and others 2000). Box 11 sets out the essential aspects of the WTO approach.

However, as IUCN has noted: "Customs and quarantine practices, developed in an earlier time to guard against human and economic diseases and pests, are often inadequate safeguards against species that threaten native biodiversity" (IUCN/SSG/ISSG 2000). New challenges include addressing the relationship between environmental change and trade, as well as growing problems of uncertainty.

Important lessons can be learnt from the legal regime developed to deal with the impact living modified organisms (LMOs) will have on biodiversity, ecosystems and human health, livelihood systems and development opportunities, as these organisms present many of the same challenges. Sanitary and phytosanitary measures historically have focused on protecting people, plants and animals from pests and diseases. However, the challenge of IAS goes beyond this to include uncertainty about possible impacts and potential conflicts between environmental, social and economic concerns.

The Cartagena Protocol on Biosafety, which entered into force in 2003, sets out the first comprehensive regulatory system for ensuring the safe transfer, handling and use of LMOs. The focus is on regulating the movement of such organisms across national borders. It is concerned with both intentional environmental introductions and LMOs that are to be

Box 10: The need for vigilant phytosanitary measures

Imported plants, including those for research and agricultural use, may introduce exotic pathogens or parasites if adequate phytosanitary checks are not undertaken on imported plants. For example:

- A new high-yielding maize variety imported into Senegal in 1948 brought in a new strain of rust which killed off local maize.
- In 1971, a Ugandan university lecturer brought back a new variety of cassava from Brazil and planted it on a university field station. Unfortunately there was a new strain of mealie bug on the imported cassava and this spread to all the cassava growing area in Central Africa.
- FAO introduced sweet varieties of cassava from South America to replace the bitter varieties used in Africa. Unfortunately, with these varieties they also introduced a mite pest of cassava which has since spread widely.

Imported plants should therefore be held in quarantine and checked for parasites and disease before the crop is released into a new environment.

Source: TAA 2000

Box 11: The WTO Agreement on Sanitary and Phytosanitary Measures 1995

This agreement seeks to promote free trade and thus provides for:

- Internationally-determined standards for SPS measures;
- Risk assessment based on scientific principles and evidence;
- Consistency in the application of appropriate levels of protection;
- Least trade restrictive alternatives;
- Acceptance of equivalent measures; and
- Transparency through notification of trade measures.

Source: Shrine and others 2000

used as food or feed, and for processing. Such organisms are also alien species and currently the extent to which these will threaten biological diversity, ecosystem and habitats is poorly understood – much remains uncertain and there are fundamental areas of ignorance and gaps in knowledge. In addressing this, the Protocol:

- Adopts a precautionary approach; and
- Establishes an advanced informed agreement system.

These approaches could be replicated to deal with IAS more widely, and are increasingly recognized as key components of a response strategy (McNeely and others 2001). The essence of this approach lies in the right to notification and prior informed consent. It includes the right to undertake risk assessment and to refuse entry of organisms due to their biological, environmental and socioeconomic impact or due to insufficient information. The African Union (AU) has developed a regime for biosafety in its Protocol on Safety in Biotechnology based on these principles. This and how to develop responses to deal effectively with scientific uncertainty are considered more fully in Chapter 9: *Genetically Modified Crops*.

CONCLUSION

The management and control of IAS present some important challenges for decision-makers. Globally, preventing their introduction is seen as the cornerstone of effective measures for dealing with IAS. This approach is believed to be the most cost-effective and environmentally-sound approach as once an invasive species becomes established, eradication may be impossible and ecological damage irreversible (Shrine and others 2000). This obligation to control IAS needs

Protecting endemic species, such as the sooty tern (*Sterna fuscata*) of the Seychelles, is an important conservation objective.

Source: Seitre/ Still Pictures

to be balanced against international trade obligations as well as social and economic concerns. Developing systems for making sound choices must be a priority for African governments.

Although the NEPAD-EAP identifies IAS as an important programme area, it is not clear how it will be addressed. The development of programmes and strategies will need to be based on a comprehensive analysis of IAS, and their associated costs-and-benefits. The need for strategic research to support this cannot be overemphasized. Research may include compiling a complete inventory of all alien species, including non-invasive ones, determining the impacts to date on ecosystems, and assessing the financial resources needed as against the cost of inaction. This will require new levels of investment in research. Partnerships and collaboration are essential for effective research. For example, the private sector could play a role in supporting research and development. Regional cooperation may help lower research costs.

The NEPAD-EAP will need to be complemented by national and sub-regional interventions. National strategies would need to identify the goals and objectives of an alien species plan. Such strategies will need to draw on existing knowledge and establishment management approaches. The shift that has taken place from species preservation to ecosystem integrity may form the basis of these responses.

Legal and institutional frameworks at national, sub-regional and regional levels will need to be refined to establish complementarity between different sectors. While the region has taken significant steps to address the problem by adopting the ACCNNR, its successful implementation will be long-term since out of the 33 countries that have signed it, only four had ratified it by March 2006 (AU 2003).

Legislation will need to create effective frameworks that are consistent with international obligations. These could benefit from the use of established legal approaches and principles, such as precaution, cost-recovery measures, rights of public participation, and rights of access to information. Other important management and decision-making tools that could be incorporated in national, sub-regional and regional frameworks include risk analysis and assessment systems, environmental impact assessment and cost-benefit analysis.

Partnerships, with a cross-section of actors at multiple scales, are an important aspect of developing appropriate responses. The inclusion of different stakeholders, from communities, NGOs, research organizations, the private sector and government, is important for developing appropriate policy as well as identifying effective interventions. Information, and its communication, is critical to bringing diverse sectors on board as effective partners. Environmental education initiatives should also highlight the problems of IAS and how they influence environmental change, which among other impacts, exacerbate human vulnerability.

The spread of IAS is directly linked to trade and human mobility. Reconciling these, and developing mechanisms that deal effectively with this challenge, is undoubtedly a priority area for policy and response.

References

AU (2003). African Convention on the Conservation of Nature and Natural Resources. African Union, Addis Ababa. http://www.africa-union.org/root/au/Documents/Treaties/Text/nature%20and%20natural%20recesource.pdf

Baillie, J.E.M., Hilton-Taylor, C. and Stuart, S.N. (2004). *2004 IUCN Red List of Threatened Species. A Global Species Assessment*. IUCN – the World Conservation Union, Gland

Binggeli, P., Hall, J.B. and Healey, J.R. (1998). An Overview of Invasive Woody Plants in the Tropics. School of Agricultural and Forest Sciences. University of Wales, Bangor http://www.safs.bangor.ac.uk/IWPT

Birdlife International (2006). Illegal imports probable cause of Nigeria flu. BirdLife International. http://www.birdlife.org/news/news/2006/02/avian_flu_nigeria.html

BirdLife International (2004). *Threatened Birds of the World 2004*. BirdLife International, CD-ROM, Cambridge

Bryant, P.J. (2002). Chapter 14: Exotic Introductions. In Biodiversity and Conservation: A Hypertext Book. http://darwin.bio.uci.edu/~sustain/bio65/lec14/b65lec14.htm

Brummett, R.E. (2000). Indigenous species for African aquaculture development. Paper presented to the World Aquaculture Society Annual Meeting, 1-5 May, Nice, France http://www.oceansatlas.com/world_fisheries_and_aquaculture/html/resources/aqua/introspec/exoticspecies.htm

CBD (2005). Invasive Alien Species. Convention on Biological Diversity http://www.biodiv.org/programmes/cross-cutting/alien/

CBD (2003). Pilot Assessments: the Ecological and Socio-Economic Impact of Invasive Alien Species on Island Ecosystems. UNEP/CBD/SBSTTA/9/INF/33. United Nations Environment Programme/Convention on Biological Diversity/Subsidiary Body on Scientific, Technical and Technological Advice. http://www.biodiv.org/doc/meetings/sbstta/sbstta-09/information/sbstta-09-inf-33-en.pdf

De Bakker, L. (2003). Combating the aliens. Radio Netherlands www.rnw.nl/science/html/030825alien.html

ESA (2004). Invasion! Ecological Society of America, Washington, D.C. http://www.esa.org/education/edupdfs/invasion.pdf

Fontenille, D. and Toto, J. C. (2001). Aedes (Stegomyia) albopictus (Skuse): A Potential New Dengue Vector in Southern Cameroon. *Emerging Infectious Diseases*. 7(6), 1066-1067

GISP (2004). *Africa Invaded: The Growing Danger of Invasive Alien Species*. Global invasive Species Programme, Cape Town. http://www.gisp.org/downloadpubs/gisp%20africa%202.pdf

Hall, J. (2003). Southern Africa: Alien plant species invade region. Inter Press Service, 27 June. http://www.afrika.no/Detailed/3761.html

Howard, G.W. and Matindi, S.W. (2003). *Alien Invasive Species in Africa's Wetlands – Some threats and Solutions*. IUCN – the World Conservation Union, the Ramsar Convention on Wetlands, and the Global Invasive Species Programme. IUCN – the World Conservation Union Regional Office for Eastern Africa, Nairobi.

Howard, G.W. (2003). Control of the invasive Indian House Crow on the Eastern Africa coast and its hinterland. A project concept note. Environment Initiative of NEPAD. IUCN Eastern Africa.

Ithula, M. (2004). Winning the war. *Executives: East African Standard*, May 5, 2004. Standard Newspaper Group, Nairobi

IRIN (2002). SOUTHERN AFRICA: Focus on invasion of plant "invasives". The United Nations Integrated Regional Information Networks. http://www.irinnews.org/report.asp?ReportID=20351&SelectRegion=Southern_Africa

IUCN/SSC/ISSG (2004). Global Invasive Species database. IUCN – the World Conservation Union Species Survival Commission, Invasive Species Specialist Group. http://www.issg.org/database/species/search.asp?st=100ss&fr=1&sts

IUCN/SSC/ISSG (2001). Special Issue on Islands: Message from the Chair. *Aliens*, 14. IUCN – the World Conservation Union, Species Survival Commission, Invasive Species Specialist Group. http://www.issg.org/aliens_newsletter/Aliens14.pdf

IUCN/SSC/ISSG (2000). IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species. IUCN – the World Conservation Union Species Survival Commission, Invasive Species Specialist Group. http://www.iucn.org/themes/ssc/publications/policy/invasivesEng.htm

ITC (undated). Mapping Invasive Plants in South Africa. International Institute for GEO-Information Science and Earth Observation

Kirby, A. (2003). Alien species cost Africa billions. BBC News Science http://news.bbc.co.uk/2/hi/science/nature/2730693.stm

MA (2006). *Ecosystems and Human Well-being: Current State and Trends*. Volume 1. Millennium Ecosystem Assessment. Island Press, Washington http://www.millenniumassessment.org//en/products.global.condition.aspx

McNeeley, J.A., Mooney, H.A., Neville, L.E., Schei, P. and Waage, J.K. (2001). Global Strategy on Invasive Alien Species. IUCN – the World Conservation Union, Gland

Ministry of Environment Seychelles (undated). Alien Invasive Species (Plants). http://www.pps.gov.sc/enviro/html/alien_invasive_species__plants.html

MoFPED (2000). *2000 Statistical Abstracts*. Ministry of Finance Planning and Economic Development, Kampala

Musil, C.F. (1993). Effects of invasive Australian acacias on the regeneration, growth and nutrient chemistry of South African lowland fynbos. *Journal of Applied Ecology* 30, 361-72

NEPAD (2003). *Action Plan for the Environment Initiative*. New Partnership for Africa's Development, Midrand. http://nepad.org/2005/files/reports/action_plan/action_plan_english2.pdf

Preston, G. (2004). Personal communication. National Programme Leader. Working for Water Programme, Cape Town

Preston, G. and Williams, L. (2003). Case Study: The Working for Water programme: Threats and Successes. *Service Delivery Review* 2 (2), 66-69 http://www.dpsa.gov.za/documents/service_delivery_review/vol2no2/threats%20and%20successes.pdf#search='water%20use%20by%20invasive%20alien%20species%20Africa%20wattle%20mesquite'

Richardson, D.M. and van Wilgen, B.W. (2004). Invasive alien plants in South Africa: How well do we understand the ecological impacts? *South African Journal of Science*. 100, 45-52 http://www.dwaf.gov.za/wfw/Docs/Papers/SAJSFeb2004richardson.pdf

Shrine, C., Williams, N., and Gundling, L. (2000). *A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species*. IUCN – the World Conservation Union, Gland.

Sweet, L. (1999). Working for Water: Removing Alien Plants in South Africa. International Development Research Centre, Ottawa. http://web.idrc.ca/en/ev-5156-201-1-DO_TOPIC.html

TAA (2002). Origins of Crop Plants and dangers arising from importing crops into a new area. Tropical Agricultural Association. http://www.taa.org.uk/Courses/Week5/Food%2520Crops.htm

UN (1992) Convention on Biological Diversity. United Nations, New York http://www.biodiv.org/convention/articles.asp#

UNEP (2004a). *GEO Yearbook 2003*. United Nations Environment Programme, Nairobi http://www.unep.org/geo/yearbook/yb2003/index.htm

UNEP (2004b). Invasive aliens threaten biodiversity and increase vulnerability in Africa. *Call to Action* 1(1). United Nations Environment Programme, Nairobi

UNEP (2003a). Lake Victoria: Dynamics of an Ecosystem. United Nations Environment Programme, Nairobi

UNEP (2003b). Treaty on International Trade in GMOs to become Law. Press Release, 13 June. United Nations Environment Programme, Nairobi. http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=321&ArticleID=4039&l=en

van der Waal, B. (2002). Another fish on its way to extinction? Science in Africa. http://www.scienceinafrica.co.za/2002/january/tilapia.htm

van Wilgen, B. (2004). The largest environmental programme in Africa continues to tackle alien invasives, CSIR Technobrief 11, CSIR, South Africa www.csir.co.za/websource/ptl0002/pdf_files/technobrief/sep2004/workingforwater.pdf

van Wilgen, B.W., Cowling, R.M. and Le Maitre, D.C. (1998). Ecosystem services, efficiency, sustainability and equity: South Africa's Working for Water programme. *Trends in Ecology and Evolution*. 13, 378

Versfeld, D.B., Le Maitre, D.C. and Chapman, R.A. (1998). Alien Invading Plants and Water Resources in South Africa: A preliminary assessment. WRC report No.TT99/98, Water Research Commission, Pretoria

WBFC (2000). Walker Bay Fynbos Conservancy. http://www.fynbosconservancy.co.za/default.htm,

Wittenberg, R. and Cock, M.J.W. (eds. 2001). *Invasive Alien Species: A Toolkit of Best Prevention and Management Practices*. CAB International, Wallington, Oxon

WRI in collaboration with UNEP, UNDP and the World Bank (2005). *World Resources 2005: The Wealth of the Poor – Managing Ecosystems to Fight Poverty*. World Resources Institute in collaboration with the United Nations Environment Programme, the United Nations Development Programme and the World Bank. World Resources Series. World Resources Institute, Washington, D.C. http://pdf.wri.org/wrr05_full_hires.pdf