Partnership Interventions for the Implementation of the Strategic Action Programme for Lake Tanganyika

Monitoring and Management of Biological Invasions in Lake Tanganyika

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Prepared by:
Geoffrey W. Howard
Global Coordinator, Invasive Species Initiative
(geoffrey.howard@iucn.org)

Esther A. Abonyo
Junior Professional Officer
(esther.abonyo@iucn.org)

List of acronyms

CBD	Convention on Biological Diversity
COMESA	Common Market for East and Southern Africa
DRC	Democratic Republic of Congo
EAC	East African Community
FAO	Food and Agriculture Organization
GEF	Global Environmental Facility
GPS	Geographical Positioning System
IAS	Invasive Alien Species
INECN	National Institute for Nature Conservation and the Environment
IUCN	International Union for Conservation of Nature
LTA	Lake Tanganyika Authority
PCU	Project Coordination Unit
RCF	Regional Conservation Forum
SADC	Southern African Development Commission
SAP	Strategic Action Programme
SBSTTA	Subsidiary Body on Scientific Technical and Technological Advice
UNDP	United Nations Development Programme
UNOPS	United Nations Office for Project Services

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Executive summary

The Strategic Action Programme for the Sustainable Management of Lake Tanganyika establishes an agreed framework for implementing priority interventions to promote conservation of biodiversity and the sustainable use of the lake and coastal resources and to manage activities in the wider catchment that have negative impacts on these resources. Invasive species were identified as a threat to biodiversity and sustainable use of the natural resources in the Lake Tanganyika basin, besides climate change, excessive sedimentation, habitat destruction, increasing pollution and unsustainable fisheries. The project being implemented by IUCN aims to establish and integrate a low-cost, sustainable monitoring and management programme for invasive species in the Lake Tanganyika basin within the overall Lake Tanganyika Regional Monitoring Programme.

A baseline survey has been going on in order to gather reliable information upon which the monitoring system can be based so that prevention and management can be initiated against invasive alien species in the lake and its catchment. During this reporting period, the surveys were carried out in the eastern and western bays of the lake in Zambia. Invasive species noted included the water lettuce, *Pistia stratiotes*, the red water fern, *Azolla filiculoides*, *Bryophyllum*, *Opuntia*, *Senna* species, *Hydrilla verticillata*, *Ceratophyllm demersum* and *Mimosa pigra*. The presence of a non-native fish, *Oreochromis niloticus niloticus* was also established thus raising fears of biodiversity loss in case it hybdridizes with the indigenous *O. n. eduardensis*. Furthermore, *O. niloticus* (subspecies unspecified) was already in aquaculture systems very close to the lake in two countries and has been promoted and proposed for cage aquaculture in the lake, which increases this risk. Among the annexes, is a detailed report of the ten day trip to the Lake in Zambia.

Geared towards raising awareness on invasive alien species issues, IUCN prepared four different leaflets with information on the invasive water hyacinth (*Eichhornia crassipes*), Creeping sensitive plant (*Mimosa diplotricha*), the giant sensitive plant (*Mimosa pigra*) which are present in the Lake and its catchment – and two significant threatening species - invasive freshwater crustacean, the Louisiana crayfish (*Procambarus clarkii*) and the Australian red-claw crayfish - *Cherax quadricarinatus*. Invasion by freshwater crayfish also poses a serious threat to biodiversity in the Lake Tanganyika basin. The leaflets and poster have been disseminated widely at several national and international meetings.

During the previous reporting period (June to August 2011), the Ministry of Agriculture and livestock Burundi had been contacted for approval of the release of biocontrol agents for the control of water hyacinth, *Mimosa pigra* and *Mimosa diplotricha.* A response from the ministry referred us to the Ministry of Environment for further action. Initial correspondence with the Minister responsible for environmental issues awaits a response so that we can proceed with the process.

The list of pathways for the introduction of alien species in the lake and its catchment has increased as more were detected. These include fish species introduced for aquaculture, pollution and eutrophication from fish food and sport fishing between the Great lakes of Africa.

Background

The Convention on the Sustainable Management of Lake Tanganyika has a major objective of ensuring "*the protection and conservation of the biological diversity and sustainable use of the natural resources of Lake Tanganyika and its Basin by the Contracting States* (Burundi, DRC, Tanzania and Zambia) *on the basis of integrated and co-operative management*." In line with this, Article 10 (Conservation of Biological Diversity) of the Convention requires the four riparian states to conserve rare, fragile and representative biodiversity and, as far as possible, to prevent or manage negative impacts from alien species (which may become invasive). In an effort towards fulfilling these obligations, IUCN, through its Global Invasive Species Initiative and Global Coordinator of Invasive Species has undertaken to suggest mechanisms for monitoring of invasive species and to build some capacity to recognize, prevent or manage biological invasions that exist or may become a threat to biodiversity in the Lake Tanganyika Ecosystem. Foreign species are being introduced, intentionally and unintentionally, to productive systems like Lake Tanganyika and these eventually cause problems with ecosystem services, water quality and quantity, yields from fisheries, forestry and agriculture as well as valuable biological diversity. This (IUCN's action) will be a contribution to the overall biodiversity monitoring programme that is still a recognized need for the lake system and its conservation and will be compatible with the larger programme when it is prepared.

Project goal

During the recent SAP Updating forum (held in October 2010), the SAP was revised and updated in response to changes in threats to biodiversity. This culminated in the Invasive Species (Alien and sometimes indigenous) threat being recognized as a significant driver of biodiversity loss in the Lake Tanganyika ecosystem. IUCN, through this sub-project, is also a component of a partnership within the Strategic Action Programme which has the immediate objective "*To protect and conserve the biodiversity and the sustainable use of the natural resources of Lake Tanganyika*".

Project objectives

The Overall Development Objective of the IUCN sub-project is "*To reduce the loss of biodiversity and ecosystem functions in the Lake Tanganyika basin – especially those threatened by biological invasions"*. The Main Objective of the sub-project is "*To build capacity to assess and respond to existing and potential threats of invasive species in Lake Tanganyika and its catchment"*

Expected results

The project aims to establish and integrate a low-cost, sustainable monitoring and management programme for invasive species in the Lake Tanganyika basin within the overall Lake Tanganyika Regional Monitoring Programme by end 2012. This, IUCN intends to make possible by:

1. Providing information to the managers and people of the Lake Tanganyika ecosystem to address actual and potential invasive species after gathering reliable information, extending the survey of likely invasive species, searching for more information and preparing a comprehensive technical working document which can be translated into the languages of the riparian states.

2. Developing and availing a workable monitoring programme for the detection of existing and potential invasive species in the Lake Tanganyika ecosystem. This will cover the open waters and edges of the lake, those parts of the catchment that affect water quality and quantity, the littoral areas of the lake edge and related terrestrial species that bring about biological invasions.

3. Managing key existing biological invasions in the Lake Tanganyika ecosystem to reduce their impact and lower their capacity to spread to new areas. Surveys will identify those invasives needing quick action to demonstrate the management process involving impact assessment, weighing management options and development of management plans.

4. Building capacity of the Lake Tanganyika Authority and four riparian governments to enable drafting of regulations for the prevention and management of biological invasions in the Lake Tanganyika ecosystem. This will be achieved by developing training documents that can build capacity in these areas through "self-training" with texts that have been developed in the context of the Lake Tanganyika ecosystem for the purpose.

5. Summary of Progress within the reporting period

5.1 Extension of the on-going baseline survey of Lake Tanganyika waters and catchment:

5.1.1 Surveys at Western bays in Zambia

During a visit in September (see Annex 1) most of the shores of Lake Tanganyika in Zambia were superficially surveyed for likely invasions and then checked in more detail, especially bays and rivers entering the lake with relevant wetland vegetation. This survey looked in depth at the waters, shores, islands and wetlands of Ndole Bay, Kasaba Bay, Nkamba Bay and the Nkamba River floodplain. It also entered the Lufubu River (3rd largest entering L.T.) and was able to venture at least 8 km upstream for river bank and floodplain assessments. Invasive species noted were *Pistia stratiotes* (water lettuce or Nile cabbage) and *Azolla filiculoides* (Red water fern). The sampling techniques employed included: snorkeling, diving, sub-surface grappling, collection of shallow water plants and superficial observation. The exact locations of plants examined were recorded as GPS points for future re-sampling. Invasive species and potentially invasive alien species can thus be monitored for expansion in range especially after the next high water levels once the rains begin.

5.1.2 Surveys at Eastern bays in Zambia

The survey in these parts led to the detection of the presence of *Azolla filiculoides* (the Red water fern). Its presence implies a slight threat of invasion thus the need for continuous monitoring. The anthropogenic factor in spread of invasions was very strong in the eastern bays. Around Mpulungu, potentially invasive species of plants were being promoted for use in gardens/ flowerbeds and hedges. Examples included *Bryophyllum, Opuntia* and *Senna* species. Advice was offered on the harm they posed to the environment and how to handle the plants while removing and burning them in order to keep their propagule pressure under control. The invasive dodder, *Cuscuta* sp., was also detected invading the native riparian vegetation zones in the Eastern bays.

5.1.3 Underwater baseline surveys

Apart from filming the invasive species present on the lake surface and its catchment and their impacts, the filming team (see section 5.1.4, below) was of great importance as they offered the technical expertise needed to do some underwater surveys (being expert divers and under-water photographers). For baseline data, they were able to film a panorama of submerged vegetation together with short videos to acquire an estimate of species and their relative density in several areas of the lake. Several species recorded have a history of invasion in other wetlands and will need to be closely monitored, such as *Hydrilla verticillata* and *Ceratophyllum demersum*, both of which are invasive elsewhere and both of

which grow in higher density with nutrients available at river mouths and in ports and near cities of the lake. Worrying was the detection of quite dense growths of *Potamogeton pectinatus* in some bays and ports – with leaves both above and below the water. While this species is indigenous to the lake, it has been described as a significant water weed in other lakes and water systems.

The invasive semi-aquatic shrub *Mimosa pigra* was prevalent along the course of the Lufubu river for many kilometres upstream from the lake and its presence in the first few kilometres of the Kalambo River (the TZ-ZM boundary down to the lake) needs to be monitored for possible future action to control it.

5.1.4 Filming of activities surrounding priority interventions around the lake

The joint efforts of PCU**,** LTA and IUCN made this exercise possible. The filming team accompanied the IUCN invasive species expert to sites where invasive species were most likely to occur. The product, which is an informative documentary which will be available on the project and LTA website, aims to raise awareness on the priority interventions being implemented to achieve conservation of biodiversity and the sustainable use of the lake and coastal resources in accordance with the Lake's SAP.

For more details on the surveys that took place in September 2011, please see the trip report attached in Annex 1.

5.2 Response from Ms. Odette Kayitesi, (Minister of Agriculture and Livestock – Burundi)

A briefing note was delivered to the Minister for Agriculture and Livestock in Burundi within the previous reporting period (June to August 2011). The letter elaborated on the danger posed by water hyacinth, *Mimosa pigra* and *Mimosa diplotricha* to the health and sustainable livelihoods of the riparian communities in Burundi as well as to the whole ecosystem. In her response, Ms Odette Kayitesi recognized the importance and urgency in taking up management actions against the three invasive species. She however referred us to the Ministry of Environment (Burundi) as what IUCN was proposing (introduction of biological control agents as the most sustainable and cheapest way of managing these invasive species) did not fall under her ministry's mandate. Initial correspondence with the Minister responsible for environmental issues awaits a response so that we can proceed with the process.

5.3 Raising awareness on Invasive Alien Species issues

5.3.1 Production of leaflets and poster

IUCN prepared four different leaflets with information aiming to raise awareness on three of the invasive plant species present in the Lake and its catchment – and one significant threatening species. The leaflets for water hyacinth (*Eichhornia crassipes*) - Annex 2, Creeping sensitive plant (*Mimosa diplotricha*) - Annex 3, the giant sensitive plant (*Mimosa pigra*) – Annex 4, are attached. The fourth referred to a serious threat to the lake and catchment from an alien and invasive freshwater crustacean which is present in the Zambezi River catchment and the Lake Victoria catchment (which are the two main "neighbouring catchments to Lake Tanganyika) - the Louisiana crayfish (*Procambarus clarkii*) as well as another alien crayfish also present in the Zambezi system – Annex 5. A relevant Invasive Alien Species poster was prepared and printed (Annex 6). These materials contain images to aid in identification, information on their impacts, control options available, how they are spread and the responsibility any person can undertake to prevent invasions or their spread. They were prepared in high-quality printable format and web versions were posted onto the LTA website and the IUCN website. To reach a larger audience, they were also posted on the Aliens Listserve (of the IUCN Invasive Species Specialist Group) and the LTA Facebook page. Both English and French versions were prepared and are

available. It is worth noting that there have been communications / questions / suggestions from people from all walks of life on invasive species issues after reading these leaflets.

5.3.2 Representation at the IUCN RCF

The leaflets were also distributed at the IUCN Regional Conservation Forum which was held in Johannesburg, South Africa from 20-21 September, 2011. The meeting brought together IUCN members, commissions and partners, government representatives from different sectors, the private sector, local community representatives, academia, research institutions and regional bodies located within the Eastern and Southern Africa Region.

5.3.3 Representation at the GEF International Waters Conference 2011

The leaflets were displayed at the 6th GEF Biennial International Waters Conference which was hosted by the Government of Croatia. The event took place in Dubrovnik from 17-20 October 2011. The general objective of the meeting was to facilitate cross-sectoral and portfolio-wide learning and experience sharing. Though we (IUCN) did not attend, we had adequate representation by the PCU.

5.3.4 Participation in CBD SBSTTA 15

Dr Howard participated in the CBD SBSTTA 15 which was held in Montreal, Canada from 7th-11th November 2011. There were discussions on addressing causes of ecosystem degradation and restoration, rehabilitation, regeneration/ revitalization of all types of ecosystems. The leaflets and poster were on display and several experiences and lessons were shared at the meeting. Discussions were also held with World Bank about possible future co-financing for the project on Lake Tanganyika.

5.3.5 Display at the Lake Tanganyika Basin Development Conference

The leaflets were carried by PCU for distribution at the above-named conference which was held in Bujumbura, Burundi from 28th-29th November 2011. The conference, organized by LTA, EAC, SADC and COMESA brought together research institutions, business communities, universities, development partners, investment authorities, foreign missions, banking industry and local and foreign investors.

5.4 Analysis of pathways for the introduction of alien species in the lake and catchment

This analysis is aimed at describing, studying and then analyzing pathways of introduction (intentional, unintentional or even accidental) of species foreign to the lake ecosystem in order to feed this information into a monitoring process in preparation as well as a management plan. The logic behind this is that it is possible and practical to either close or monitor a pathway for any suspect passage of potentially-invasive species. There has been continued identification of such pathways:

5.4.1 Fish species introduced for aquaculture

While compiling the report after the field surveys in September, there was interest to identify the fish species that were displayed after a catch by one of the fishermen at Ndole bay. It was evident that aquaculture was already being practiced in the catchment. This being one of the pathways of introduction of Invasive fish species which grow and reproduce fast, clarification was sought. The images were sent out to the local fish expert, Dr Gaspard Ntakimazi and Dr Martin Van Der Knaap, the FAO consultant. The worry, as communicated by Dr Ntakimazi, is that could there be hybdridization

between the non-indigenous *Oreochromis niloticus niloticus* (from the images, it is already in Lake Tanganyika) and the indigenous *O. n. eduardensis*, then distinguishing them would be quite a task, not to mention the effect this would have on the lake's fish biodiversity. Furthermore, later communications with fisheries experts in the region revealed that *O. niloticus* (subspecies unspecified) was already in aquaculture systems very close to the lake in two countries and has been promoted and proposed for cage aquaculture in the lake. Additionally, the GIFT (Genetically Improved Farm Tilapia which is a hybrid of several strains of Nile tilapia) has also been proposed as an aquaculture species for the lake basin – this is also worrying.

5.4.2 Pollution and eutrophication from fish food

It was noted that most of the aquaculture cages were situated in places lacking water currents to disperse remnants of uneaten fish food and fish excrement. This often leads to eutrophication which may significantly modify the ecosystem equilibrium thus encouraging biological invasions. This is already evident in a number of harbours where *Ceratophyllum* and *Hydrilla sp* are denser for example, at the Kigoma fish landing area, at the mouth of the Malagarasi and near Ndole bay lodge.

5.4.3 Sport fishing

It is increasingly being recognized that sport fishing tourism between the Great lakes of Africa is an important pathway for transmission of freshwater invasive species that could affect Lake Tanganyika. The Zambian Fishing Competition, which is held annually at Nkamba Bay, involves boats from far away in (and outside) the country as well as fishing gear and fishing clothing. All of these can carry seeds of alien plants, remnants of alien aquatic plants, alien spores and other propagules of plankton and possibly other freshwater organisms. For these reasons all such fishing and boating equipment should be thoroughly washed before leaving other waters and again upon arrival at the water's edge of Lake Tanganyika or its major rivers in Zambia. Interlake tourism is also increasing – and may become quite common between Lakes Victoria, Malawi/Nyassa and Tanganyika as well as others such as Mweru and Kariba or Kahora Bassa.

5.5 Preparation of the Monitoring Plan

With the detection of additional pathways that may enhance introduction of invasive species and the detection of potentially invasive fish already present in the lake, the monitoring plan that is being drawn up will seek to address these serious issues whose implications have already been discussed in section **5.6** of this document.

6. Challenges so far

6.1 Paucity of limnological information and equipment

Invasive Alien Species can be found in all taxonomic groups. However, there is no current information about zooplankton, phytoplankton and microscopic algae communities. This is holding back the completion of the baseline surveys and may remain a gap until the resources to survey such biota are available and thought to be of sufficient import to be studied. We will however continue enquiring from the four-country teams about the presence of plans for any such facilities or activities (e.g. limnological sampling) that could make the monitoring plan more complete.

7. What next?

The next progress report is scheduled for delivery at the end of March, 2012. Activities planned for the next four months include:

- Extension of baseline surveys to Lunzua delta and outflow, DRC
- Securing of biological control agents and commencement of management process of water hyacinth, *Mimosa diplotricha* and *Mimosa pigra*
- Further collaborations with INECN concerning the Burundi invasive species strategy and the possible development of draft regulations and laws to enable the prevention and management of introductions of invasive species to Burundi and the lake basin
- Development of training modules from the information gathered so-far

Report compiled by: The IUCN Global Invasive Species Initiative Team, 29th November, 2011.

ANNEX 1 –Trip report, Zambia, September 2011

OBJECTIVES

- To extend the baseline survey of likely invasive species to the western and eastern bays of the lake in Zambia
- To identify any further species of submerged and emergent aquatic plants in the Zambia portion of the lake and shores
- To enquire about the presence of any likely invasive alien fish species (in the fishery), any other fish and the details of existing and planned aquaculture in and near the lake
- To visit and understand the projects of the Zambian LT teams and check on the possibility of invasive species involved

ITINERARY

Thursday, 1st September: KQ724, NBO-LUN, 08.30 – 10.20; meet Wayne Cole, Staravia Pilot, fly to Nkamba Bay in C210, 9J-ADJ, 12.10 – 15.00; met by Nkamba Bay Lodge, met film team and Craig from Ndole Bay, discussed plans for the next days, boat ride to Ndole Bay Lodge, stay at Ndole Bay until Monday, 5th

Friday, 2nd: Visit likely lake and shoreline sites in the western bays – with Saskia and the Zambian project (Health Department) boat with Coxswain Friday and assistant Musonda – including riparian site near Ndole Bay Lodge, Ndole Village area, Kachese, Chisala River and Nsumbu Island; visit village vegetable production assistance scheme and then the lakeside at Munjera stream; return to Ndole Lodge and process samples

Saturday, 3rd: Accompany filming team in search of hippos and crocodiles and visit Kasama Bay and extend sampling there; return to Nkamba Bay, discuss relevant issues and then visit the bay and wetlands around Katobo stream at the western side of Nkamba Floodplain [*Pistia* and *Azolla*!], inspect the anchorage of Ndole Bay and sample flowering *Potomogeton pectinatus*

Sunday, 4th: Accompany film team to nearby bays and assist filming; carry out sub-surface vegetation sampling for detailed baseline data in riparian site near Ndole Lodge; complete filming and interview for the film-making team; work at Ndole Bay Lodge

Monday, 5th: Finalise details, close-up images of Ndole Bay plants; leave by boat for Mpulungu via the mouth of River Lufubu, *M. pigra* on river banks, fuel problem, arrive Mpulungu 17.35; met by Simbotwe, etc. and VJ, stay at Great Lake Product Lodge

Tuesday, 6th: Visit PCU office in Mpulungu, plan day, take boat to western bay and Mbete village (improved dambo vegetable gardens), by road to Mwanamboko (village fish ponds and vegetables), small hydro station on Lunzua River, return to project office, visit Martin Peace's bar and learn of possible Salvinia infestation; stay at Great Lake

Wednesday 7th: Chris and Dan leave early by road to Lusaka, Saskia and GH meet team at project office; GH to Martin's Lake View, meet Martin then Mrs Chalcraft, check lakeside wetlands with Pattson (no Salvinia); check other wetland and lake edges in Niamkolo area; afternoon boat journey to TZ border and Kalambo River, up river (*Mimosa pigra*), lake edge to Luanzua River mouth, return to office and discussions; stay at Great Lake

Thursday, 8th: Drive leaving Mpulungu at 08.00 in project vehicle to Kasama; take PO 203, Kasama – Ndola, 14.40 – 15.55; PO 307. Ndola – Lusaka, 16.25 – 17.15, stay in Lusaka until check-in for the KQ flight to NBO

Friday 9th: KQ734, LUN-NBO (via Lilongwe), 00.20 – 05.40

FINDINGS

Introduction: This 8-day visit to the Zambian shores of Lake Tanganyika was timed to coincide with the presence of the Film Team preparing the awareness and account of the SAP on Lake Tanganyika – to share experiences and boat movement between sites and between the two parts of the Zambian shore where invasive plants are most likely to occur. It required considerable planning and cooperation and GH was fortunate to also accompany colleague Saskia Marijnissen as well as the two film operators Chris Martin and Dan Burton in sharing boat traffic and other facilities. They also, together with the

host at Ndole Bay Lodge, dived and snorkeled on my behalf to collect samples and images from as deep as 5m.

Baseline Survey of possible invasive plants - Western Bays: This was carried out at ten sites where GPS readings were recorded and consisted of various sampling methods including superficial observation, collection of shallow water plants and emergents, subsurface grappling using a garden rake and snorkelling and diving (by my colleagues). These samples were collected along the shores and in relatively shallow waters in-shore from a point several km.to the west of Ndole Bay to the village at site 10, east of the outflow of the Lufubu River (site 9), see Figure 1.

Most of the riparian and shallow water vegetation was as described in previous reports of the Burundi and Tanzanian shores including a range of submerged species, several with emergent stems and flowers (the *Potamogeton* species *P. pectinatus* and *P. schweinfurthii*) and some specimens of the bulrush *Typha domingensis* that were 6-7 m in all, with 2 m beneath the water). These, and the familiar submerged species, are listed and illustrated in Annex 2. One species not previously recorded in the lake survey was *Najas maritima* sub sp. *armata* (see Figure 2, below) encountered in relatively shallow waters at Kasaba Bay (site 6, Figure 1). This species is relatively common as a short, bottom-dwelling plant in still or slow-flowing waters in the region and was recorded in Lake Tanganyika by Coulter (1991), so is no surprise. Interestingly, this subspecies is confined to coastal areas of Africa and Rift Valley lakes of both Africa and the Middle East (Triest, 1989).

The western part of the Nkamba Floodplain that adjoins the Katobo Stream (site 7, Figure 1) harboured the floating and sometimes invasive alien plant *Pistia stratiotes* (Water lettuce or Nile cabbage) which was either washed into this area from the lake at higher water levels or came down the stream from the uplands of northern Zambia in the Katobo catchment. In this survey, Pistia was not encountered elsewhere despite several verbal reports that it has been sighted both in the western bays of the lake in Zambia and around Mpulungu to the east. This species was found mostly beneath the semi-aquatic tree *Aeschynomene elaphroxylon* or on bare black clay that had clearly been inundated recently (Figure 3) and in this situation it is unlikely to spread until the next high water level comes to the lake or the stream flows increase from the catchment; nevertheless this should be monitored if possible to estimate its current entire distribution and to check whether its young plants (which were abundant) are likely to infest the lake or the floodplain to any extent that can be considered worrisome.

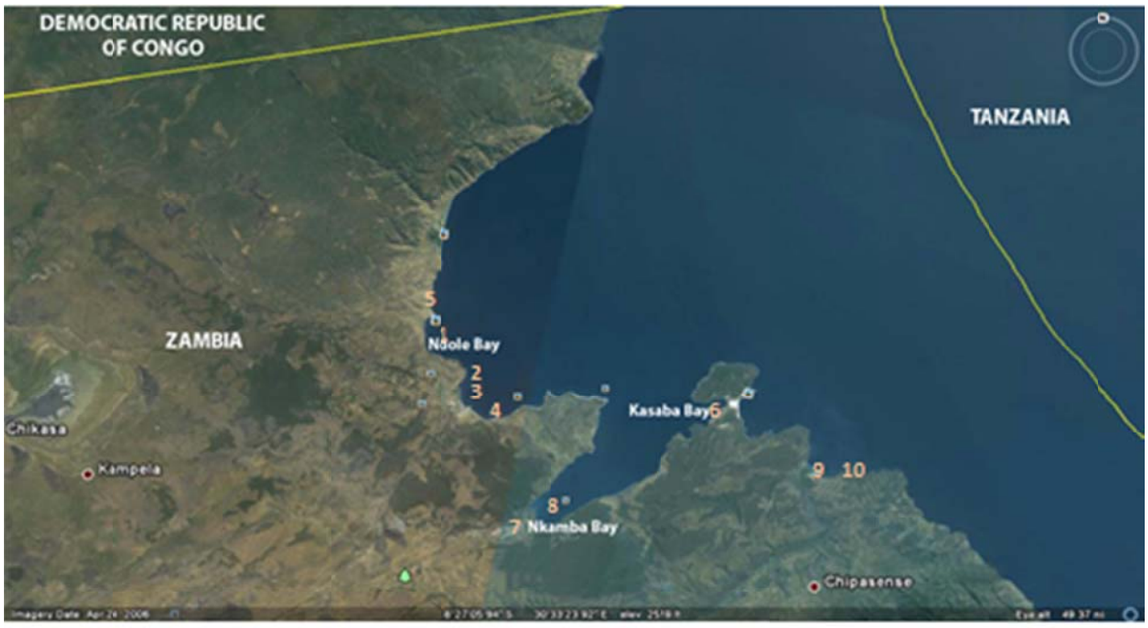

Figure 1. Western bays of the Zambian shore of Lake Tanganyika showing sampling sites: 1.= Ndole Village wetland, 2. Kachese old fishing harbor, 3. Chisala River, Mwando Village, 4. Nsumbu Island, 5. Munjera Village, 6. Kasaba Bay, 7. Nkamba Floodplain, Katobo stream, 8. Nkamba Bay lake edge; 9. Lufubu River, 10. Lufubu village.

Figure 2. ***Najas maritima*** **sub sp.** ***armata*** **from Kasaba Bay, Zambia**

Figure 3. *Pistia stratiotes*, under *Aeschynomene* trees and associated with sedges on the Nkamba Floodplain

Another potentially invasive macrophyte seen in the same area as the Pistia was the Red Water Fern, Azolla, probably *Azolla filiculoides.* This plant is also a surface-floating species and was found in association with *Pistia stratiotes* as well as in more open areas amongst the semi-aquatic grasses and sedges of the floodplain. This species was also seen in the eastern bays and the wetlands around Mpulungu – it was in low density at the Nkamba Floodplain site. Its presence implies a slight threat of invasion, so, as with Pistia, it should be monitored, especially once the rains begin and water levels rise.

The presence of likely invasive plants some distance back from the lake edge (as seen in Burundi and parts of Tanzania) was not at all noticeable (apart from some garden escapes in and around the lodges). This is certainly due to the almost complete lack of roads and traffic as well as the uncleared, mostly undisturbed, bush (thicket and woodlands of the area) which reduce species ability to move into the wild and without areas of disturbance to enable fast establishment. This is contrary to the situation in the eastern parts of the lake, especially around Mpulungu, where the opposite is true. Advice was given to the lodge at Ndole Bay to reduce the density of some garden plant species that could possibly escape into the wild in the wet season and also that removed plants should be burnt to prevent spread of propagules – this was especially true of several species of *Bryophyllum* (succulents) and *Opuntia* (cactus).

An opportunity to establish a baseline estimate of subsurface aquatic plants (macrophytes) for comparison with future samples became possible with the presence of the film team and their ability to work underwater. Thus, at a site near the Ndole Bay lodge (but further to the east and close to a complex of emergent vegetation, at S 08^{o}, 28. 799', E 30^{o}, 27.187') Dan filmed a panorama of submerged vegetation in 55 successive stills and five short videos to acquire an estimate of species and their relative density in that area for future reference. This was a trial which should provide baseline data for the detection of any changes that can be attributed to plant invasions in the submerged vegetation of the lake. Several species already recorded have a history of invasion in other wetlands and lakes but there is no evidence of this in Lake Tanganyika so far. The image in Figure 4 (below) shows the situation in the submerged vegetation on just one image to illustrate that it is possible to estimate relative densities of species within one image and then in a wider panorama of approximately ten stills per pan, supported by a short video of the same sequence.

Figure 4. One of the images from a panorama of submerged vegetation (from left to right): *Potamogeton schweinfurthei*, upright *Hydrilla verticilata*, taller upright *Potamogeton pectinatis*, lake floor covered with *Najas horridus;* 2 m below the water surface.

Several small streams were sampled along the shore of Lake Tanganyika to check for any plants in their deltas or associated wetlands – and the only ones recorded were Pistia and Azolla as above. The Lufubu River is the largest (in terms of flow and catchment which exceeds 7,000 km^2) in the Zambian part of the lake catchment and as such is navigable for a considerable distance. We moved up this winding river for, perhaps, 10 km and recorded significant growths of ***Mimosa pigra***, a south- central American shrub that is quite widespread in African wetlands and which has become invasive in many floodplains and wetlands over the last 20-30 years. *M. pigra* is thought to have been present in parts of Africa for at least 200 years but may have become invasive recently due to the arrival of its root-inhabiting bacteria (from the Americas) which may have given it the enhanced spread and growth rate to invade new wetlands. This spiny shrub (see Figure 5) was well represented amongst the riparian vegetation along the Lufubu River and was also seen many meters back from the river's edge in what must be flooded areas during the river's high flow. This situation should be monitored in case this population of *M. pigra* is in the process of expansion and invasion.

Figure 5. *Mimosa pigra* growing tall (3m high) on the bank of the Lufubu River near Lake Tanganyika

Baseline survey of possible invasive plants – Eastern Bays: From the village east of the Lufubu River, there is a stretch of hardly-occupied and sparsely vegetated coastline of the lake, often with almost vertical rock faces, until quite close to Mpulungu and associated villages. Thus the first of seven sample sites amongst the eastern bays of the Zambian portion of the lake began at Mbete Village, west of Mpulungu town. This was a project site of the Zambian PCU where villagers had responded to suggestions to grow vegetables in damper areas such as dambos away from the lake. GH surveyed the lakes edge for more than one km but found no aquatic hydrophytes apart from some washed up fragments of *Vallisneria* and *Ceratophyllum*, common submerged species seen all around such shores in Lake Tanganyika. In the riparian zone, occupied mainly by *Phragmites mauritianus*, there were several species invading the area – especially the dodder, *Cuscuta* sp., which was abundant in some areas and was seriously covering the reeds – see Figure 6.

Figure 6. Dodder, *Cuscuta* sp. entwined around Phragmites reeds, Mbete Village west of Mpulungu

The "yellow oleander", *Thevetia peruviana*, (recently renamed *Cascabela thevetia*) had also infiltrated the reeds in some areas and was appearing to dominate there as an invasive alien species – especially in the riparian zone. This species was widely used in the same village as a hedge plant which was, no doubt, the origin of its invasion of the reed areas (Figures 7 and 8).

Figure 7. *Thevetia peruviana* infiltrating riparian giant reed*, Phragmites mauritianus,* Mbete Village

Figure 8. Yellow oleander, *Thevetia peruviana*, as a (large and small) hedge, Mbete Village; the likely source of the infiltration of the same species into natural riparian growths of the Common Reed (Fig. 7)

Other alien species of plants in this and nearby villages included: the shrubs *Senna occidentalis* and *S. obtusifolia*, *Lantana camara* (planted as a hedge) and Castor Oil Plant (*Ricinus communis*) as well as trees of *Leucaena leucocephala* and the agricultural weed *Trichodesma zeylanicum*. These are all capable of invasion in this part of Zambia, but are not problematic if managed and prevented from spreading into crops, pastures or wild areas important as buffer zones (such as the reed-covered riparian zone of the lake) that separate habitation from the waters of the lake and prevent erosion of sandy shores. Other villages visited and some peri-urban areas of Mpulungu have the same combination of potentially invasive terrestrial plants – many of which can affect run-off and silt management for the lake and so should be at least recognized and noted in case of spread and invasion at the lakeside. Another common invasive alien plant in the Mpulungu area was the Yellow Mexican Sunflower, *Tithonia diversifolia*, often planted as a hedge and able to produce large amounts of seed to aid its spread and sometime invasion of riparian areas. A newly-planted hedge species noticed near the lake edge and which is invasive in at least one neighbouring country, was *Senna alata* (Figure 9). This fast growing and prolific seed producer can in a thicket situation grow to 4 m high and become impenetrable and affect riparian areas – as it has done near Lake Nyassa. We saw only one set of plants (near the Great Lake Lodge where we stayed), but this species is capable of fast spread, especially where seeds can be moved by surface water flows, and it should be monitored for possible invasion around small streams and riparian areas.

Figure 9. *Senna alata* showing attractive yellow and orange flowers and green pods which turn brown when mature

The survey of riparian plants was extended to some wetlands close to the lake at Niamkolo, north of Mpulungu town, where there was preparation for paddy rice planting. This area had quite large areas of Azolla sp. (again, probably *A. filiculoides*, Figure 10) which, however did not appear to be invasive. Other water plants in the wetland area included the rooted aquatic fern, *Marsilea* sp., various sedges (Cyperaceae), *Ludwigia stolonifera*, water lilies (*Nymphaea* sp.) and the sponge-bearing vine *Luffa* sp.

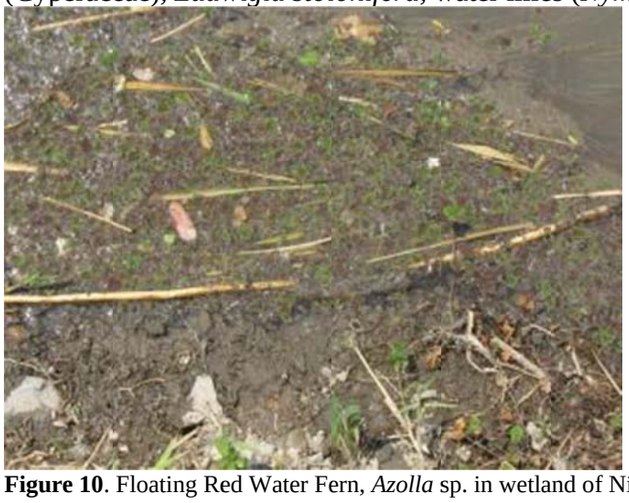

Figure 10. Floating Red Water Fern, *Azolla* sp. in wetland of Niamkolo, Mpulungu

The visit to the river mouths was successful in that the Kalambo River (border with Tanzania) was reached and we ventured upstream about 5km until the river was too shallow for passage of the project boat. Here we recorded *Mimosa pigra* (in relatively low density) but noted its presence (Figure 10) for future reference; in case it spreads in the future and invades the farms, pastures and wild vegetation there.

Figure 11. *Mimosa pigra* 2m from the edge of Kalambo River, near Lake Tanganyika; *Cyperus (Pycreus) mundtii* and riparian grasses in the foreground

The same River Kalambo was harbouring another (previously unrecorded?) submerged/emergent aquatic macrophyte near the river mouth into the lake. In quietly-flowing water around 15 cm deep, *Potamogeton octandrus* (Figure 12) was growing: this species could become problematic if more areas of slow-flowing waters were available. This species may have been recorded previously (e.g. Coulter, 1991) as *P. filiformis*, but the presence of submerged leaves on the specimens collected identifies it as *P. octandrus.*

Figure 12. *Potamogeton octandrus* in a shallow, slow-flow area of the Kalambo River near Lake Tanganyika

The lake edge from this river around the eastern bays to the outflow of the Lunzua River had the usual riparian vegetation in swampy areas of reeds, water grasses and tall sedges n one small river delta; so nothing notably different from other areas of the lake.
Alas, by the time we reached the Lunzua Delta and outflow (Figure 13.) it was almost dark and so not possible to visit in detail especially as the water was very shallow where silt was deposited by the outflowing river (see Figure 14). This will need attention at some later visit as the structure of the delta and river meanders appears on Google Earth to be conducive to wetland vegetation (Figure 14) and may harbor some potentially invasive floating or emergent freshwater plants.

Figure 13. Lake edge of the delta (and outflow) of the Lunzua River (late afternoon)

Figure 14. Google Earth view of the Lunzua River delta and river meanders – with shallow lake waters near the outflow; showing riparian and possibly swampy vegetation widespread, including on a floodplain to the west

Fisheries and aquaculture: There is a thriving commercial and artisanal fishery in the Zambian waters of Lake Tanganyika but enquiries failed to find any evidence of unusual species (or aliens) in the regular catches - although some local experts thought that *Oreochromis niloticus* may be present – but the issue of sub-species made this difficult to be sure if, indeed, there are introduced *O. niloticus* in this end of the lake.

Aquaculture is being promoted for food sustainability in Zambia and there were several fish farms in operation in the catchment, near the lake and some organizations preparing for cage aquaculture operations in the waters of the lake – in both the western and eastern bays visited. In all cases, we were assured that only fish indigenous to the Lake Tanganyika catchment were being, or would be, used and at one village fish farm, (Figure 15; Mwanamboko, with running waters from a tributary of the Lunzua River) the species being grown were *Oreochromis tanganyikae* and *Tilapia rendalli* –both native to Lake

Tanganyika. However there were rumours of intentions to introduce alien species, especially of the genus *Oreochromis*, to enhance the growth rate of fish in cages and/or to hybridise with the native *O. tanganyikae* for the same reason. However such rumours were not confirmed. However they should be kept in mind considering that all aquaculture systems (at village or commercial level) can "leak" fish eggs, larvae or fingerlings, whether they are attached to a mountain stream, remotely using the waters of Lake Tanganyika or immersed in the waters of the lake. Once an alien or hybrid enters the lake, it would be almost impossible to remove or eradicate it – unless it was discovered in an accessible area as soon as it was introduced. The experience of such introductions in other lakes and rivers in Africa tells us that they always have negative impacts on native fish species (and sometimes on other freshwater animals as well as plants).

Figure 15. Mwanamboko Fish Farm – a tributary of the Lunzua River brings water in on the left of this image

Possible causes and pathways of invasion

The current situation of biological invasion in the areas surveyed in, on and around Lake Tanganyika in Zambia are not showing serious threats to the environment or, especially, to the biodiversity of the lake. We have no current information about phytoplankton, zooplankton and microscopic (as well as small macroscopic) algae, crustaceans, etc., the communities of which could possibly have been invaded by foreign species. This will remain a gap until the resources to survey such biota are available and thought to be of sufficient import to be studied. But for the macrophytes and fish we can continue to collect information directly and indirectly to prepare a monitoring system that can detect the threats or arrival of species that may become invasive.

One of the ways to do this is to consider the pathways along which foreign species may travel - into the catchment or into the waters of the lake – and then become invasive and so destructive to biodiversity and ecosystem functions. Many such pathways are assisted by people, but some are natural for much of their length but may have human influence at their start. Below we list several possible pathways of invasion that could affect Lake Tanganyika in Zambia.

Natural flowing waters - rivers and streams: aquatic alien species (or semi-aquatics or amphibious species) may be intentionally or unintentionally introduced to the upper catchments of streams and rivers and then be washed downstream by stream flows or run-off after rain – and end up in or near the lake. This is the reason for inspecting the deltas and outflows of rivers and large streams around the edges of Lake Tanganyika. This is a pathway for alien macrophytes (both flowering and non-flowering aquatic and semi-aquatic species) whether they are floating, emergent or submerged species. Also, for aquatic and amphibious animals (fish, amphibians, some reptiles, larger crustaceans and molluscs).

Artificial flowing waters: the same as above can be true of storm-water drains and canals, irrigation drains and urban waste water drains – involving the same types of species. These are uncommon on the Zambian coast of Lake Tanganyika except around Mpulungu and its peri-urban settlements. This may become true of other developments (such as the international airport under construction at Kasaba Bay and any large tourism and accommodation establishments near to the lake.

Aquaculture: as described above, aquaculture can be the source or start of freshwater pathways that can lead to biological invasions in the lake AND in its catchment – and so also feed the natural water-flow pathway described above. The species involved can be amphibious as well as truly aquatic – as is the case in other catchments with alien amphibians (accidentally introduced with aquatic species) or alien amphibious species (such as freshwater crayfish, intentionally bred for [usually specialty] foods).

Aquarium fish collection and breeding: indigenous (and endemic) species of fish in Lake Tanganyika are collected for the aquarium trade – often from small endemic habitats in the lake. They are then taken to breeding and/or holding facilities for later transport to markets elsewhere – in Zambia and as far away as Europe and USA. During breeding or holding, some may die or be judged unsuitable for markets or travel and be discarded into the lake (the facilities that we have seen are located at the lake edge) where some eggs or larvae of adult fish may survive. If these species were collected in habitats far from the breeding/holding facility, they may be endemic elsewhere but alien to the waters where they have been discarded and so could possibly become invasive.

Contamination of fishing and boating equipment: This applies mainly to sport fishing (e.g. the Zambian Fishing Competition held annually at Nkamba Bay) and involving boats from far away in (and outside) the country as well as fishing gear and fishing clothing. All of these can carry seeds of alien plants, remnants of alien aquatic plants, alien spores and other propagules of plankton and possibly other freshwater organisms. For these reasons all such fishing and boating equipment should be thoroughly washed before leaving other waters and again upon arrival at the water's edge of Lake Tanganyika or its major rivers in Zambia. Interlake tourism is also increasing – and may become quite common between Lakes Victoria, Malawi/Nyassa and Tanganyika as well as others such as Mweru and Kariba or Kahora Bassa; the same applies to tourists, their equipment and possibly boats in this context.

Contamination of boats and ships from other parts of the lake: artisanal and commercial fishing craft, freight ships, barges and passenger vessels move around Lake Tanganyika – and in and out of Zambian waters. All are capable of carrying propagules of potentially invasive species of animals and plants on their hulls, in their bilge or bilge waters, on anchors and other structures that are used in fishing, loading and unloading and general boat maintenance. Inspection or washing/cleaning are rare so that movement of alien species is quite possible.

Roads and road-making near the lake: vehicular traffic on even small roads can carry alien species and their propagules – both actually on or in the vehicles or in the vacuum behind a travelling vehicle – which is especially true of small seeds and other plant parts that can regenerate once dropped from a stationary vehicle. This is hardly relevant amongst the western bays of the Zambian coast of Lake Tanganyika where roads are few and vehicles sparse. However, once the bridge across the Lufubu River has been completed, this situation will change – both for visitors and for local transport - and so increase the chances of these few roads becoming pathways for invasion. In addition, plants (mainly through seeds) can be moved quite long distances by road-making machinery – unless it is cleaned before moving from one locality to another. This is a well-established pathway across Africa which has resulted in the widespread distribution of some seriously invasive plants - both within and between countries.

Urban and village gardens and hedges: In northern Zambia, as in most parts of the world, people prefer to have plants in their villages that fulfill specific purposes and which will grow fast and are easily transplantable. The result is usually a series of alien species used as hedges and other enclosures, windbreaks, shade trees and woodlots. The species concerned are most often foreign (introduced) species and many of them can become invasive if allowed to "escape" into the surrounding environment. An example is that of *Thevetia peruviana* (see figures 7 and 8, above) which is a hedge plant selected because of its unpalatability to livestock and its attractive flowers. A similar situation can occur in urban gardens where plants may be selected for some of the attributes mentioned above and/or for their attractive flowers or foliage. Most are alien to Zambia and some, if allowed to escape ("jump the fence"), can become invasive in the wild. Both of these pathways exist in the Zambian catchment of the

lake and are already resulting in small invasions of drainage, swamp and riparian (buffer zone) areas of the lake shore.

Travellers and tourists: People, their clothing (including footwear) and luggage are also capable of unintentionally spreading invasive species from plants (seeds) and insects (eggs or pupae) and micro-organisms (in food). They are also capable of intentionally moving plants and all manner of animals – often despite the knowledge that this is not permitted or could spread an invasion. Some would term the people to be the vectors and the next category the pathway – the distinction does not change the way that many biological invasions have been initiated and will continue to be so – unless public awareness is raised to reduce desire of people to move species from their origin to new ecosystems.
Aircraft and road vehicles: Air corridors and roads/highways can also be categorized as the pathways for movement of alien species by aircraft, buses, lorries and cars as well as agricultural and earth-moving equipment. It is clear that both these pathways and vectors are capable of introducing alien species that might become invasive and this probability will increase with the growth of Mpulungu Town and the finalisation of the Kasaba Bay long runway and the bridge across the Lufubu River – with consequent risks of invasion for Lake Tanganyika and its waters
This is not meant to be an exhaustive list of possible pathways for potentially invasive species, but to illustrate some common pathway types relevant to the Zambian waters and catchment of Lake Tanganyika and so to the eventual monitoring plan for invasive species that is to be developed.

Acknowledgements: This report was made possible through access to some parts of the Zambian waters of Lake Tanganyika which would not have been available without the film-makers Chris and Dan and the support in diving by Saskia, Craig and Dan. The project team based in Mpulungu were essential to our work and travel and are thanked sincerely – especially Simbotwe and Pattson and Ms V. Jere. Use of the Ndole Lodge boat, the Zambia Health Department Boat and the LT Project Boat is acknowledged gratefully for places to work from, access to parts of the lake, its shores and rivers, and for transport from the western to the eastern bays of the lake.

GWH, 22nd September, 2011

ANNEX 2 – Water Hyacinth leaflet

Water Hyacinth, an Invasive Plant in the Lake Tanganyika Basin

What is an invasive species?

An invasive species is an animal or plant which is introduced into a new area where it does not occur naturally. If the introduction occurs without the accompaniment of its pests and diseases that keep the species in check (under control) in its natural range and if it is able to survive, establish and spread thus causing damage to biodiversity, peoples' livelihoods or development, it is called "invasive". Water hyacinth, sometimes called the World's Worst Water Weed, is becoming invasive in the Lake Tanganyika basin and on the shores and wetlands of some parts of the lake.

Water hyacinth (*Eichhornia crassipes*) is an exotic free-floating aquatic plant from the Amazon River basin in tropical South America. The dark green, shiny leaves have expanded hollow stems (petioles) that enhance its ability to float and can extend to 2 m above the water level. Below the water surface, there are root-like structures (rhizoids) which balance the plant and keep its aerial parts upright while taking up water and some nutrients. It reproduces through flowers and seeds (which can remain viable for up to 15 or more years) and has vegetative propagation by its stolons which are lateral extensions from the main plant which produce new plants which eventually leave the "mother plant".

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Impacts of water hyacinth

- *Eichhornia crassipes* can form dense floating mats that cover large areas of water surface - thus excluding light, and air. This then affects animals (including fish) and plants that live and grow below the water surface; the area of a water hyacinth mat can double over several days when conditions of water and temperature are optimal;
- The floating water hyacinth mats can have serious mechanical impacts on water supply systems, drainage canals, inflows to hydropower turbines, movement of ships and river flows;
- Water hyacinth increases evapotranspiration well above that of open water (often over 3 times "open pan" evaporation) thus causing significant water loss to dams, reservoirs and wild waters;
- The crowding of plants at edges of water bodies can prevent people's access to the water for domestic use, fishing and transport, and can, at the same time, make the water unsuitable for human use;
- The mats provide habitats for intermediate hosts of human diseases such as bilharzia-carrying water snails and larvae and pupae of malaria-spreading mosquitoes;
- The floating plants and the mats they produce can also provide habitats for dangerous animals (snakes, crocodiles) and can support other aquatic plants that then form "floating islands" that can block water flows and damage machinery - such as hydropower turbines.

It's presence in the Lake Tanganyika ecosystem

Water hyacinth is present and invasive in wetlands and swampy shorelines around Bujumbura and other parts of the Burundi shoreline. This is a recent invasion which entered the lake in the late 1990s and has spread widely – to the detriment of other aquatic plants, fish, other aquatic animals and people. We do not have records of lake-side invasions in the other riparian countries of the lake (DRC, Tanzania and Zambia) but are aware that this water weed is present in other parts and catchments of all three countries – and in upland wetlands and lakes in Burundi as well as in Rwanda. *Eichhornia crassipes* is quite able to spread across the lake and establish in suitable sites – but does not seem to have done so – YET.

How does it spread?

Water hyacinth came to the lake from infestations upstream in the Rusizi River and from "water gardens" where the plant was growing in cities and towns near the lake – where it was kept for its attractive foliage and beautiful flowers. Once it is established in a wetland or water body it can spread through wind propulsion of floating plants (or plant fragments), through water currents and on the feathers and feet of the numerous species of local and migratory waterbirds. In other countries in Africa it has been spread by people – as a green cover for dams and other water supplies; and as packaging for fresh fish on their way to far-off markets.

How can it be controlled?

- Mechanical control can be effective (in the short-term), using manpower and machines. However, this has to be repeated frequently because once the plants flower, seeds accumulate in the substrate and can then germinate from the seed bank – sometimes several times a year for many, many years;
- Herbicides have been used and can be effective, but there is always concern for effects on non-target aquatic biodiversity and peoples' use of the waters; and poisoning does not affect the seed bank which will replace the poisoned plants within months;
- Biological control is the most effective, affordable and self-sustaining means of management and some very effective agents (insects) have been used effectively in many large and small water bodies across Africa;
- Integrated control where two or more of the above methods are combined to manage the plant to reduce its impacts and stop its spread;
- Water hyacinth requires some dissolved nutrients in its waters to grow and spread. Thus effective control of water pollution from agricultural run-off, rural and urban drainage and insufficiently treated sewage should be maintained to ensure that if there is a first infestation, it is unable to grow into a significant water hyacinth invasion.

What is my role in controlling this invasive species and so retaining the benefits of Lake Tanganyika?

- Ensure that any effluents that are released into the lake or its tributaries are treated first to avoid providing nutrients to the water hyacinth plants;
- Discourage or ban the sale of water hyacinth plants for decoration and the sale of its flowers which can easily spread seeds and encourage private growing of the plants;
- After clearing the invading plants from urban areas, do not dispose of the debris on the river banks or lake shore because decomposition that follows will release nutrients that will then flow back into the water; also plant fragments from such clearing can regrow if they reach the water. If possible transport all waste from the clearance site and burn the debris elsewhere;
- If any new infestations are noticed, please inform the relevant authorities or LTA;
- It is inadvisable to make any economic use of cleared plants of water hyacinth as this is likely to give this plant economic value and so stop its control and management. If utilisation is desirable or congruent with current national policy then carry this out in drainage basins far from Lake Tanganyika.

IUCN Global Invasive Species Initiative
IUCN ESARO Regional Office, Nairobi, Kenya
For more information: contact: info@lta-alt.org or geoffrey.howard@iucn.org or esther.abonyo@iucn.org

ANNEX 3 – *Mimosa diplotricha* leaflet

WARNING! The highly destructive invasive, *Mimosa diplotricha* is in Bujumbura!

What is an invasive species?

An **invasive species** is an animal or plant which is introduced into a new area where it does not occur naturally. If the introduction occurs without the accompaniment of its pests and diseases that keep the species in check (under control) in its natural range and if it is able to survive, establish and spread thus causing damage to biodiversity, peoples' livelihoods or development, it is called "**invasive**". *Mimosa diplotricha* is an invasive plant in some parts of Africa and has recently come to Burundi.

Mimosa diplotricha, commonly known as the "creeping sensitive plant", is a spiny shrub or climber that prefers to grow in damp places, but can survive in many situations. It originally comes from Brazil and its introduction into Africa is continuing to be felt as it spreads across the continent. This plant has long, square-sided stems that scramble or climb on other plants and have many small spines along their length . It has many small green pinnate (having many leaflets) leaves and round pink flowers that may become pale with age. The small seed pods are pale green (turning to brown if they dry on the plant) and are found in groups of 5 to 20 at the ends of short stems; both the leaf stems and the pods also have small spines. The term "sensitive plant" describes the habit of the leaflets to close up if touched.

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Areas invaded

Mimosa diplotricha was first recognized as an invader in Bujumbura in 2007 near the shore of Lake Tanganyika. Since then, it has spread across parts of the city, along roads, city drains and damp areas, as well as more of the lakeshore, irrigation areas and farms. It is now widespread at the Ntahangwa River delta where it is also moving into the reed swamps as well as combining with another destructive invasive, spiny related species, the giant sensitive plant, *Mimosa pigra*. It is also reported from "up-country" Burundi and is growing well amongst the Oil Palm plantations near the lake, south of Bujumbura to Nyanza.

Working with the Lake Tanganyika Authority and the UNDP-GEF project on monitoring the biodiversity of Lake Tanganyika, the IUCN Global Invasive Species Initiative has prioritized this invasive plant for detailed attention and management alternatives because it is known to be very destructive in other parts of Africa, Asia and Australia, and it appears to be spreading further and further as time goes by. *Mimosa diplotricha* is especially destructive because it can thrive across a range of ecosystem types: forests, grasslands, wild lands, disturbed areas and roadsides, wetlands, crop lands and pastures

How does it spread?

- The impenetrable thickets that it forms make it attractive for use as a hedge plant;
- The plant also produces beautiful pink/ mauve flower balls and people have used it as a garden flower thus enhancing its spread;
- The seed pods are spiny, flattened and can easily stick on to animal fur/coats and people's clothing thus enhancing spread;
- Earth-moving activities like road building and soil dumping have been implicated in its spread as soil containing seeds is moved from one place and dumped in another; seed may also be spread on earth- moving equipment.

Options for control

- *Mimosa diplotricha* may be controlled physically by slashing, harvesting and burning the plants, but this is hampered by the thorns and the seeds can endure the heat of fire and germinate later;
- Chemicals such as paraquat and glyphosate have been used quite effectively but their effects on non-target species makes this risky - especially when dealing with aquatic ecosystems where the poisons may affect water quality, fish, irrigation and peoples' domestic use;
- The most sustainable and cheapest means of management is biological control using its natural enemies from its homeland, IUCN and LTA are pursuing this possible control method.

Impacts

- The plant can grow to at least 5 meters high and the four angled stem is covered with prickly, hooked spines that face in opposite directions – these help it to climb on other plants. It grows very fast and can form impenetrable thickets that prevent access to water, pasture, and fruit trees and can reduce crop yields as a weed on farms and thus livelihoods obtained from fishing, farming and livestock are affected;
- Its dense growths can also prevent the growth of other plants;
- As a pest it can vigorously scramble over crops like cassava and coffee thus smothering them and breaking their stems with its weight. Generally, it grows best in full sunlight and where soil moisture and fertility are high;
- It produces many flowers and pods with many seeds that are readily spread by water and animals;
- It is difficult to remove manually because of its thorns and readily grows back from plant remnants and the seed bank it leaves in the soil.

What is my responsibility in the fight against this Invasive Alien Species?

- Do not select it for use as a hedge plant (for a live fence), plant indigenous species instead;
- Do not use it for flower gardens;
- If and when you notice it on your property, uproot and burn it before it sets flower (and thus seed);
- Carefully inspect clothes, shoes and luggage for seeds that may attach on these items and avoid carrying them to new places.

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IUCN ESARO Regional Office, Nairobi, Kenya
For more information: contact: info@lta-alt.org or geoffrey.howard@iucn.org or esther.abonyo@iucn.org

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ANNEX 4 – *Mimosa pigra* leaflet

The invasive *Mimosa pigra* is extending its range in the Lake Tanganyika ecosystem

What is an invasive species?

An invasive species is an animal or plant which is introduced into a new area where it does not occur naturally. If the introduction occurs without the accompaniment of its pests and diseases that keep the species in check (under control) in its natural range and if it is able to survive, establish and spread thus causing damage to biodiversity, peoples' livelihoods or development, it is called "invasive". *Mimosa pigra* is an invasive species in many places in Africa and is spreading.

Mimosa pigra, the giant sensitive plant, is a prickly leguminous shrub that can reach up to 4m in height. It originates from tropical South and Central America but has been in Africa for at least 200 years. It has long brown woody stems that branch from the base and which bear many sharp, curved thorns. The leaves are soft, green, finely-pinnate and fold inwards when touched (hence the name "sensitive plant"). The flowers are balls of stamens usually pink or mauve, sometimes almost yellow in colour. The fruits are clustered pods, with a furry brown coating of small plant hairs, which break up into small sections (with one seed in each) when they mature. This plant has gradually become invasive in wetlands, lake and river edges and floodplains across Africa – during the last 30 to 40 years and continues to spread and invade.

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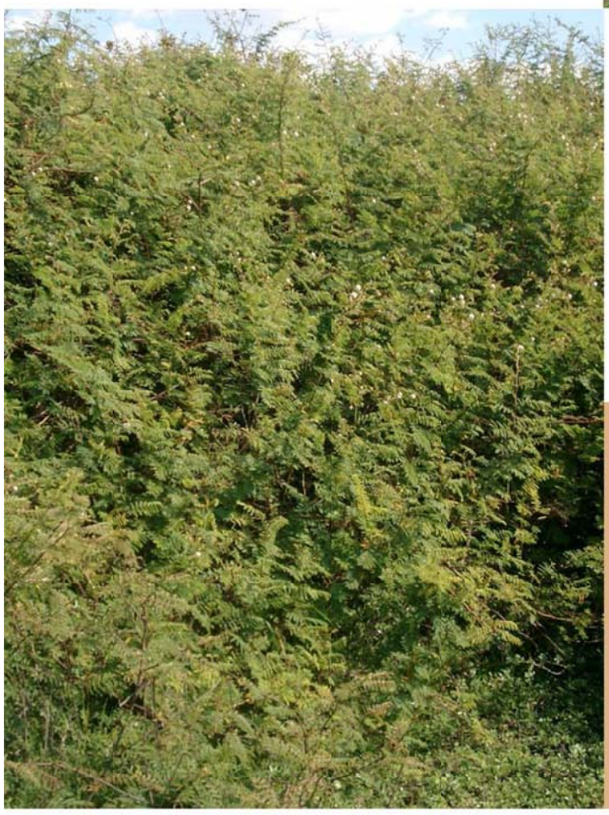
Impacts of *Mimosa pigra*

- *Mimosa pigra* is known to cause extensive damage to local vegetation by displacing native vegetation while forming a single species thicket which can be impenetrable to people and most animals;
- *Mimosa pigra* can diminish grazing/pastoral lands especially floodplains and reduces habitat diversity for wild animals and plants;
- It can block waterways with impacts on transport and fisheries and can prevent peoples' access to both aquatic and terrestrial habitats;
- Tourism is at times affected when this plant invades protected areas and wildlife can be excluded from their feeding grounds by *Mimosa pigra* invasions;
- *M. pigra* can also affect water flow in natural streams and irrigation canals and is very difficult to remove in the long-term.

Why should we be concerned?

Mimosa pigra, despite being present in Africa for possibly two centuries, has only recently begun to spread and become invasive. This may possibly be due to the recent arrival of soil micro-organisms from its original area that allow it to grow faster. But, whatever the reason, it is becoming a problem in almost every country in Africa – through invasion and changing the vegetation and uses of wetlands, lakes and rivers in many places. It is thus a threat to the coasts, wetlands and inflowing waters of Lake Tanganyika in all four riparian countries – which is a concern for the Lake Tanganyika Management Authority and the four countries concerned (Burundi, DRC, Tanzania and Zambia).



How does it spread?

- The seeds are readily spread be floating on water and being swept away by currents – in streams and floodplains;
- The seedpods adhere to clothing and coats of mammals (including cattle and small stock) and feathers of birds and can thus spread far and wide;
- The seeds and pods can also stick onto vehicle tyres facilitating their spread – by cars, farm vehicles and earth-moving machinery.

How can it be controlled?

- Before thickets are established, isolated plants can be managed by mechanical removal through slashing, excavation of roots and burning. The method is very labour-intensive and may stimulate seed germination due to the removal of seed coats.
- Herbicides may be used with subsequent sowing of competitive plants to suppress regeneration from seed; aerial spraying may be needed when the height and density of *Mimosa pigra* hinders access
- Biological control is the most cost effective and long-term control strategy for *Mimosa pigra* and there is a range of biocontrol agents available which have been used in Asia and Australia.
- A more integrated plan combining mechanical, chemical and biological control may result in quicker and more effective management results to reduce an invasion and prevent its spread.

What is my role in the fight against this invasive species?

- Sightings of *Mimosa pigra* should be reported to relevant authorities and then uprooted and burnt if the plant density is low
- To combat spread via vehicle tyres, have wash-down facilities to prevent movement of seeds to other areas
- After passing through areas infested with *Mimosa pigra*, clothes, shoes and luggage should be inspected and cleaned to avoid dropping seeds in other non-infested areas.
- General awareness of the risks of allowing *Mimosa pigra* to become established and then invasive should be available to farmers, livestock owners, managers of biodiversity and protected areas and local authorities; this species can be prevented from becoming invasive if precautions are taken in time.

IUCN Global Invasive Species Initiative
IUCN ESARO Regional Office, Nairobi, Kenya
For more information: contact: info@lta-alt.org or geoffrey.howard@iucn.org or esther.abonyo@iucn.org

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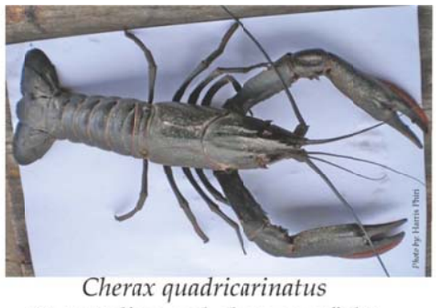
ANNEX 5 – Invasive Crayfish leaflet



Cherax quadricarinatus

(Australian red-claw crayfish)

The colour of *C. quadricarinatus* ranges from dark brown to blue-green and adult males have a distinct red patch or stripe on the outer margin of the chelae (claws) and may measure up to 20cm in length.

WHY SHOULD WE BE WORRIED?

- There are no native freshwater crayfish in mainland Africa or its islands (apart from Madagascar) and this species can out-compete and even eat native freshwater crabs
- These Crayfish are omnivorous and veracious feeders. In areas where this species has been introduced, it may impact freshwater native fauna through direct competition and predation
- The species may also modify the aquatic habitat thus making it unsuitable for native species
- This crayfish may spread previously unknown parasites into native populations of crustaceans and other aniamls. It has been reported to be a carrier of a number of pathogens, including viruses, bacteria, fungi, protozoan and metazoan parasites.

CONTROL OPTIONS:

Crayfish are extremely difficult to control and while predatory fish have been tried, none has been very successful. The use of reproductive hormones in small water bodies is being tested, but otherwise only drainage and physical removal have been effective. It is next to impossible to drain natural wetlands and certainly true of large lakes. Other management strategies include creating barriers to prevent its spread, prohibiting the transport of live crayfish, and improving public education about it risks to the environment. Encouraging farming of native species as well as research on economically productive harvesting of native alternatives has the potential to reduce further introductions.

WHAT IS MY ROLE IN PREVENTING SUCH INVASIONS?

- Do not introduce any species of freshwater crayfish into wetlands (for aquaculture or aquarium trade) as this aids the spread.
- Report any sightings of these crayfish to appropriate authorities (e.g. Government, Fisheries Departments or Environmental Agencies.
- Freshwater crayfish has aheady been recorded in the Zambezi River basin, the Lake Victoria basin and freshwater wetlands and rivers in the eastern Rift Valley and on some of our island countries. Mapping their spread is important in order to issue alerts of threats to wetlands not yet invaded and to take measures to prevent introductions – as these creatures are a serious threat to the endemic and indigenous freshwater biodiversity of Africa.

IUCN Global Invasive Species Initiative
IUCN ESARO Regional Office, Nairobi, Kenya
For more information contact: geoffrey.howard@iucn.org, or esther.abonyo@iucn.org

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Invasive crayfish alert!

Procambarus clarkii **(Louisiana crayfish)**

This freshwater crustacean, native to Southern USA, has become a big threat to African wetlands since its introduction several decades ago. Adults are dark red-brown in colour and may measure up to 15cm in length. It is considered one of the most adaptable crustaceans and is able to grow quickly, even in only seasonally present water, being tolerant of dry spells for four months.

WHY SHOULD WE BE WORRIED?

This alien freshwater crayfish has a destructive feeding behavior. It feeds on: submerged and emergent water plants, semiaquatic vegetation, snails and other molluscs, small fish, other crustaceans found in natural and man-made wetlands (dams, reservoirs, farm ponds, swamps, lakes and floodplains) in shallow water and on the edges of deeper water bodies.

- *Procambarus clarkii* can destroy native wetland vegetation and the snail and crustacean fauna of aquatic ecosystems. It has been held responsible for the disappearance of water lilies and submerged vegetation as well as many species of snails in wetlands of Eastern and Southern Africa where it has become invasive.
- It is possibly a threat to the existence of smaller fish of biodiversity value.
- Its burrowing habits can damage dams and reservoirs.
- It may out-compete the native freshwater crabs and other aquatic species, and is a vector for the crayfish plague *Aphanomyces astaci*, for crayfish virus vibriosis and a number of worms parasitic on vertebrates.

PATHWAYS OF SPREAD:

- In some cases *P. clarkii* was introduced to man-made wetlands to control bilharzia-spreading snails from where it spread to other wetlands.
- It was introduced to some water bodies to enhance fisheries catches and has also escaped from aquaculture where it is bred to provide a specialty food.
- As it is an 'air-breather', the adults can travel considerable distances across land (especially in damp grass) and so spread from one wetland to another and even from one river or lake catchment to another in this way.

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ANNEX 6 – IAS poster

ALIEN INVASIVE SPECIES
in Lake Tanganyika and its catchment

Mimosa pigra grows in lakeside wetlands

Eichhornia crassipes grows in lake waters

Mimosa diplotricha smothers lakeside plants

Canna indica grows in damp areas replacing other plants

The Lake Tanganyika ecosystem

Lake Tanganyika is of great ecological and biological importance. It is a freshwater biodiversity hotspot harbouring over 240 endemic species of fish as well as hundreds of endemic crustaceans and molluscs and microscopic plankton organisms. It is also the source of livelihood for millions of people in the riparian states of Burundi, DRC, Tanzania and Zambia. However, foreign species have been (and are being) introduced to this ecosystem which is posing a threat to the precious biodiversity and the peoples' welfare.

The project

The UNDP/GEF has contracted IUCN, through its Invasive Species Initiative to establish the risks presented by invasive species and prepare a monitoring and management programme that will lead to their prevention and management into the future. This is in an attempt to fulfil Article 10 of the Lake Tanganyika Convention and to support the overall biodiversity monitoring effort for this lake and its catchment.

Management of IAS

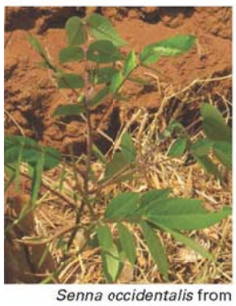
Prevention: The first line of defense against IAS is to prevent their introduction. This is the most cost-effective option.

Eradication: If prevention has failed and an introduced species is becoming invasive, eradication is the preferred course of action before the invasion does serious damage and spreads.

Control: The last step in the sequence of management options is the control of an invasive species when eradication is no longer feasible. The aim of control is to reduce the density and abundance of an invasive organism to keep it below acceptable threshold. Control can be done mechanically, chemically, biologically and by habitat management.

Monitoring: An important aspect of taking steps to reduce the threat of biological invasion is to monitor the ecosystem of concern (Lake Tanganyika and its catchment) in a systematic way to detect any changes in the presence of species or populations. This requires a programme of observation and sampling – such as the Monitoring Programme being designed by IUCN for LTA and the riparian states.

Tithonia diversifolia is spreading in the catchment



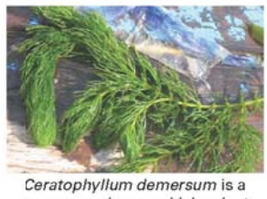
Senna occidentalis from tropical America spreads near the shore

Senna hirsuta is spreading near the lakeshore

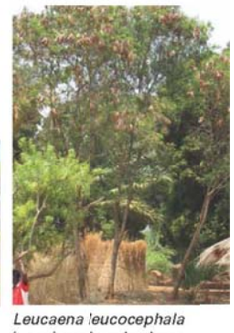
Lantana camara is an invasive shrub in the catchment

Procambarus clarkii Invasive alien freshwater crayfish are present in the region, but not yet in the lake or catchment

Hydrilla verticillata is a submerged water plant in the lake which is invasive in some other water bodies



Ceratophyllum demersum is a common submerged lake plant that might become invasive through pollution



Leucaena leucocephala is an invasive shrub or tree often spreading from villages

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For more information: contact: geoffrey.howard@iucn.org or esther.abonyo@iucn.org or info@lta-alt.org