Chapter 10

The importance of freshwater species to livelihoods in the Lake Victoria Basin

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10.1 Introduction

Freshwater biodiversity plays a significant role in supporting the livelihoods of human communities around the world, particularly of people in rural and poor communities. In the developing world, 56 million people are involved in small-scale freshwater fisheries and in Sub-Saharan Africa, fisheries are a key source of nutrition and income for much of the rural population (Béné *et al.*, 2010). Additionally, the value of large-scale fisheries and of other harvested freshwater species, primarily decapods, molluscs and plants, are important for rural communities across Africa, providing not only nutritional but medicinal, structural and cultural values, amongst others.

The Lake Victoria Basin is home to over 30 million people (Kayombo and Jorgensen, 2005) with a population density of about 500 people per km^2, which is much greater than the average for the African continent (Kolding *et al.*, 2014). Lake Victoria and other small lakes within the basin have endured multiple stressors, particularly in the last half of the 20th

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century, associated with human population growth, increased cultivation of riparian land, introduction of non-native species, and climate change (Hecky *et al.*, 2010; Kolding *et al.*, 2008). All these stressors have been accompanied by a fundamental change in biodiversity, including in fisheries production.

Despite these perturbations, fisheries productivity has continued to expand and currently produces around one million tonnes of fish per year (Marshall and Mkumbo, 2011; Taabu-Munyaho *et al.*, 2016), which is twice as high as the total catches of all of the other African Great Lakes combined. Without considering the contribution of other small lakes in the basin, which is immense in terms of local livelihoods and nutrition, Lake Victoria alone currently employs around 800,000 people through fishing and related value chain processes. This is much higher than the total employment by all other African Great Lakes combined. When the dependants of fishery sector employees around Lake Victoria are included, Lake Victoria directly supports household livelihoods of about four million people (Mkumbo and Marshall, 2015).

The Lake Victoria Basin is home to the most extensive wetlands in Eastern Africa and these wetlands support remarkably high levels of floral biodiversity. Freshwater plants have a diverse range of uses, with variations in use depending on the plant part and life stage. Medicinal use of plants is very common in rural communities, as there is often no access to modern medical facilities, and investigations of the medicinal properties of plants have been conducted for centuries (Juffe-Bignoli and Darwall, 2012).

Given these attributes, Lake Victoria (and its basin) is uniquely central to curbing problems of both malnutrition and poverty if measures can be put in place to ensure sustainable use of its biodiversity. In this chapter, we provide a summary of our detailed assessment of the use and livelihoods value of the freshwater fishes and plants of the Lake Victoria Basin. The aim of this assessment was to collate information on the many and varied uses of these species, in order to increase awareness of their great importance to the livelihoods of the communities of the Lake Victoria Basin, and demonstrate that conservation of this biodiversity is of vital importance.

10.2 Methods

10.2.1 Data collection

Within the IUCN Species Information Service (SIS) database, which holds all data behind the IUCN Red List, information related to the use and livelihoods value of species is currently stored in two different places, with some degree of overlap in content: i) high level information on use and trade, as well as detailed information on livelihoods, is stored in the use and trade section of Red List assessments; and ii) detailed information on use and trade is stored in a separate use and trade assessment module. For this project, we wanted to compile data relevant to both sections and therefore, for ease of data collection in a workshop setting, we created a separate spreadsheet capturing all fields from both modules (see Data Collection Sheet in Supplementary Material (Livelihoods), hereafter Data Collection Sheet). The aim is for these data to later be migrated to the IUCN SIS database to be made available through species Red List assessments on the IUCN Red List website. Related to this, a species benefits assessment, which could incorporate data from both sections existing in SIS and from landscape level assessments produced as part of the People in Nature (PiN) knowledge basket by the IUCN Commission on Environmental, Economic and Social Policy (CEESP), is currently under development (Davidson-Hunt *et al.*, 2017).

The data collection sheet allowed information to be captured for individual species/use combinations on several factors including: the scope of use; end use/product; driver of the harvest; harvesters of the product; consumers of the product; level of reliance on the product; value of the product to livelihoods and the economy; source of the harvest; details of the harvested individuals; volume of the harvest; conservation benefits to species and habitats resulting from the harvest; and threats resulting from the harvest. The end uses follow the End Use classification scheme in the IUCN SIS database. This classification scheme is designed to cover all taxonomic groups and as a result, some of the broad use titles may not seem appropriate to the taxonomic groups covered here. For example, a use of 'Pets, Display Animals, Horticulture' in the context of freshwater fishes refers to ornamental use in the aquarium trade, and in the context of freshwater plants refers to ornamental horticulture. The data collection sheet also allowed species/use combinations to be captured at multiple scales or locations, in case the importance or manner of use of a species for a particular product differed between countries, for example (see Data Collection Sheet).

10.2.2 Taxonomic scope

From the priority taxonomic groups considered in the Red List assessment process (see Chapter 2), we decided to focus on compilation of use and livelihoods data on the freshwater fishes and plants of the Lake Victoria Basin as these two groups have the most direct human uses.

10.2.3 Species use and livelihoods workshop

A three-day species use and livelihoods workshop was held in Kisumu, Kenya in October 2016. Participants included

Figure 10.1 Participants at the species use and livelihoods workshop held in Kisumu, Kenya in October 2016. © Mary Kishe-Machumu

nine experts with knowledge of the utilisation of freshwater fishes or plants in the Lake Victoria Basin, two facilitators from the IUCN Global Species Programme's Freshwater Biodiversity Unit, two staff from Uganda Coalition for Sustainable Development (UCSD), and a member of the IUCN CEESP involved in PiN (Figure 10.1).

The experts were split into two groups based on their taxonomic expertise and a separate data collection sheet was completed by each group. For each taxonomic group, the processes followed and summaries of the results found are presented separately below. The Data Summary in Supplementary Material (Livelihoods), hereafter Data Summary, contains lists of the species for which use and livelihoods data were recorded, along with details of the unique end uses recorded for each species. This is only a subset of the data compiled – for the complete data collection sheets please see the Fishes Livelihoods Data and Aquatic Plants Livelihoods Data, both in Supplementary Material (Livelihoods).

10.3 Freshwater fishes

10.3.1 Summary of data

Through the Red List assessment process (see Chapter 4), 234 taxonomically described freshwater fish species were identified as native to the Lake Victoria Basin. Given this large number of species to consider and the time available at the workshop, it was decided to prioritise the species list by identifying the species that were commonly landed and, therefore, likely to be most important in terms of their uses and contribution to livelihoods. The experts went through the species list and marked each species as: commonly landed (including in which countries); landed but not commonly (including in which countries); not landed; or no information. Use and livelihoods data were then compiled for the commonly landed species for each of the relevant countries.

The original aim of the workshop was to collect use and livelihoods information at the species level. However, after discussion with the experts at the workshop it became clear that this was not appropriate for two groups of species: *Labeobarbus*/*Enteromius* species (including *L. altianalis, E. jacksoni, E. profundus, E. serengetiensis* and *E. viktorianus*) and the haplochromine cichlids (including 78 commonly landed species). Individual species within these groups are not distinguished by harvesters or fisheries and, therefore, it is not possible to compile data at the species level on their importance in terms of use and livelihoods. Instead, data were collected on the *Labeobarbus*/*Enteromius* species group and *Haplochromis* species group (see Data Summary for the list of species considered within these groups).

The freshwater fish experts invited to attend the workshop had particular expertise on the Kenyan, Tanzanian and Ugandan parts of the Lake Victoria Basin, the countries bordering the lake itself. Unfortunately, the expert with particular knowledge on Uganda was unable to attend at the last minute due to illness. Instead, this information was contributed via email, but following the same process discussed above. The majority of the use and livelihoods data compiled came from the experts own experience and knowledge, with the exception of the fisheries catch statistics and value estimates which came from a report by LVFO (2016).

In total, use and livelihoods data were compiled on 24 individual native species, the native *Labeobarbus/ Enteromius* species group (including five species) and the native *Haplochromis* species group (including 78 species), totalling 107 native species. Additionally, data were recorded on two introduced species (Nile Perch (*Lates niloticus*) and Nile Tilapia (*Oreochromis niloticus*)) as these species have high livelihoods value (see Data Summary for a list of the species on which data were compiled). The mean number of uses recorded for all species investigated was 4.2, and the maximum recorded was five (for all species in the *Haplochromis* species group).

10.3.2 Uses of freshwater fishes

10.3.2.1 Summary of end uses

Seven unique uses were recorded for the 107 native freshwater fish species (Table 10.1). The most frequently coded uses (Food – Human; Food – Animal; Medicine – Human and Veterinary; Pets, Display Animals, Horticulture; Research) are discussed below.

Table 10.1 End use categories recorded for 107 freshwater fish species native to the Lake Victoria Basin. Note these seven categories come from a list of 17 in the End Use classification scheme in the IUCN Species Information Service (SIS) database (see Data Collection Sheet). Species that were considered non-native (Nile Perch (*Lates niloticus*) and Nile Tilapia (*Oreochromis niloticus*)) are not included in this table.

End use category	Number of freshwater fish species
Food – Human	104
Medicine – Human and Veterinary	87
Food – Animal	86
Research	85
Pets, Display Animals, Horticulture	83
Manufacturing Chemicals	1
Establishing *ex situ* production	1

10.3.2.2 Food (human)

Food for humans was the highest ranked end use category with 96.3% of the native species of freshwater fishes assessed having this use (Table 10.1). Most of these native species are largely consumed by households of poor and average wealth and, depending on the size of the species, are consumed whole after boiling, frying, smoking, salting or sun drying. However, most of the large-sized species are smoked to enhance the shelf life (Figure 10.2).

10.3.2.3 Food (animal)

Use as animal feed was also a major end use category with 79.6% of the freshwater fish species surveyed coded for this use (Table 10.1). The major form this use takes is as bait for other fishes in commercial fisheries. Here, the most commonly used species are: *Haplochromis* species, known as Fulu in Kenya, Furu in Tanzania and Nkeje in Uganda, which are used as bait for harvesting Nile Perch; and species belonging to the family Mormyridae. The other form this use takes is incorporation into poultry, fish and other animal feeds as a source of protein. The most

Figure 10.2 African Catfish (*Clarias gariepinus*) from Lake Wamala, a small lake within the Lake Victoria Basin, after smoking and ready for sale at Katiko landing site. © Vianny Natugonza

commonly used species in this form are Dagaa or Silver Cyprinid (*Rastrineobola argentea*), locally known as Omena in Kenya, Dagaa in Tanzania and Mukene in Uganda, and the *Haplochromis* species group.

10.3.2.4 Medicine (human and veterinary)

Medicine was the second most important end use category among the native freshwater fish species, with 80.6% of the species assessed coded as having this use (Table 10.1). These medicinal values were primarily related to treating allergies (especially in older women) or use as aphrodisiacs (in men). The most commonly used species included: *Labeo victorianus*, known locally as Ningu; *Mastacembelus frenatus*, known as Okunga in Kenya and Mkunga in Tanzania; *Schilbe intermedius*, known as Sire in Kenya, Nembe in Tanzania and Nzere in Uganda; and some species belonging to the family Mormyridae. Other species such as African Lungfish (*Protopterus aethiopicus*), known as Maamba in Kenya, Kamongo in Kenya and Tanzania, and Mamba in Uganda, are used for treating a range of medical conditions (see **Species in the Spotlight – African Lungfish (*Protopterus aethiopicus*)**, this chapter).

10.3.2.5 Ornamental use

The end use category of ornamental use, which is coded for 76.9% of the freshwater fish species surveyed (Table 10.1), is dominated by the *Haplochromis* species group. These fishes, especially the males, are traded and displayed in aquarium tanks internationally because of their bright colours. A couple of prominent examples of these fishes include *H.* (*Pundamilia*) *pundamilia* (Figure 10.3) and *H.* (*Paralabidochromis*) *sauvagei* (Figure 10.4).

10.3.2.6 Research

The end use category of research, which is coded for 78.7% of the freshwater fish species surveyed (Table 10.1), is also dominated by *Haplochromis* species. The endemic *Haplochromis* species of the Lake Victoria Basin have been at the centre of scientific investigation on evolution, adaptive radiation, speciation, morphological nomenclature, dietary shifts and ecological changes. Other common endemic fish species, such as *Labeobarbus*/*Enteromius* species, are also used for research.

10.3.3 Livelihoods value of freshwater fishes

Lake Victoria is a multiple-species fishery consisting of both native and introduced species. The species targeted in the fishery include a number of species that were introduced to the lake in the 1950s, as well as over 200 native species of haplochromine cichlids, non-cichlids and tilapia whose

Figure 10.3 *Haplochromis* (*Pundamilia*) *pundamilia*, a colourful haplochromine cichlid from Lake Victoria that is used as an ornamental species in the aquarium trade. © O. Selz & O. Seehausen

Figure 10.4 *Haplochromis* (*Paralabidochromis*) *sauvagei*, a colourful haplochromine cichlid from Lake Victoria that is used as an ornamental species in the aquarium trade. © Ole Seehausen

richness and abundance are declining due to a number of contributory factors such as overfishing, pollution and competition and predation from introduced species (see Chapter 4). However, currently three species dominate the Lake Victoria fishery in terms of livelihoods value: i) the introduced Nile Perch, which is known by the common names of Sangara in Tanzania, Mbuta in Kenya, and Mputa in Uganda (Figure 10.5); ii) the introduced Nile Tilapia, which is known by the common names of Sato in Tanzania, and Ngege in both Kenya and Uganda (Figure 10.6); and iii) the native Dagaa or Silver Cyprinid (*Rastrineobola argentea*), which is known by the common names of Dagaa in Tanzania, Omena in Kenya, and Mukene in Uganda (Figure 10.7).

The value chain and economic activities associated with the Lake Victoria fishery provide an indicator of the great livelihoods value of freshwater fishes. Within the value chain associated with the Lake Victoria fishery, direct and indirect activities such as fish capture and production, fish transportation, fish processing, fish trading, fish marketing and fish governance occur and provide jobs for local people. Furthermore, the varied end uses of freshwater fishes as food, animal feed, aquarium fish, sport fish and industrial raw materials, amongst other things point to the diverse livelihoods value of this group.

The introduced species of Nile Perch and Nile Tilapia dominate the fishery in terms of livelihoods value. Catches are sold and traded in both domestic and export markets. Nile Perch is a highly commercialised fish and exports are targeted to markets in Europe, as well as non-European countries such as Israel. Its fish maw (the dried swim bladder) is also in high demand in Asia, especially China, leading to increases in its price. It is used for isinglass, surgical threads, anaesthetic drugs, condoms, soups or stews (as a collagen source). In November/December 2015, 13,569 metric tonnes of Nile Perch (Figure 10.5) were caught across Lake Victoria (LVFO, 2016).

The Nile Perch fishery has had social impacts on the communities of the Lake Victoria Basin, although the full extent of these are still not clear. Reynolds and Greboval (1988) voiced concerns that industrial-level operations in the fishery could marginalise artisanal fishermen and lead to the displacement of small-scale fish distributors, primarily women, who depend on trade for their income. At present, many fishermen operate on behalf of fish processing factories, which supply them with equipment that allows them to fish further afield, such as nets and outboard engines. As a result, these fishermen are obliged to sell their catch to the factories (at a market price fixed by the factory traders) to pay back for the equipment. This creates an unequal relationship between fishermen and factories, and results in an unequal distribution of income (Geheb *et al.*, 2008). Concerns have also been raised that the lucrative export market could contribute to food insecurity within the

Figure 10.5 Fishermen carrying a Nile Perch (*Lates niloticus*) harvested from Lake Victoria. © Leonard Akwany

Figure 10.6 A harvest of the introduced Nile Tilapia (*Oreochromis niloticus*). © Vianny Natugonza

region by transferring fish protein supplies away from food deficit areas (Kirema-Mukasa and Reynolds, 1991; Reynolds and Greboval, 1988). However, Geheb *et al.* (2008) argue that high levels of malnutrition are in fact due to insufficient income from fisheries making its way back into households. This is because men control much of the fishery but women are held responsible for upkeep of their families. The majority of studies on the social impacts of the Nile Perch fishery are old and there is a need for updated research on this topic.

Nile Tilapia (Figure 10.6) is normally landed for domestic market and targets upmarket consumers in cities and hotels. In November/December 2015, 1,674 metric tonnes of Nile Tilapia were caught across Lake Victoria (LVFO, 2016).

Dagaa or Silver Cyprinid (Figure 10.7) fishing is critical and leads in terms of weight of landed fish, with 46,567 metric tonnes caught across Lake Victoria in November/December 2015 (LVFO, 2016). It is fished for both domestic and regional markets and the driver of the harvest is for production of animal feeds and human food. This species is primarily harvested for human food but quality is often reduced due to post-harvest conditions and as a result much of the catch ends up being used in animal feed factories. Consumers of products from Dagaa differ depending on the end use and location. This cheap fish was previously primarily consumed by poor to average income households for human food, as the drying process is considered unhygienic and the smell can be off-putting. However, it is of high nutritional value (rich in protein and micronutrients) and as awareness of this value is increasing, popularity of this fish is increasing in richer households. This species is now considered an essential staple for food and nutritional security. When used for animal feed, it is primarily average to rich households who use Dagaa, as these are the households with the equipment for agriculture or aquaculture. However, harvesting of this species is at night-time by men from poorer households.

Figure 10.7 A harvest of the native Dagaa or Silver Cyprinid (*Rastrineobola argentea*) for sale at a market in Uganda. © Vianny Natugonza

10.3.4 Patterns of distribution of freshwater fishes of livelihoods value

The spatial distribution of species richness of freshwater fishes of livelihoods value in the Lake Victoria Basin (Figure 10.8) largely mirrors the distribution of overall freshwater fish species richness (see Chapter 4). The greatest richness of freshwater fishes of livelihoods value is found in Lake Victoria itself where 74 species were coded as being used (Figure 10.8). This is unsurprising given the presence of the large haplochromine cichlid species flock in the lake, of which the commonly caught species were coded as having five unique end use types (see Data Summary).

10.3.5 Threats to freshwater fishes of livelihoods value

The freshwater fishes of Lake Victoria are the basis for one of the largest continental inland fisheries, which supports over four million people (directly or indirectly, and including dependents) in its entire value chain (Mkumbo and Marshall, 2015). Fisheries production from the lake is expanding and is currently estimated at one million tonnes (Marshall and Mkumbo, 2011; Taabu-Munyaho *et al.*, 2016). Based on an estimated production of half this mass, Odongkara *et al.* (2005) valued this harvest at over 600 million USD annual return (Njiru *et al.*, 2008). However, the freshwater fishes of Lake Victoria have not been spared from the many impacts associated with the Anthropocene. The main driver of these threats is an increasing regional human population necessitating increased fish production for food and nutritional security, in combination with demand from the export market in Europe and Asia, and demand for fish related industrial raw materials, such as for the animal feeds industry.

Overharvesting is a threat to the lake fisheries as indicated by increasing fishing effort to counter declining fish stocks in an attempt to meet the demands associated with the increasing population and export markets discussed above. This is augmented by immature and undersize fish catches through use of illegal fishing gears and unorthodox fishing methods, such as fish poisons. These have led to increased, and on occasion hostile, competition between fishermen.

Cage aquaculture is a new emerging threat to fish biodiversity in Lake Victoria and studies into its impacts have so far had

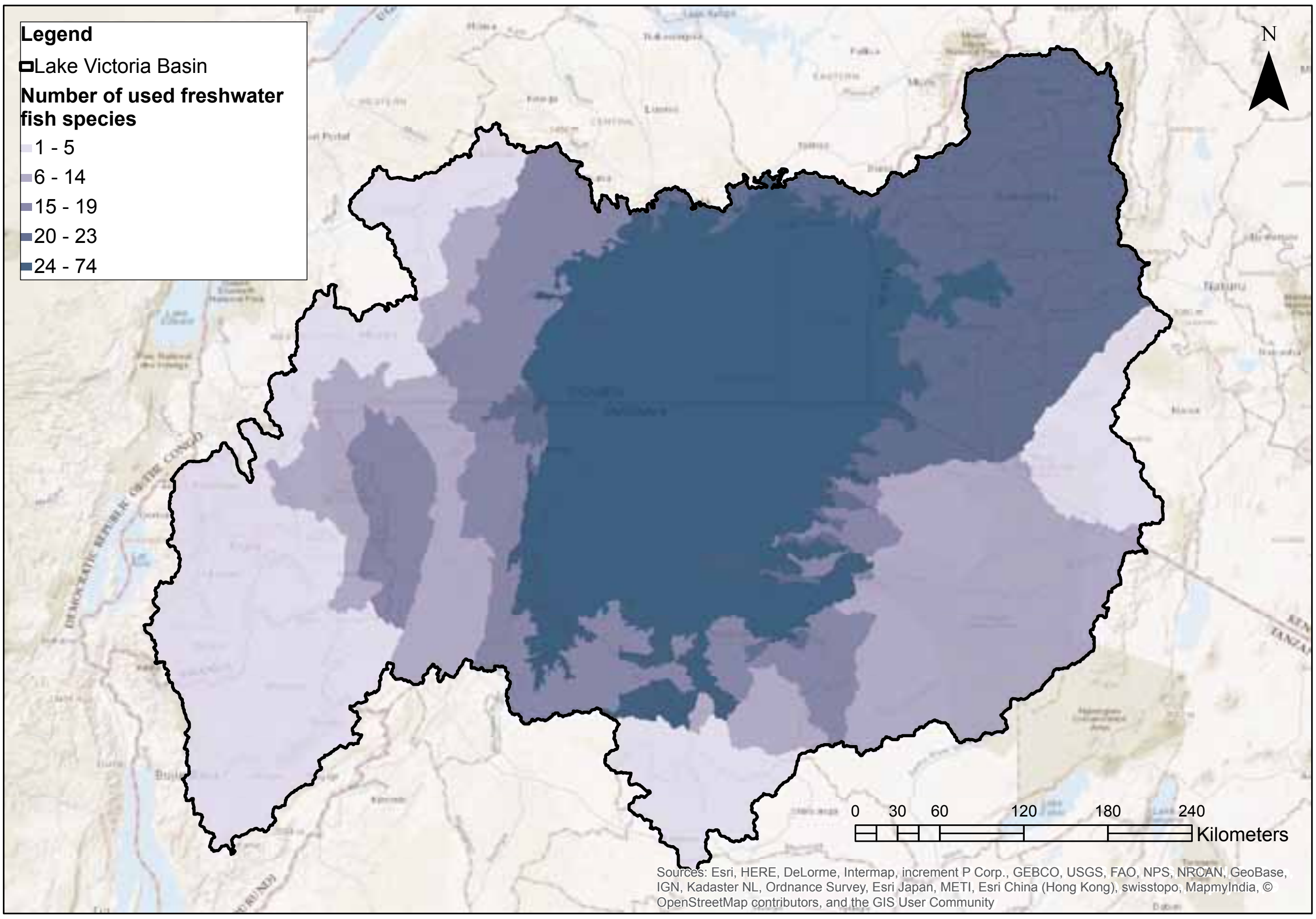

Figure 10.8 Distribution of used freshwater fish species in the Lake Victoria Basin based on species distributions for the IUCN Red List assessments (spatial data coded as Presence 1 (Extant) and Presence 2 (Probably Extant)) and species recorded as being used. Richness data are classified using quantiles.

varying conclusions (Aura *et al.*, 2018; Kashindye *et al.*, 2015). As fish cages are preferably sited in shallow inshore areas, which are often also areas of high species diversity or breeding and nursery habitats, there is real danger of impacting many endemic fish species that are sometimes only found in these areas, especially haplochromine cichlids, due to enhanced eutrophication and anoxia in these shallow habitats. In addition, as fish species selected for cage farming are often not native (e.g. Nile Tilapia), escapees from the cages will also impact native species through competition and predation as discussed in more detail below. Cage fish farming urgently requires formal guidance and appropriate legislation if it is to be socially, economically and environmentally sustainable. A study to map potential sites for cage farming that would have minimal environmental impact is recommended.

Pollution from domestic, urban and industrial sources, such as sewage, sugar and agro-chemical factories situated in the Lake Victoria Basin, also threatens freshwater fisheries. This is compounded by eutrophication caused by nutrient input from basin-wide agricultural activities leading to extensive algal blooms. Pollution and eutrophication result in poor water quality, oxygen deficiency and anoxic conditions, which are not conducive for supporting fish species in a complex food web (Naigaga *et al.*, 2011).

Introduced species of flora and fauna are well documented for their negative impacts on freshwater fishes. One clear example is the exotic Water Hyacinth (*Eichhornia crassipes*) (see Chapter 7: **Species in the Spotlight – Water Hyacinth (*Eichhornia crassipes*)**), which competes with native primary producers, blocks sunlight to underlying species, and mechanically inhibits fishing operations as its prolific growth leads to heavy mats forming over fishing territories. It should be noted that fisheries themselves have contributed to the negative state of Lake Victoria in terms of introduced species. Fish species were introduced to Lake Victoria in the 1950s, reportedly to convert fish stocks in the lake, primarily composed of small and bony haplochromines, into larger more economically valuable species, such as Nile Perch (Pringle, 2005). These introductions have had significant negative ecological impacts on the lake through heavy predation, in addition to competition (see Chapter 4). However, as discussed above, Nile Perch is important in terms of livelihoods value in the Lake Victoria fisheries due to its commercial viability.

The degradation of wetlands and associated fish breeding habitats also threatens freshwater fishes. This is the product of increased reclamation or clearance of wetlands throughout much of the Lake Victoria Basin primarily for agriculture, settlements and water-related infrastructural development. Preparation of fish through smoking, which is required to enhance the shelf-life of large species that cannot be sun-dried (e.g. African Catfish (Figure 10.2), Nile Perch), is also a driver of forest clearance for the provision of charcoal. However, with regards to Nile Perch, it is not clear to what extent this process is an issue today because much of the Nile Perch that is landed is now exported frozen (Anderson, 2016). Together these processes lead to direct destruction of wetland habitats, impairment of environmental flows and ultimately the loss or degradation of wetlands critical for fish breeding and for the survival for those fish species restricted to wetland habitats (Chapman *et al.*, 1996a; Naigaga *et al.*, 2011).

Finally, climate change, as expressed through seasonal variability, extreme weather events (floods and droughts), increased or reduced temperatures and precipitation, has impacted Lake Victoria, in particular due to its shallow depth and high dependence on precipitation – 80% of water recharge and associated water release is through rainfall and evapotranspiration. Freshwater fish communities require suitable water temperatures, primary food production, and adequate water quality and quantity, all of which are potentially threatened by climate change (Ficke *et al.*, 2007).

10.3.6 Conclusions and recommendations

This assessment of the use and livelihoods value of freshwater fishes native to the Lake Victoria Basin aims to showcase the role of freshwater fish biodiversity in sustaining local livelihoods and economies, and hence to provide additional justification for prioritising fish biodiversity in policy planning. We found that the majority of the fish species surveyed are used as food, although most species have multiple uses. These findings highlight the importance of healthy fish populations in alleviating hunger and malnutrition in the hunger- and poverty-stricken riparian communities of the Lake Victoria Basin.

This assessment also shows that the livelihoods value with regards to fisheries in the Lake Victoria Basin is dominated (in order of importance) by two introduced fish species, Nile Perch and Nile Tilapia, and one native species, Dagaa or Silver Cyprinid. There has been a continuous and unabated increase in fishing effort within Lake Victoria, especially within the last two decades, and additional research and new management approaches are required if these fisheries are to be a sustainable component to local livelihoods and national and regional economies.

Most of the species of high livelihoods value are in the main lake and influent rivers and streams. These critical fish habitats, therefore, must be protected from threats, such as siltation, pollution and alterations to water flows.

Species in the Spotlight

African Lungfish (*Protopterus aethiopicus*)

Kishe-Machumu, M.A.[1]

African Lungfish (*Protopterus aethiopicus*) are very primitive and ancient lobe-finned fishes, which get their name from their ability to extract oxygen from the atmosphere, as well as from the water. This ability means that African Lungfish can survive drought by burrowing into mud and enveloping themselves in a cocoon, and as such they are found in environments that experience severe desiccation and low oxygen conditions, including swampy vegetated areas of lakes, floodplains and major river systems (Greenwood, 1958), as well as in more stable environments. This species is widely distributed across Eastern Africa and in the Lake Victoria Basin it occupies both the pelagic zone and shallow littoral swamps (Chapman *et al.*, 1996b).

The Lungfish Fishery

Fishing for African Lungfish in Lake Victoria has been practiced for a long time, but by a limited number of specialised fishermen. Gillnets and long lines are the main fishing gears employed, and these are placed along the lakeshore, close to the vegetation zone (mostly papyrus stands). For the long line fishery, hooks are baited with the flesh of freshwater mussels or haplochromines in Tanzania (Goudswaard *et al.*, 2002) and with pieces of meat, rats and frogs in Uganda (Walakira *et al.*, 2011). Bottom trawling is used for catching African Lungfish from deep waters (Figure 10.9), whereas basket traps and spears are commonly used to catch the species in seasonal wetlands. In the dry season, these fish are dug up from the mud in wetlands where they are aestivating in their mucus cocoons.

Catches from lake-wide bottom trawls confirm a decline in African Lungfish landings of the three riparian countries of the basin between the 1970s and 1990s (Ochumba, 1995; Ogutu-Ohwayo, 1990). The decline was attributed to overexploitation, environmental degradation including the large-scale conversion of wetlands to agricultural land, and harvesting of nest-guarding males leading to decreased recruitment of young fishes (Balirwa *et al.*, 2003; Goudswaard *et al.*, 2002). In the Mwanza Gulf in Tanzania, the area monitored most intensively for the longest period, catches dropped an order of magnitude between 1973 and 1990 (Goudswaard *et al.*, 2002). More recently, catch data from Ugandan waters dropped from 411,800 metric tonnes in 2005 to 366,600 metric tonnes in 2010 (Uganda Bureau of Statistics (UBOS), 2010). In contrast to the reported declines in many other fish species in Lake Victoria, Nile Perch predation and eutrophication are not thought to be key factors contributing to the dramatic decline of the African Lungfish.

Preliminary observations indicated some recovery of the African Lungfish in the 1990s (Bugenyi and van der Knaap, 1997) and the observed resurgence was attributed to the invasion of Water Hyacinth (*Eichhornia crassipes*) in the late 1980s (Njuguna, 1991). The extensive mats of this weed along the lake's shore, and particularly the hypoxic water beneath the mats, extended ecotonal refugia and therefore, increased availability of habitat for this species. Additionally, the mats reduced access by fishermen, which reduced harvesting pressure and allowed population recovery. However, any benefits will only last as long as Water Hyacinth is widespread and efforts are underway to rid Lake Victoria of this weed (see Chapter 7: **Species in the Spotlight – Water Hyacinth (*Eichhornia crassipes*)**).

Figure 10.9 African Lungfish (*Protopterus aethiopicus*) catch from bottom trawling in Lake Victoria. © Mary Kishe-Machumu

[1] Tanzania Fisheries Research Institute (TAFIRI), Dar es Salaam, Tanzania

Consumption as food

In the Lake Victoria Basin, the African Lungfish is either highly appreciated or strongly disliked as food, with consumption patterns varying by community. For example, for the Luo who live south of the Nyanza Gulf in Kenya and in the Mara Region of Tanzania, African Lungfish is particularly popular as a food (Graham, 1929; M. Kishe-Machumu pers. obs.) and the Luo people say *"Kamongo yasinda nyama"*, which translates to "*Lungfish is more delicious than beef!*". It is considered a delicacy and normally prepared for special groups of people, for example in-laws. In contrast, the Sukuma who live around Mwanza and Shinyanga dislike this fish due to its taste. In some areas, the African Lungfish is not eaten at home, and fishermen who catch them prepare and consume them only at their landing sites (M. Kishe-Machumu pers. obs.). African Lungfish is a delicacy among groups in the northern, eastern and some parts of western Uganda but a high number of people from central region of Uganda have never eaten this species (Walakira *et al.*, 2011). The main reasons given for not eating African Lungfish were: local taboo, tribal or traditional beliefs that restricted them from eating the fish; little knowledge about the fish; religious beliefs about "scaleless" fish; and its external appearance. Additionally, Bruton (1998) reported that some women do not eat African Lungfish because they consider it as a "sister fish" with some undesirable consequences for the female consumer. However, in recent years, African Lungfish is acceptable to both women and men as a food locally and regionally, and some women have now even engaged in African Lungfish trade.

Medicinal use

In villages African Lungfish is highly valued for its benefits for human health, for example as treatment for problems involving lactation (P.O.J. Bwathondi pers. comm.), to treat alcoholism (the pancreas), to enhance male's sexual performance (the tail), to boost the immune system (Walakira *et al.*, 2011), to treat kwashiorkor (severe malnutrition), gonorrhoea, breast cancer and backaches, and for general revitalisation of the body (Kayiso, 2009). As this species is malacophagous and can consume up to 200 snails per day, it is also used as a biocontrol agent against *Schistosoma* vector snails (Daffalla *et al.*, 1985; Walakira *et al.*, 2011).

African Lungfish processing and markets

African Lungfish is a source of income through trade to most communities in Africa and women play a major role in harvesting, processing and marketing. Products available through markets include fried fish, cured or smoked fish, whole fresh gutted fish and fish-based soup. From the southern coast of the lake in Tanzania between Speke Gulf and Emin Pasha Gulf, almost all dried African Lungfish is transported to Kenya and the area north of Musoma where the Luo people live (K.P.C. Goudswaard pers. comm.). Huge numbers of African Lungfish are caught in Kagera's satellite lakes and transported to Rwanda and Uganda while they are fresh (M.A. Kishe-Machumu pers. obs.; Figure 10.10).

Prices differ depending on location with prices generally lower in rural areas than in towns or cities. At the time of writing, in East African countries, wholesale prices for fresh African Lungfish ranged between USD 0.9–2.5 per kg, while retail prices can go beyond USD 2.5 per kg. The price for smoked African Lungfish ranged from USD 6–8 per kg (Walakira *et al.*, 2011; M.A. Kishe-Machumu pers. obs.).

Use in aquaculture

African Lungfish have been reported as a potential aquaculture species in Uganda, and more broadly in Sub-Saharan Africa, as the species is air-breathing and can survive prolonged droughts and poor water conditions (Walakira *et al.*, 2012). Initiatives to culture African Lungfish involve collection of wild nestlings that are then raised in earthen ponds. Fish farmers have already inadvertently farmed African Lungfish that entered their ponds during flood periods.

Figure 10.10 Weighing fresh African Lungfish (*Protopterus aethiopicus*) caught in Lake Kalenge (a small lake at Kagera, Tanzania) ready for packing and transportation to Uganda markets. © Mary Kishe-Machumu

10.4 Freshwater plants

10.4.1 Summary of data

One hundred and thirty-five freshwater plant species native to the Lake Victoria Basin were assessed for the Red List through this project (see Chapter 7). This list of species was used as the starting point for collection of data on use and livelihoods of freshwater plants. However, the experts consulted found that this list was not representative of the freshwater plant species of greatest importance to livelihoods in the Lake Victoria Basin. As a result, efforts were focussed on compiling data on freshwater plant species with targeted uses and livelihoods value based on the experts own experience and knowledge, as well as based on the literature. This resulted in use and livelihoods data being recorded for many species that are not currently included on the IUCN Red List and representing only a subset of the original 135 species.

Use and livelihoods data were compiled for 96 native freshwater plant species, including 52 species that have not yet been assessed for the IUCN Red List. The mean number of uses recorded was 1.4 and the maximum recorded was six (for *Cyperus articulatus*). Additionally, data were recorded on two non-native species (*Hyptis lanceolata* and *Mimosa pigra*) as these species have high livelihoods value. Many other non-native species are considered to be important to local livelihoods but the focus of this exercise was on species native to the Lake Victoria Basin (Data Summary lists the species on which data were compiled).

Data were compiled on targeted uses rather than on secondary uses, such as grazing. However, it is important to acknowledge the importance of pasture land in wetland areas and grazing of Cyperaceae and Poaceae species in the riparian zone, which represent an important contribution to local food and cultural systems. Other species also play important roles in freshwater ecosystems such as recycling nutrients, protecting against riverbank erosion and providing habitat and food for fish and aquatic invertebrates, which themselves support other species and human livelihoods.

The freshwater plant experts at the workshop had particular geographic expertise on the Kenyan, Rwandan, Tanzanian and Ugandan parts of the Lake Victoria Basin. The use and livelihoods data came from the experts own knowledge, as well as from the following data sources: Adjanohoun *et al.* (1993), Bally (1937), Becker *et al.* (2014), Burkill (1994), Geissler *et al.* (2002), Glover *et al.* (1966), Greenway (1941), Hamill *et al.* (2000), Jeruto *et al.* (2008), Kamatenesi-Mugisha and Oryem-Origa (2007), Kokwaro (2009), Lye *et al.* (2008), Neuwinger (2000), the PROTA database (2016), Ssegawa and Kasenene (2007), Tabuti *et al.* (2003) and Vollesen (2008).

10.4.2 Uses of freshwater plants

10.4.2.1 Summary of end uses

Eleven unique uses were recorded for the 96 native freshwater plant species (Table 10.2). The most frequently coded uses (Medicine – Human and Veterinary; Food – Animal; Food – Human; Construction or Structural Materials) are discussed below. Much of the information presented here on the use of plants is based on traditional and indigenous knowledge from the regional communities, which is passed from one generation to another.

10.4.2.2 Medicine (human and veterinary)

The rural poor of the Lake Victoria Basin often lack access to modern medicine and instead rely on the local natural pharmaceuticals, many of which can be derived from the freshwater plants of the region. Medicine is the most frequently reported use of the native freshwater plant species surveyed, of which 77% are used for medicine (Table 10.2). These medicinal uses vary from spiritual and psychological medicine (e.g. *Pistia stratiotes* is used to treat dementia) to chronic illness (e.g. *Culcasia falcifolia* is used to treat epilepsy; Figure 10.11). Various parts of these medicinal plants may be used fresh or in processed forms. Processed plant parts are often sun-dried, made into an ash or boiled. Harvesting, processing and application methods for these medicinal plants vary by community, many are taken orally and others are applied externally. Freshwater plants also

Table 10.2 End use categories recorded for 96 freshwater plant species native to the Lake Victoria Basin. The 11 categories presented come from a list of 17 in the End Use classification scheme in the IUCN Species Information Service (SIS) database (see Data Collection Sheet). Species that were considered non-native (*Hyptis lanceolata* and *Mimosa pigra*) are not included in this table, but are used for food and medicine.

End use category	Number of freshwater plant species
Medicine – Human and Veterinary	74
Food – Animal	15
Food – Human	15
Construction or Structural Materials	13
Handicrafts, Jewellery etc.	5
Other Household Goods	4
Fibre	2
Other Chemicals	2
Pets, Display Animals, Horticulture	2
Poisons	2
Establishing *ex situ* production	1

supply a number of intangible benefits, such as use in traditional healing and ceremonies, although some of these traditions are being lost.

10.4.2.3 Food (animal and human)

Food is the second most frequently reported end use among the species surveyed, with 16% of all native species being used for food for humans and 16% for livestock (Table 10.2). Communities throughout the Lake Victoria Basin use different parts of plants as food ranging from tubers to leaves, which may be taken raw or processed. These plants are mainly used as food during drought when the usual food items are in short supply. During dry seasons, when terrestrial plants are not available, freshwater plants serve an important role for livestock feeding and bedding throughout the Lake Victoria Basin. Wealthier pastoralists sometimes harvest fodder in large quantities of freshwater plants for their livestock in the dry season. These plants (mainly grasses) are primarily found in the riparian zones or otherwise nearby water bodies.

10.4.2.4 Construction or structural materials

The third most frequently reported use for the species surveyed is in construction and as other structural materials, with 14% of all native species categorised with this use (Table 10.2). Use as a construction material is dominated by emergent macrophytes, and includes constructing sheds, fencing and rafts, and making mats and ropes. Communities throughout the basin make posts and rafts from large freshwater plant species such as the Pith Tree (*Aeschynomene elaphroxylon;* Figure 10.12) and thatch buildings with a wide variety of sedges (Cyperaceae) (see **Species in the Spotlight – Papyrus Sedge (*Cyperus papyrus*)**, this chapter) and grasses (Poaceae/Gramineae).

10.4.2.5 Other uses

Other uses are identified for around 10% of the species surveyed (Table 10.2). Five percent of all species are reported to be used for handicrafts such as jewellery made with bulrush (Typhaceae), rushes (Juncaceae) and sedges. Many grasses (e.g. *Leersia hexandra*) are used for cleaning dishes and *Phragmites* species are used for making fish traps. Riparian aroids (e.g. *Pistia stratiotes*) are used as fertiliser. The Jointed Flatsedge (*Cyperus articulatus*) and a riparian mallow (*Triumfetta althaeoides*) are used for making ropes and mats. The Jointed Flatsedge is also used to make a perfume. The flowering Spotted Calla Lily (*Zantedeschia albomaculata*), Blue Lotus (*Nymphaea nouchali;* Figure 10.13), and submerged macrophytes such as the Hornwort (*Ceratophyllum demersum*), among others, are reported to be used in horticulture. Some species are also kept in *ex situ* production including riparian acanthus (e.g. *Brillantaisia owariensis*) planted in homegardens (Whitney *et al.*, 2017a), and free-floating macrophytes (e.g. Water Cabbage, *Pistia stratiotes;* Figure 10.13), whose roots are used for attachment of fertilised eggs during propagation of fish. It should be noted that Water Cabbage is considered invasive in some countries of the region, following import for various uses and its subsequent spread into natural aquatic systems (Global Invasive Species Database, 2017). The horseweed plants (*Conyza* species) are often used as insect repellents.

Figure 10.11 *Culcasia falcifolia* is used to treat epilepsy. © Quentin Luke

Figure 10.12 Flowers of the Pith Tree (*Aeschynomene elaphroxylon*). This freshwater plant is used to make posts and rafts. © Quentin Luke

10.4.3 Livelihoods value of freshwater plants

Freshwater plants are important for the livelihoods of the rural poor of the Lake Victoria Basin who use them for household activities in their day-to-day lives. Communities gather these plants for their own personal use and rely on them for a variety of medicinal, nutritional and technical uses. This constitutes an important resource, since many communities either lack access to or cannot afford market goods. In the data collated, 85% of freshwater plant product consumers are from poor households and therefore, rely heavily on products they can make themselves from natural resources freely available to them. However, our data also show that in most cases communities do not rely upon specific individual species but rather that any species from a set of options can be used to create a particular product, with 95% of species being classed as optional alternatives for a use. This is beneficial for communities as it means they are not solely reliant on single species, which could be problematic if the species were to become more difficult to access or the population of the species declines. This is also likely to result in less harvesting pressure being put on individual species overall, although the majority of uses coded (82%) are based on non-lethal removal of parts of the plant and for only six percent of the species/use combinations is harvest considered a risk to the survival of the species.

The data collated through this work suggest that freshwater plants are more important for direct benefits and play only a small role in local monetary economies. The collated data indicate that economic exchange of freshwater plants and plant products rarely contributes to local incomes in the basin, with the majority of species/use combinations having no annual cash income. However, an exception to this is handicrafts produced from freshwater species. Handicrafts, such as mats and woven baskets, are commonly made from *Cyperus* and *Juncus* species, and can be coloured using dyes from freshwater plants, such as *Ludwigia* species. The invasive Water Hyacinth (*Eichhornia crassipes*) is also

Figure 10.14 Agaseke made in Rwanda, usually from *Cyperus papyrus*, *C. latifolius* and *Juncus* species, and woven with Agave sisalana. © Samuel Nshutiyayesu

Figure 10.13 Blue Lotus (*Nymphaea nouchali*) and Water Cabbage (*Pistia stratiotes*) in the Ugandan part of Lake Victoria. Blue Lotus is used in horticulture, and the roots of Water Cabbage are used for attachment of fertilised eggs during propagation of fish. © Catherine Sayer

used in this way (see Chapter 7: **Species in the Spotlight – Water Hyacinth (*Eichhornia crassipes*)**). Women are mainly involved in such activities, especially those who may be considered vulnerable, for example widows or landless women. In Rwanda, for example, many women's associations have been established to craft an iconic handicraft basket locally known as Agaseke (Figure 10.14). These associations are able to sell their products at international markets, bringing significant benefits to the livelihoods of association members. Freshwater plants and plant products are generally sold for modest income generation, although more directed efforts and research are required to assess the economic value of these goods given that quantitative estimates were not possible based on the data collated through this project.

10.4.4 Threats to freshwater utilised plant species

The primary threats to utilised freshwater plants include land use changes and environmental threats, including climate change (see Chapter 7). However, these plants are also threatened by the loss of traditional practices and knowledge that plays a strong role in their conservation and conservation of their habitats. Many wetlands are being reclaimed for agriculture (Verhoeven and Setter, 2010), for example in the south-west of Uganda wetlands are being drained for grazing as traditional cultures shift from fishing and hunting to cattle ranching (Whitney *et al.*, 2017a). The decline in these traditional practices is leading to a loss of knowledge of the use of freshwater species and, therefore, degrading their apparent values and leading to a negative impact on their conservation. Knowledge on the use of freshwater plants is passed from one generation to another in most communities, but as young people move away and populations become urbanised, this traditional knowledge is lost.

Socio-cultural and biological landscapes are changing throughout the Lake Victoria Basin. One major change in the last years is the introduction of Water Hyacinth (see Chapter 7: **Species in the Spotlight – Water Hyacinth (*Eichhornia crassipes*)**). While the plant has led to the decimation of a number of aquatic plants, such as the free-floating *Pistia stratiotes* and *Azolla pinnata*, and *Trapa natans*, its occurrence in lakes has led to increase in others, for example *Vossia cuspidata* and other emergents. Another nuisance macrophyte in the basin, *Egeria densa*, has been recorded only in the Kenyan portion of Lake Victoria. The plant is rooted and submerged and is expected to interfere with transport and fisheries in lakes and other water bodies in the region.

10.4.5 Conclusions and recommendations

Freshwater plant species are abundant in the Lake Victoria Basin, many of which may be protected on account of their value in traditional uses. Better understanding of the role that the traditional use of plants plays in the protection of these species may provide useful conservation insights. This understanding is thought to be critical for the future survival of many threatened species given the changing socio-economic and ecological conditions of the basin. The work presented highlights species groups and geographical locations to help focus conservation actions for freshwater plant species of livelihood interest.

Some of these findings were presented at the African Great Lakes Conference 2017 held in Entebbe, Uganda (African Great Lakes Conference 2017 Contribution in Supplementary Material (Livelihoods); Whitney *et al.*, 2017b). Additionally, a field guide to the important macrophytes for livelihoods in the Lake Victoria Basin is being drafted. The forthcoming field guide on these plants and their uses will aim to make these species and their uses more widely known and encourage their conservation.

The findings presented here and the data provided in Summary Data should be coupled with that included within the species Red List assessments (see Chapter 7) to inform priority-setting and other conservation actions.

10.5 Overall conclusions

The aim of this assessment was to demonstrate the important role of freshwater biodiversity to the livelihoods of the communities of the Lake Victoria Basin, in order to raise awareness of the overall importance of these groups, as well as highlighting key species. The majority of the species assessed contribute to human livelihoods through multiple and diverse uses. The most frequently recorded uses for freshwater fishes and plants were as human food and medicine, respectively. These uses have direct links to human health and wellbeing, which highlights the vital role that freshwater species and ecosystems play in supporting the communities of the Lake Victoria Basin.

However, freshwater species and ecosystems in the Lake Victoria Basin are under threat. For fishes of livelihoods value, the primary threats are overharvesting, invasive species and habitat degradation, resulting from many threats, such as pollution. For freshwater plants of livelihoods value, invasive species and habitat degradation are also threats, but harvesting tends to be sustainable. It is thought that many freshwater plant species could be effectively protected directly or indirectly through their traditional uses, which are unfortunately in decline. Conservation of this biodiversity is vital to support the livelihoods of human communities in the Lake Victoria Basin.

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