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Assessment of the socio-economic value of freshwater species for the northern African region

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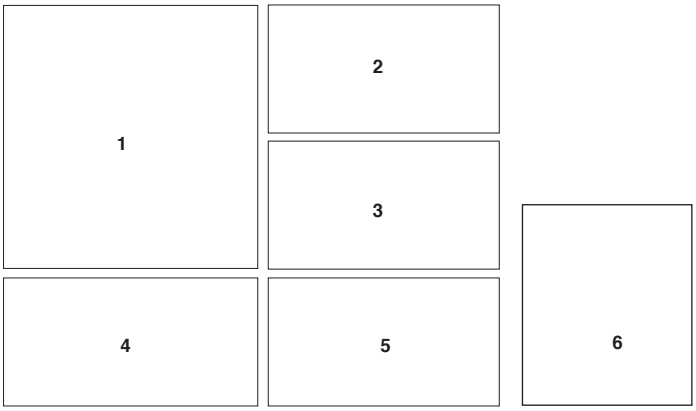
Assessment of the socio-economic value of freshwater species for the northern African region

Edited by Diego Juffe-Bignoli and William R.T. Darwall



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3.- Fishermen in the river Nile, in Egypt. Photo © dingoup.

4.- Mint species trade in a local market in Marrakech, Morocco. Photo © besopha.

5.- Use of *Juncus articulatus* and *Juncus maritimus* in Saidia, a touristic resort in north-eastern Morocco. Photo © M. Melhaoui.

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Reservoir, Ouezzane, Morocco. Photo © Gilles Jacquemin.

EXECUTIVE SUMMARY

Every day of our lives we benefit from what nature provides for us. The food we eat, the water we drink, the clothes we wear, even our mobile phones and computers have been manufactured with natural resources extracted from species and ecosystems that have played a major role in our success as a civilization. In technologically advanced societies this link to nature may seem distant and probably irrelevant, but it is there through complex supply chains, and we still depend on it. In many parts of the world people rely on the resources nature provides by using them directly, selling them or working in activities that exploit them. Even so, despite the innumerable services that nature provides, for centuries we have consumed these resources as if they were infinite, destroying habitats, putting thousands of species at risk and causing the extinction of many others.

Freshwater ecosystems contain a remarkable proportion of the world's biodiversity: they hold 9.5% of all known species, including a third of all vertebrates, even though they occupy less than 1% of the earth's surface. Despite the significance of freshwater biodiversity, it is one of the most threatened resources on earth. Nevertheless, people benefit from freshwater ecosystems all over the world. They use the water and plants, they gather fish, molluscs and crabs, they cultivate crops in their floodplains, or they use them for recreational activities. There is unanimous agreement in the scientific and conservation community that there is a need not only to protect freshwater ecosystems and their associated services, but to guarantee that people in barren rural areas have access to these resources in order to ensure their health and livelihoods without compromising the integrity of these supporting ecosystems. This project aims to assess the socio-economic value of freshwater species across the northern African region within the context of the threats to those species as previously determined and documented by the IUCN Red List of Threatened Species™.

Northern Africa is a place where the balance between the allocation of freshwater for human consumption and the protection of freshwater biodiversity is complex and at risk. Water resources in the region are already under great stress from the pressures exerted by a growing population, such as the increased demand for drinking water and water for agriculture. Water itself, however, is only one of many services that freshwater ecosystems provide. Freshwater ecosystems in northern Africa, like others throughout the world, also support species that are of direct socio-economic importance to local communities, providing products such as food, construction and craft materials, and medicines. However, freshwater species in northern Africa also face some of the highest levels of threat in continental Africa, with 28% of all fishes, molluscs, crabs, dragonflies and damselflies, and aquatic plants threatened with extinction.

IUCN has recognized the importance of integrating information on species conservation status with the socio-economic benefits they provide. The aim here is to link IUCN Red List data on the extinction risk for 877 species across northern Africa with information on these freshwater species' socio-economic value, and to evaluate levels of dependence on wetland services in conjunction with the known threats faced by the species underpinning these services. The results of this project have enabled us to identify species of high socio-economic importance and the threats to their long-term survival and sustainable use. Actions needed to ensure the future sustainable use of these resources are discussed. Such an integrated approach aims to greatly strengthen the body of evidence in support of the case for conserving wetland biodiversity. Nonetheless, species and ecosystems should not be protected just because they are useful to humans, but because biodiversity sustains all life on earth, including humankind.

The information presented here was collated through a combination of literature survey and email correspondence alone. It was outside the

scope of the project to draw directly upon the wealth of knowledge of individuals, such as would be possible through workshops. Therefore, when similar studies are attempted in future, we thoroughly recommend that regional workshops should be held to better access the wealth of additional information that could not be retrieved in this study.

GENERAL OUTCOMES

- Almost one-third (31.26%) of all the species included in this study provide direct socio-economic benefits to people in the northern African region.
- One in four (24.75%) of the utilized species are already at risk of extinction within the northern African region.

FRESHWATER FISHES

- Of the 128 freshwater fishes included in this study, at least 59 (46.09%) are of socio-economic value and utilized in northern Africa, and 99 (77.34%) are utilized in continental Africa. Twenty-two species of fish previously valued in fisheries are already Regionally Extinct.
- More than one-third (35.59%) of the 59 utilized freshwater fish species in northern Africa are threatened with regional extinction, including one endemic species, which is hence also globally threatened. The main threats are habitat loss and degradation due to human activities, which affect more than 60% of freshwater fish species.
- The most frequent uses of freshwater fish are for food (through inland fisheries or aquaculture), the ornamental fish trade and game fishing.
- At least 378,000 people in Egypt depend directly on activities related to the harvesting and/or farming of freshwater fishes, an activity that generated around USD 355.7 million in 2009.
- In the Maghreb countries, inland fisheries and aquaculture operate at a smaller scale than in Egypt but still provide an important input to the livelihoods of many thousands of people. Here, there are few freshwater fish species so there will potentially be fewer harvesting options if the species that are used are lost. A few species, such as the European Eel (Critically Endangered), are particularly important.
- Fish families with the largest numbers of utilized species are the Cichlidae (Cichlids), Cyprinidae (Barbs and Barbels) and Mochokidae (Catfishes).

Large Tilapia cages near Alexandria, Egypt. Photo © Graeme Macfadyen.

AQUATIC PLANTS

- Over a quarter (27.61%) of the freshwater plant species native to northern Africa are used directly by people in the region, and 70% of these species are collected from the wild.
- One in five (20.28%) of the 143 aquatic plant species used in northern Africa are threatened with regional extinction. The Rif mountain range and Mediterranean coast of Morocco, the area from the Kroumiria region in Algeria to the Sejenane region in Tunisia, and the Nile Delta area hold large numbers of threatened plants of socio-economic value.
- The five main uses of plants are: for medicines, as food for people, as ornamentals, for animal feed, and in the production of handicrafts and construction materials.
- Plant families with the highest numbers of utilized species are the Cyperaceae (Sedges) and Poaceae (Grasses), and those providing the highest socio-economic value in terms of the numbers of people involved and income generated are the Poaceae (Grasses), Juncaceae (Rushes), Lamiaceae (Mints) and Typhaceae (Bulrushes).
- Of the plants included in this study, 66% are Crop Wild Relatives (CWR); they are of clear value to people in that they provide the genetic base upon which many commercial crops depend.
- Further studies are required to complete an overall economic assessment of the socio-economic value of aquatic plants in northern Africa.

RECOMMENDATIONS

- Given the important role that aquatic plants and freshwater fish play in the lives of people in northern Africa, the protection and sustainable use of these resources must be taken into account in development plans through environmental impact assessments and integrated catchment management approaches.
- Local communities whose livelihoods depend on these resources should be encouraged and empowered to participate in conservation planning, and to develop or participate in sustainable harvesting and/or farming programmes and ecotourism.
- Priority areas for conservation identified through this project are those that hold a high proportion of threatened species of socio-economic value. These include the Lower Nile and Nile Delta, the Rif, Middle Atlas and High Atlas mountain ranges in Morocco, and the coastal mountain ranges of Algeria and Tunisia.
- Species identified as both under threat and of high socio-economic value should be prioritized for conservation initiatives aimed at minimizing or mitigating impacts on their habitats through integrated management initiatives at catchment and/or sub-catchment scale.

Sparganium erectum is listed as Near Threatened in the northern Africa region. Photo © M. Menand.

1 INTRODUCTION

Diego Juffe-Bignoli[1]

River system in Morocco. Photo © Jean-Pierre Boudot.

[1] Freshwater Biodiversity Unit, IUCN Global Species Programme, Cambridge, UK.

1.1. FRESHWATER ECOSYSTEMS: CONSERVATION STATUS AND SOCIO-ECONOMIC VALUE

Freshwater ecosystems contain a remarkable proportion of the world's biodiversity: they hold 9.5% of all known species, including a third of all vertebrates (Strayer & Dudgeon, 2010), even though they occupy less than 1% of the earth's surface. Despite the significance of freshwater biodiversity, it is one of the most threatened resources on earth (Dudgeon, 2010; Vörösmarty, et al., 2010). Based on those species groups that have been globally assessed, the IUCN Red List of Threatened Species™ reveals that a high proportion of freshwater-dependent species are either threatened or extinct (Thieme, et al., 2010) including 35% of amphibians, 46% of freshwater mammals and 38% of freshwater turtles. In continental Africa, one in five freshwater species (21%) is at risk of global extinction (Darwall, et al., 2011).

It is widely accepted that freshwater ecosystems, which include not only rivers, lakes, marshes and fens but also extensive rice fields and large deltas, provide a varied range of services to people, such as food, clean water, flood control and recreation opportunities, among many others (Millennium Ecosystem Assessment, 2005). Furthermore, access to clean water and sanitation is considered a fundamental human right by the United Nations (UN) and yet a significant proportion of the world's population (884 million) does not have access to improved sources of drinking water (WHO/UNICEF, 2010). This shortfall is predicted to become even greater because as global population, and therefore freshwater demand, rises the quantity and quality of freshwater remains limited and simply may not meet demand in the future.

Drinking water is not the only service provided by freshwater ecosystems. The classical view of services provided by wetlands is well known among the conservation community (Figure 1.1) but it has been historically ignored by governments and decision makers, with the result that exploitation of wetland habitats has led to irreversibly degraded conditions or conversion to alternative uses. Nevertheless, people benefit from freshwater ecosystems all over the world. They use the water and plants, and they gather fish, molluscs and crabs, to name just a few of the many wetland products. These are provisioning services and are the main focus of this report. Freshwater ecosystems may also provide other, less obviously quantifiable services such as climate regulation, water purification and detoxification of wastes, climate change mitigation and cultural services. For example, the cultural and spiritual values of wetlands are sometimes difficult to quantify but can play an important role in local livelihoods, especially in remote and pristine areas where tourism might take place. People in the United States are reported to spend USD 24–37 billion each year on tourism activities related to recreational fishing (Millennium Ecosystem Assessment, 2005). Even if not tourism related, non-quantifiable religious or spiritual values of wetlands can be equally important, and this is not restricted to developing countries. For example, freshwater ecosystems in the Doñana National

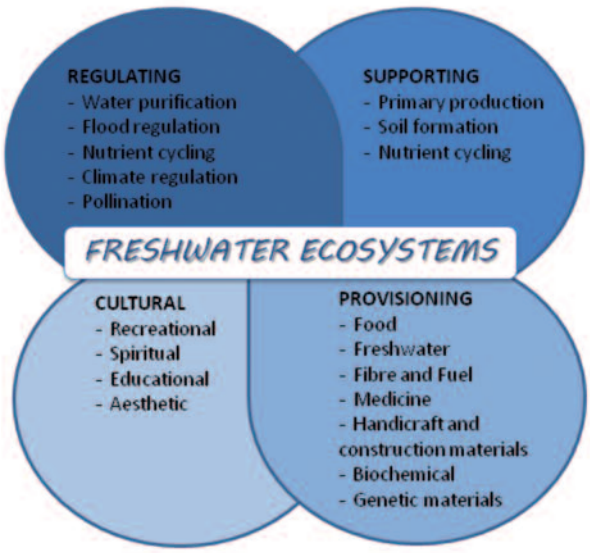

Figure 1.1. Ecosystem services provided by freshwater ecosystems (adapted from Millennium Ecosystem Assessment, 2005).

Park in Spain play a key role in the Pilgrimages of the Virgen del Rocío. This is a centuries-old religious and cultural event of regional significance in Spain, which still involves hundreds of thousands of people and usually becomes a major media event each year (Papayannis, 2008).

What is the role of species in the services that freshwater ecosystems provide? In addition to the evident provisioning services described above, freshwater species underpin all other services as ecosystem function depends upon the functional characteristics of these species and their distribution and abundance over space and time (Hooper, et al., 2005). Balvanera et al. (2006) aimed to quantify the effects of biodiversity on ecosystem functioning by carrying out a meta-analysis of studies over a 50-year period (1954–2004). They concluded that biodiversity had positive effects on most of the ecosystem services studied but they stress that further research is necessary to confirm the nature of these relationships. This is particularly true for freshwater biodiversity where, even though the links between biodiversity and ecosystem functioning seem evident to scientists and practitioners, the way these links function and the effects of biodiversity loss on them is still unclear (Dudgeon, 2010). Nonetheless, the understanding of these links is a vital area of research for informing the sustainable management of natural resources, and most authors recommend taking a precautionary approach in which the importance of biodiversity to ecosystem service provision is assumed.

The social and economic benefits of freshwater systems and their species are also well known and there are many examples available in the literature. Economic valuation of freshwater ecosystems has been widely acknowledged as an essential step towards well-informed planning and decision making (De Groot, et al., 2006). A classic study is the economic valuation of wetlands in the Zambezi River basin (Turpie, et al., 1999), a vast and diverse hydrological system covering more than 1.38 million km2 in eight countries and sustaining the livelihoods of nearly 30 million people across southern Africa (SADC, 2008). The study covered four large areas in the region (Barotse Floodplain, Caprivi–Chobe Wetlands, Lower Shire Wetlands and Zambezi Delta), and assessed the value of wetland resources by focusing on many aspects of the livelihoods of local communities. Results showed that the contribution of wetlands was essential to people's livelihoods, as all the wetland communities made use of fish, wild animals, palms, grasses, reeds, papyrus *(Cyperus papyrus)* and food plants. Plant use, including the value added through production of mats and baskets, had a total economic value of between USD 436,000 and 2.8 million. Fish provided between 13 and 43% of total income and in all areas this resource was more important than cattle or crops in terms of total and relative income. Inland fisheries are in fact an important component of the livelihoods of hundreds of thousands of people in Africa. Neiland and Béné (2003) carried out a review of fisheries valuation in the major river basins of West and Central Africa. They revealed that the total potential annual fisheries production for all the river basins in West and Central Africa is 1.34 million tonnes, with a potential annual value of USD 749 million and employing around 227,000 fishers. The contribution of freshwater ecosystems and species to local livelihoods in Africa and northern Africa will be explored in further chapters of this report.

Freshwater ecosystems are highly significant in developing countries. Hundreds of thousands of people depend on freshwater species and ecosystems in rural and poor communities. Béné et al. (2010) established that 56 million people are directly involved in inland small-scale fisheries in the developing world, and that small-scale fisheries are a vital source of nutrition and income for a large part of the rural population living near freshwater bodies in sub-Saharan Africa. This does not include large-scale fisheries or the harvest of other wetland resources such as water, plants, crabs or molluscs, which are also important for many thousands of people across Africa. Local communities in Africa rely not just on natural resources but also on wetland agriculture and, as

the population in Africa is predicted to grow, pressures on these resources are very likely to increase (Darwall, et al., 2011). As agricultural development and direct resource use increase, the capacity of wetlands to sustain the wide range of ecosystem services they currently provide may be compromised (Rebelo, et al., 2009).

It should not be ignored that in some cases the unsustainable use of freshwater resources may be implicated as a significant cause of species extinction. Such over-exploitation is generally associated with a number of more complex issues. For example, the real cause of the decline of the Critically Endangered European Eel, *Anguilla anguilla*, endemic to the Mediterranean and Europe, is not well understood. Threats to this species include over-harvesting but in combination with many other anthropogenic activities, such as water over-abstraction, water pollution and dam construction. These have simultaneously degraded and destroyed the habitat, increased species mortality levels, and rendered the Eel unable to complete its life cycle. The story of this species is dealt with in Chapter 3 (Case study 3.1: European Eel).

Given the importance of freshwater ecosystems to people and the high level of threat to the species supporting these ecosystems, there is an urgent need to protect them and their associated services, and to guarantee that people in poor rural areas have continued access to these resources to ensure their health and livelihoods without compromising the integrity of the ecosystem. This is not an easy task. To achieve this goal the conservation status of freshwater biodiversity needs to be assessed, the ways in which these freshwater systems provide their services needs to be understood, the socio-economic value of freshwater systems needs to be determined, and finally resources need to be allocated in a sustainable manner. Red List status has already been assessed for 877 species across northern Africa (García, et al., 2010). This project now aims to integrate these assessments with newly collated information on the socio-economic value of these freshwater species. We will subsequently be able to evaluate levels of dependence upon wetland services in conjunction with the known threats faced by the species underpinning these services. Actions needed to ensure the future sustainable use of these resources can then be developed. Such an integrated approach aims to greatly strengthen the body of evidence for the importance of conserving wetland biodiversity.

1.2. SITUATION ANALYSIS FOR THE NORTHERN AFRICAN REGION

The northern African region (NAR) is a place where the balance between the allocation of freshwater for human consumption and the protection of freshwater biodiversity is complex and at risk. Water resources in the region are already under great stress from the pressures exerted by a growing population, such as the increased demand for drinking water and water for agriculture. As pointed out above, drinking water itself is not the only service that freshwater ecosystems provide (see Figure 1.1). It is likely that freshwater ecosystems in northern Africa, like others throughout the world, also include species of socio-economic importance to local communities and national economies, providing food, construction and craft materials, and medicines. Several studies in the region already confirm this (e.g. Benessaiah, 1998; Khattabi, 1997; Khattabi, 2006).

The northern Africa Freshwater Biodiversity Assessment (García, et al., 2010) was carried out between 2007 and 2009 and involved several workshops and thorough data compilation in order to assess the conservation status and map the distributions of freshwater species in the region. The project assessed the conservation status of all fishes, crabs, odonates (dragonflies and damselflies) and molluscs and a selected number of plants, making a total of 877 species. The assessment was part of a larger six-year project that aimed to assess the status of freshwater biodiversity throughout continental Africa. This involved dividing the continent into six regions and

conducting similar assessments in each one. The regional reports on western Africa (Smith, et al., 2009), eastern Africa (Darwall, et al., 2005), central Africa (Brooks, et al., 2011), southern Africa (Darwall, et al., 2009) and northern Africa (García, et al., 2010) are freely available online. The north-eastern African assessment was completed but has not been published in report form. The main results of the five reports and of all the species assessments are also available through the IUCN Red List website (www.iucnredlist.org). A final collation of all data from these regional assessments resulted in the Pan Africa report (Darwall, et al., 2011), which summarizes the findings and assesses the conservation status of all species at the level of continental Africa. Overall, the Pan Africa biodiversity assessment involved the work of more than 200 scientists and Red List specialists, who assessed some 5,000 freshwater species.

Freshwater species in northern Africa are among the most threatened in the world. The northern Africa Freshwater Biodiversity Assessment revealed that 28% of all species assessed are threatened with extinction, 9% are Near Threatened and 14% are Data Deficient. This means that half of the freshwater species in the NAR are either at risk of extinction (classified by IUCN as Threatened species), are very close to meeting the thresholds (Near Threatened species), or there is not enough information available to determine whether the species are at risk or not (Data Deficient species). Several freshwater ecoregions of northern Africa are of conservation concern and were identified as priorities for conservation by Thieme et al. (2005) (Figure 1.2). Both the Permanent Maghreb region and the Nile Delta were regarded as Critical (Table 1.1). The main threats identified in the Permanent Maghreb region, for example, were the sensitivity of freshwater habitats to the effects of invasive species, water over-abstraction, overgrazing, tourism, urbanization and infrastructure development, with overall water scarcity of primary concern. In the Nile Delta, wetlands have lost more than 50% of their original area in the past century due to land reclamation for agriculture, sedimentation and erosion.

Table 1.1 Freshwater ecoregions in northern Africa—some relevant figures

Freshwater ecoregion	Conservation status	Biological distinctiveness	Priority class
Permanent Maghreb[1]	Critical	Globally outstanding	I
Nile Delta	Critical	Nationally important	IV
Lower Nile	Vulnerable	Nationally important	V
Red Sea Coastal[2]	Vulnerable	Bioregionally outstanding	V
Temporary Maghreb[3]	Relatively stable	Continentally outstanding	III
Dry Sahel	Relatively intact	Nationally important	V

Source: Thieme, et al., 2005. The latest version of Freshwater Ecoregions is available in Abell, et al. (2008).

[1] Recently divided into two ecoregions: Atlantic Northwest Africa and Mediterranean Northwest Africa.
[2] Recently renamed Western Red Sea Drainages.
[3] Recently renamed Sahara.

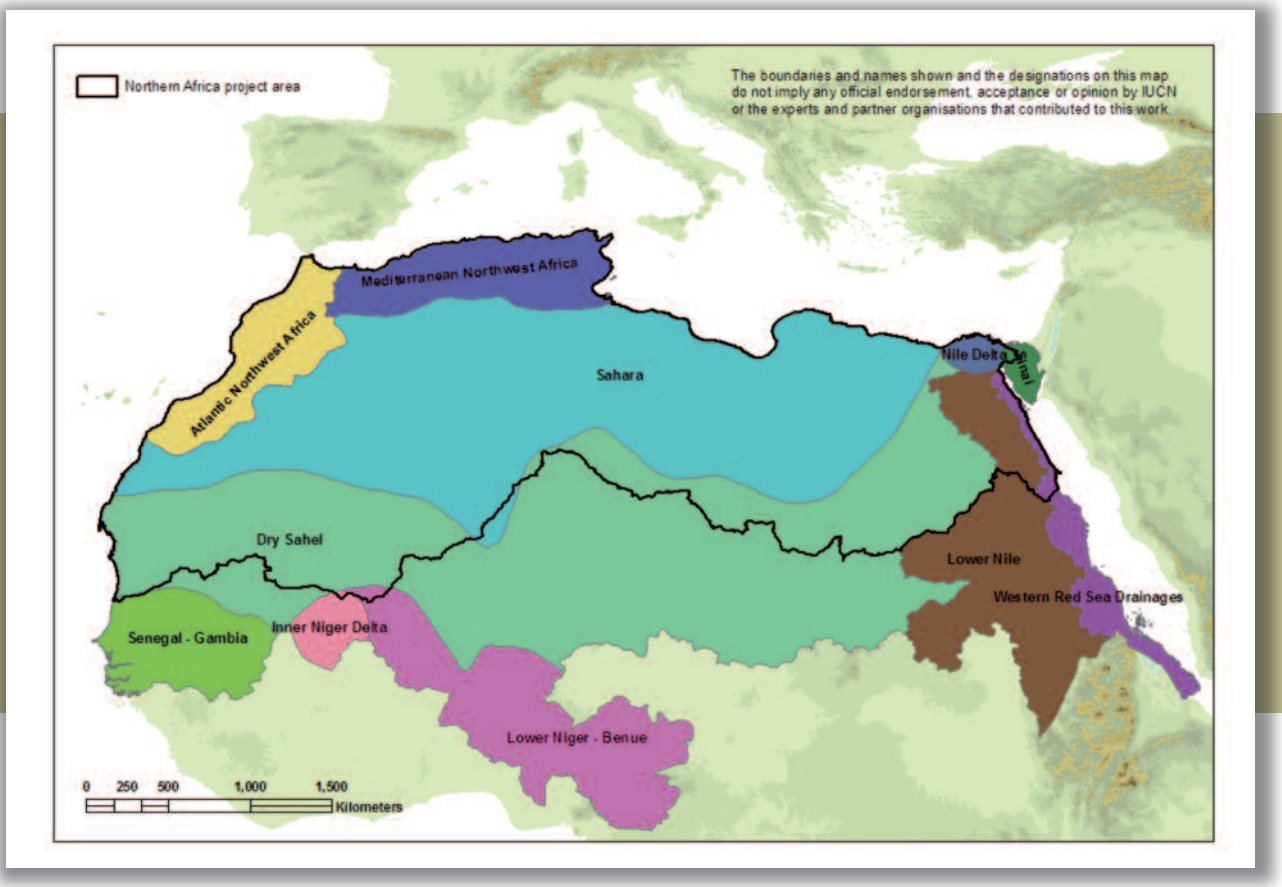

Figure 1.2. Freshwater ecoregions in northern Africa (from Abell, et al., 2008).

1.3. OBJECTIVES OF THE STUDY

In recognition of the value of integrating information on both the conservation status of species and their socio-economic benefits, IUCN is now collating information on their livelihood value in conjunction with existing data on their extinction risk held in the IUCN Red List. The extinction of species of socio-economic importance is a double loss: a loss of biological diversity and the loss of a natural resource on which humankind depends. As outlined above, freshwater species in northern Africa are among the most threatened on the continent and yet the importance of these species to the livelihoods of thousands of people is not fully understood. This project aims to fill in this information gap through a process of data compilation and expert consultation and the subsequent integration of the findings with existing information on species conservation status as held in the IUCN Red List. **This will enable us to identify those species that are both threatened and of high socio-economic importance.** It will also allow us to determine and report on the overall socio-economic value of freshwater species throughout the region.

The aim of this study is therefore to assess the socio-economic value of all the freshwater fish and plant species previously assessed for the northern Africa Freshwater Biodiversity Assessment and to associate this value with their regional and global conservation status.

2 METHODOLOGY

Diego Juffe-Bignoli[1]

The Siwa Oasis in Egypt. Photo © K evin Smith

[1] Freshwater Biodiversity Unit, IUCN Global Species Programme, Cambridge, UK.

In this section we describe how data on the use of and trade in species were compiled, the geographical scope of the project, and methods for the assessment of socio-economic value. Further information on the species selection criteria and species assessment mapping methodologies is available in García, et al. (2010).

2.1. ASSESSMENT OF THE CONSERVATION STATUS OF NORTHERN AFRICAN FRESHWATER SPECIES

The conservation status of each species was assessed during the northern Africa Freshwater Biodiversity Assessment (García, et al., 2010). The assessments were carried out according to the 2001 IUCN Red List Categories and Criteria: Version 3.1 (IUCN, 2001) and followed the Guidelines for Application of IUCN Red List Criteria at Regional Levels (IUCN, 2003). Species were listed within one of the 11 regional categories, ranging from species that are not at immediate risk of extinction, classed as Least Concern, to species that are Regionally or Globally Extinct (EX) (Figure 2.1).

The raised index mark^{RG} is used to indicate regional categories of threat. For example, the species Alestes dentex VU^{RG} is globally listed as Least Concern (LC) but is considered Vulnerable across its range in northern Africa. For all regionally endemic species, such as the Critically Endangered *Aphanius saourensis*, regional and global conservation status are the same.

2.2. DATA COMPILATION

During the northern Africa Freshwater Biodiversity Assessment, in addition to the information needed to

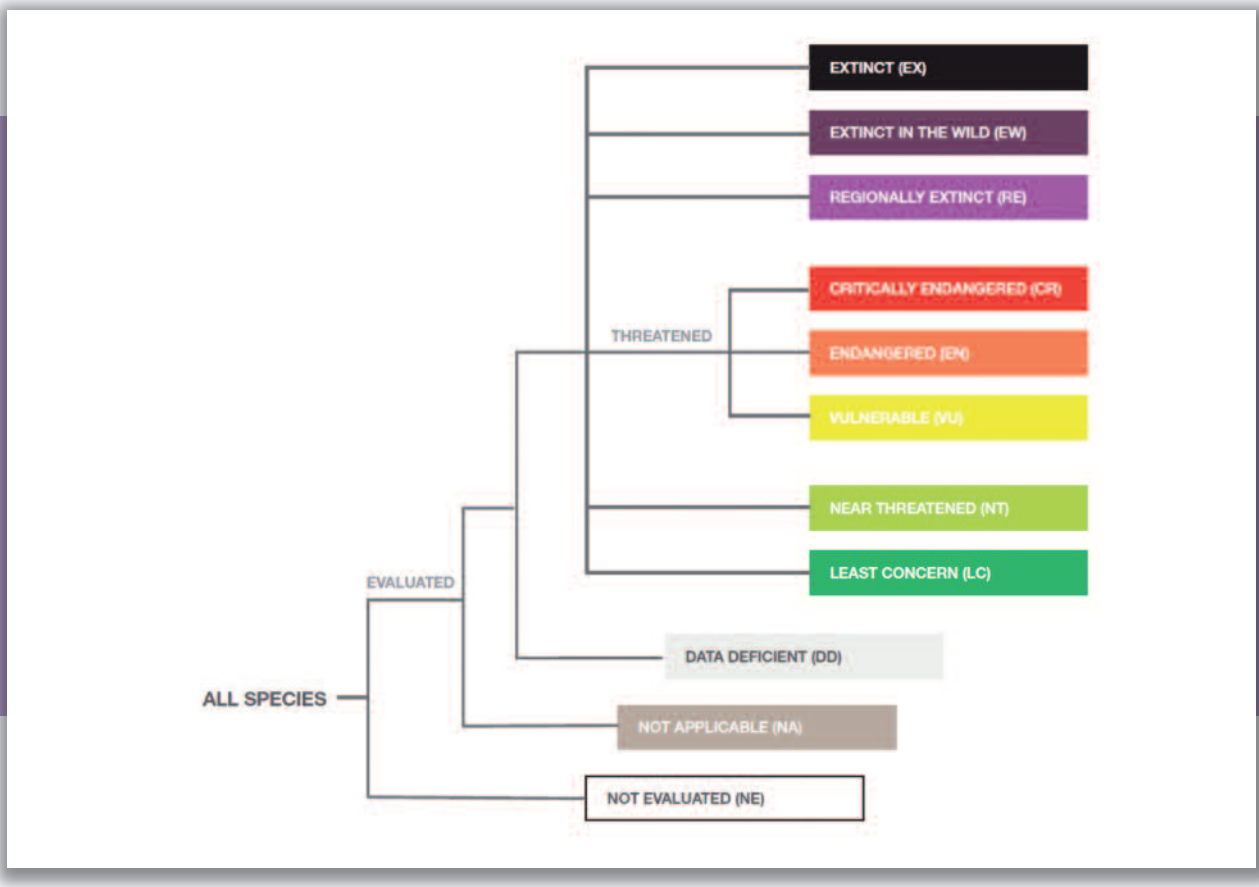

Figure 2.1. IUCN Red List Categories at the regional level (IUCN, 2003).

assess species extinction risk (distribution, population and population trends, habitats, threats, etc.), data on the utilization of species across the region were also compiled. This was not done systematically as the primary aim of the workshops was to assess the conservation status of the species. Nevertheless, the information that was collected is valuable and provides an excellent starting point for the current study on the socio-economic importance of freshwater species in the region.

First, the list of assessed species was revised to update any taxonomic changes and to include information on any new species. Freshwater fish and aquatic plant definitions were as given by García, et al. (2010). Information on the use and economic value of these species was then compiled from that obtained through the five regional assessments and the final Pan Africa assessment, all carried out between 2005 and 2010. In a third step, new data were gathered through desk-based literature research and consultation of regional experts via email. More than 40 experts on northern African freshwater plants and fishes and conservation professionals involved in the utilization of species were invited via email to contribute to the project by supplying published and in-press studies, unpublished surveys and local knowledge. The IUCN–SSC Medicinal Plant Specialist Group and the IUCN–SSC Crop Wild Relative Specialist Group were contacted to provide relevant information from their own databases.

For each of these species information was gathered, where possible, on:

- **USE:** types of use, where the species is used and by whom, and whether it is harvested from the wild and/or cultivated;
- **VALUE:** whether the species is valued as a subsistence resource and/or is traded at local, national and/or international levels; information on the monetary value of species was also collected where available;
- **LIVELIHOOD IMPORTANCE:** the importance of the species to the livelihoods of local communities, including, for example, the numbers and identity of people depending on it;
- **LEVEL OF THREAT:** the existing IUCN Red List status of the species.

Information on the first three categories above was combined with existing data on the level of threat to each species. It was then possible to determine the number of species considered to be of socio-economic value, the places where they are used, the spatial relationships between used species, and their conservation status, with a focus on those species identified as being both threatened and of high socio-economic importance. Finally, these results revealed the overall importance of freshwater ecosystems to the livelihoods of northern African people.

Data were collected in a custom-designed Access database with the aim of later migrating these data into the Species Information Service database (SIS), which is used to manage the information contained in the IUCN Red List, thus bringing together information on species' conservation status and socio-economic value. The project database holds information on the utilization, trade and livelihood importance of any species which has also had its conservation status assessed for the IUCN Red List. This information will be combined with that on species conservation status within SIS. Information within SIS is made freely and widely available to conservation decision makers, scientists and educators through the IUCN Red List website.

The spatial data used in this project were extracted from the geodatabase generated during the northern Africa Freshwater Biodiversity Assessment (García, et al., 2010) and the aquatic plants of the Mediterranean basin regional biodiversity assessment (IUCN, 2010).

2.3. GEOGRAPHICAL SCOPE

The countries included in this study are those that lie within the geographical area covered by the

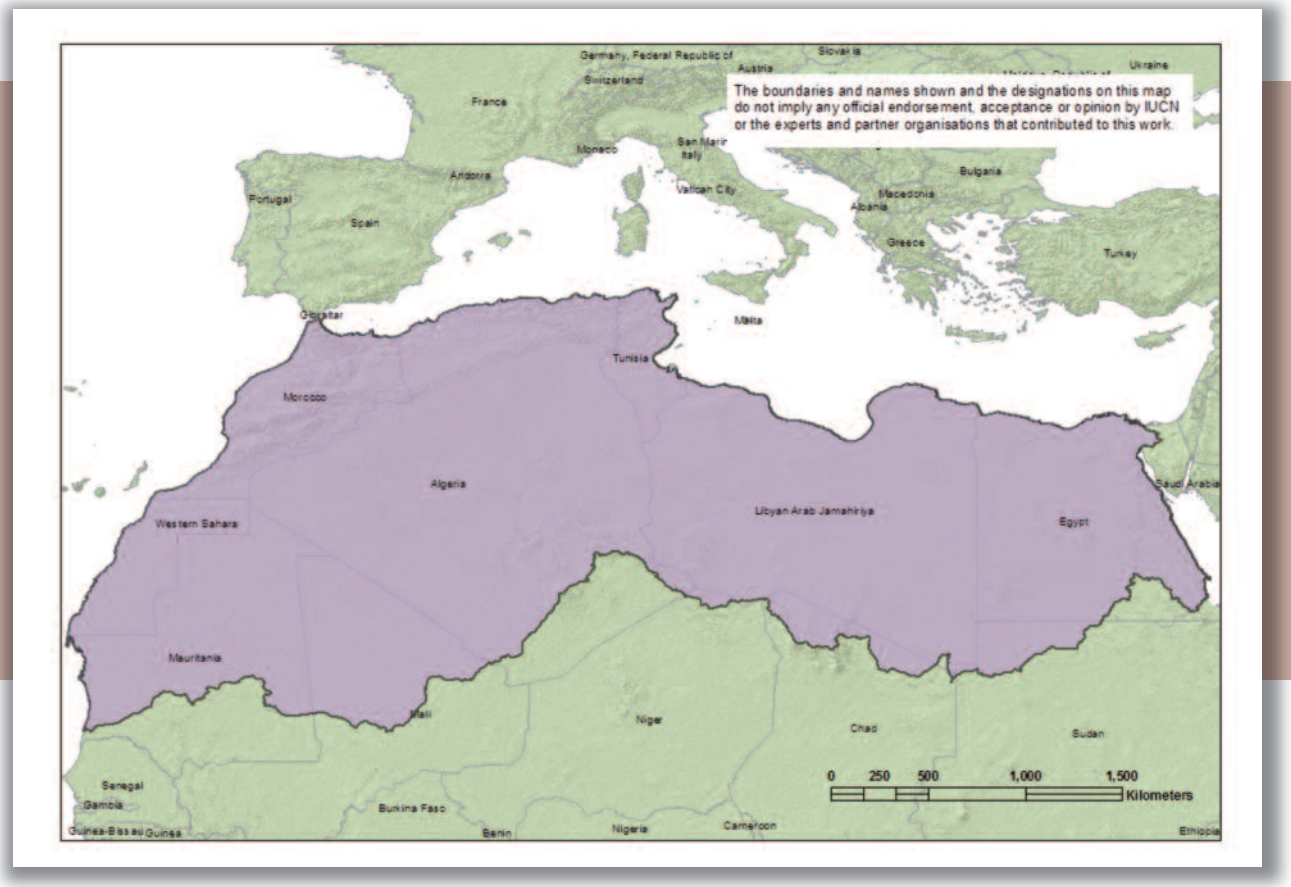

Figure 2.2. Northern Africa assessment area (source: IUCN Freshwater Biodiversity Unit).

northern Africa Freshwater Biodiversity Assessment (García, et al., 2010), focusing mainly on Algeria, Egypt (downstream of the Aswan Dam), Libya, Morocco and Tunisia (Figure 2.2). The area covered by Lake Nasser within Egypt and upstream of the Aswan dam has been excluded in order to be consistent with the geographical range over which these species were originally assessed. However, given the large amount of available data on fisheries within this immense reservoir, we occasionally refer to information for this area.

Some species not known to be used in northern Africa may in fact be used in other African countries. Where this is the case, this information is also recorded and the species is recognized to be of potential socio-economic value within the project region. This is important as a species may: i) be used in northern Africa but its use has not been recorded, and/or ii) have potential value for future use. Consequently, the use of sub-Saharan species is also mentioned in the results, where such information is available.

2.4. SPATIAL ANALYSIS

Spatial analysis was carried out using ArcGiS software developed by ESRI. The minimum planning units used for mapping and analysing freshwater species distributions and use were modified HYDRO1K river catchments (Figure 2.3). The HYDRO1K Elevation Derivative Database at the highest level of resolution (Level 6) was developed by the United States Geological Survey's EROS Center. This dataset aims to provide detailed global topographic information on streams, rivers and drainage basins for use in continental- and regional-scale modelling and analyses (USGS EROS, 2011). HYDRO1K

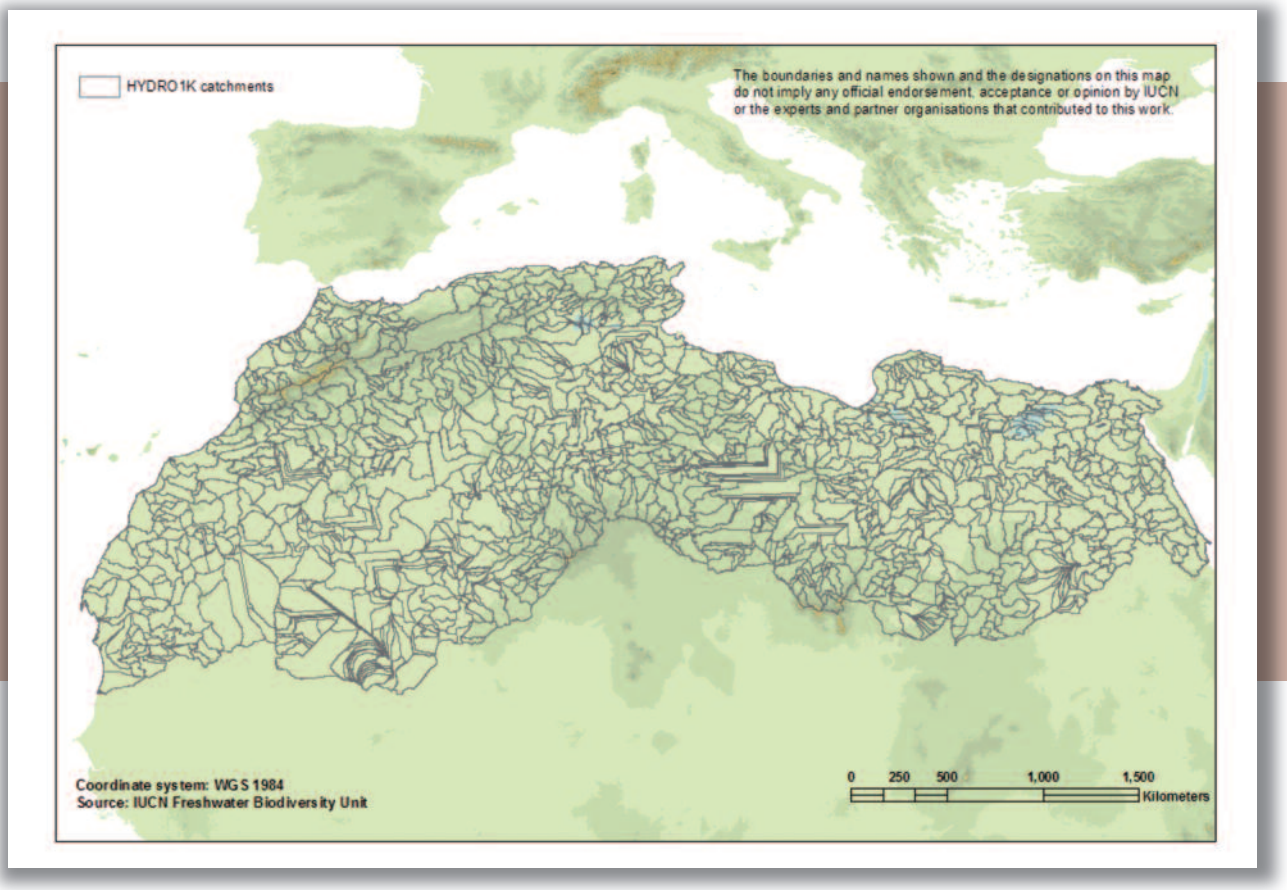

Figure 2.3. HYDRO1K catchments in the northern African region.

catchments were chosen as it is generally accepted that the river/lake basin or catchment is the most appropriate management unit for inland waters. It is recognized that a species may be not utilized in all parts of its river sub-catchment, but until finer-scale spatial detail becomes available each species is assumed to be used throughout its distribution range. For more information about the methodology followed for mapping species distributions, see García et al. (2010).

2.5. USE AND LIVELIHOOD VALUE

When should a species be considered of socio-economic value? The most obvious answer would be: when it is exploited for some kind of economic, social or cultural activity that benefits people in any aspect of their daily lives. However, this only takes account of the direct use and current value of the species. The picture is much broader than that. Barbier (1993) set out a methodological framework proposing a number of different methods for valuing wetland benefits, which then inspired other models all based on the same basic concepts that can also be applied to species. Figure 2.4 shows a schematic of the total economic value of wetlands, including information on how the various component values relate to ecosystem services.

Only the direct use value of species was recorded for this report. This is recognized to represent only a small, more readily quantified component of the overall ecosystem services provided by wetlands (see Figure 2.4). Nonetheless, information on direct use values of species will help to demonstrate the great importance of wetland species to many people dependent on them. A species was initially considered to have direct

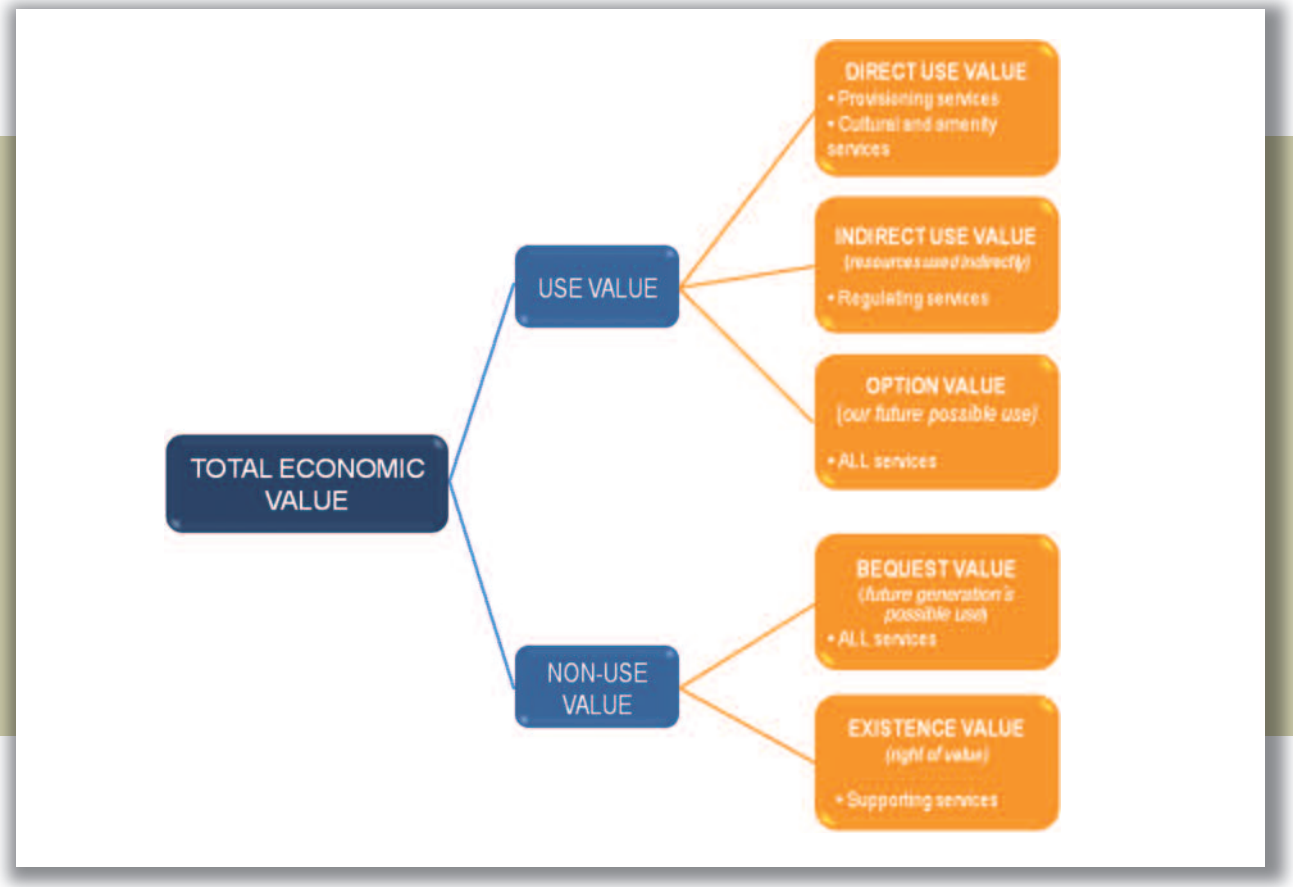

Figure 2.4. Total economic value of wetlands and ecosystem services involved (adapted from De Groot, et al., 2006).

socio-economic value if the IUCN Red Listing process had recorded it as being used in some way. This initial information set was then further developed and expanded by means of the literature search and expert consultation conducted under this project. A species is therefore considered to be of socio-economic value when it has been reported as being utilized in some way. This can be any kind of direct use, including as medicine, food, animal feed, handicraft or construction material, or for extraction of chemicals for industries, ornamental use, etc.

3 THE SOCIO-ECONOMIC VALUE OF FRESHWATER FISH

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European Eel in Venice Fish Market, November 2010. Photo © Mats Forslund, WWF-SE.

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In the following sections the socio-economic value of freshwater fish in the northern African region (NAR) will be assessed. First, the conservation status of freshwater fish in the region is outlined (Section 3.1). Then, the socio-economic importance of freshwater fishes in the area is analysed, showing which species are used, how are they used and where they are collected, and focusing on the most common uses and the most important freshwater fish species and families (Section 3.2). Section 3.3 examines the importance of freshwater fishes in people's livelihoods. Patterns of distribution of utilized and threatened species and the threats to those species are described in Section 3.4. Section 3.5 deals with threats to species of socio-economic value. Lastly, some final conclusions are presented (Section 3.6).

3.1. CONSERVATION STATUS OF FRESHWATER FISH SPECIES

A total of 128 freshwater fish species and subspecies were included in this study, accounting for all those known to occur in northern Africa at the time of completion of the original northern Africa Freshwater Biodiversity Assessment (see Section 1.2 for further details of this project). All species were assessed to determine their regional risk of extinction within northern Africa except for *Oreochromis niloticus*, the Nile Tilapia, assessed as Least Concern (LC) in continental Africa. One species, *Arius lasciatus*, was excluded from the analysis as it is not considered to be a freshwater species. With the exception of the European Eel (*Anguilla anguilla*) all the species included in this study are endemic to continental Africa.

Threatened species account for 27.6% of all species assessed at a regional level and 31.3% of all freshwater fishes endemic to northern Africa (for the latter group of species the assessment represents their global status) (Table 3.1). This level of threat is considered high as it is above the proportion of threatened fish listed for continental Africa at both regional (21.8%) and global (22%) scales (Darwall, et al., 2011). It is the highest level in all the regional assessments, the next highest threat levels being recorded in eastern Africa, where 26.7% of the regionally assessed species and 27.7% of the endemics are threatened with extinction (Darwall, et al., 2005).

Table 3.1 Number of freshwater fish in each regional Red List Category in the northern African region

IUCN Red List Category	All Fishes	%	Endemics	%	
Extinct (EX)	1	0.8%	1	3.1%	
Regionally Extinct (RE)	23	18.1%	0	0%	
Critically Endangered (CR)	1	0.8%	1	3.1%	Threatened categories
Endangered (EN)	8	6.3%	2	6.3%	
Vulnerable (VU)	26	20.5%	7	21.9%	
Near Threatened (NT)	2	1.6%	2	6.3%	
Least Concern (LC)	26	20.3%	11	34.4%	
Data Deficient (DD)	41	31.5%	8	25.0%	
Total number assessed	**127**[1]	**100%**	**32**	**100%**	

[1] This table does not include *Oreochromis niloticus*, the Nile Tilapia, as it has not been assessed at a regional level in northern Africa. This species has been listed as Least Concern in continental Africa. However, given the key socio-economic value of this species, it is included in this study.

A total of 23 freshwater fish species were listed as Regionally Extinct (RE), one as Extinct (EX) and 41 as Data Deficient (DD), together accounting for 51.1% of all species assessed. Thus half of the species native to northern Africa are either already extinct in the region or there are insufficient data to assess their current risk of extinction. In view of these figures, freshwater fish in northern Africa are clearly not only among the most threatened on the African continent but have already suffered important losses in diversity. Threats to species of socio-economic value are discussed in Section 3.5.

3.2. SOCIO-ECONOMIC VALUE

Ninety-nine species (77.3%) of freshwater fish native to the NAR are of socio-economic value to people across continental Africa, according to the definition in Section 2.5. Of these, 59 species are known to be used in the NAR, which represents 46% of the freshwater fish included in this study. The difference between the number of species used throughout Africa and the number used in northern Africa is accounted for by: i) the fact that 22 of the 23 Regionally Extinct species, which are therefore no longer available for harvesting within the NAR, are still harvested in sub-Saharan Africa, and ii) the selective use of some species in sub-Saharan Africa but not in northern Africa. The study also revealed that 11 (25%) of northern African endemic fishes are used by people in the region.

The two main end uses of freshwater fish are for food and for the ornamental fish trade (Figure 3.1). Aquaculture and game fishing are the third and fourth most frequently recorded uses. Other reported uses are as fishing bait, for research and as ornamental species in public aquaria or ponds. The source of the fish (captured in the wild or bred in captivity) was recorded for each of four end use categories (Figure 3.2). To correctly interpret the data in Figures 3.1 and 3.2, it must be understood that a single species may be sourced both from the wild and from captive breeding and also used for several purposes. For example, many fishes from the Cichlidae family are both caught in the wild and raised in fish farms. Species such as *Oreochromis niloticus* (LC), *Oreochromis aureus* (LC^{RG}) or *Tilapia zillii* (LC^{RG}) are captured by local fishermen in the Nile River and certain lakes in northern Egypt and sold to the markets, and they are also raised in fish farms to be sold for food. Other species such as *Barbus callensis* may be caught

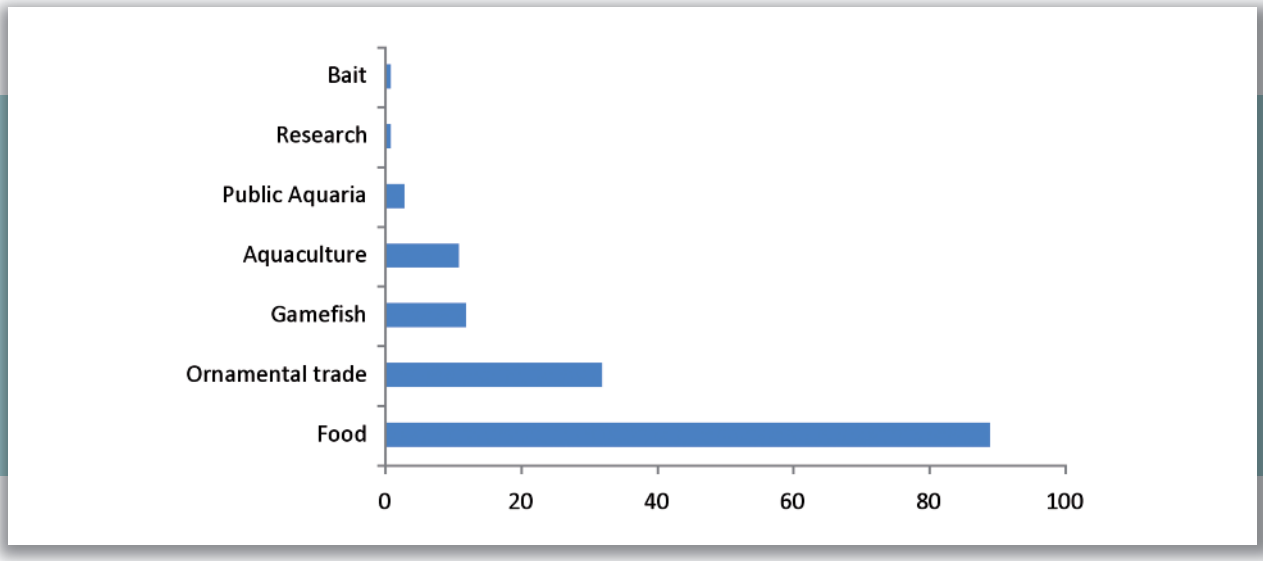

Figure 3.1. Number of species used for each recorded purpose (source: IUCN Freshwater Biodiversity Unit). Note that a single species might have several recorded uses.

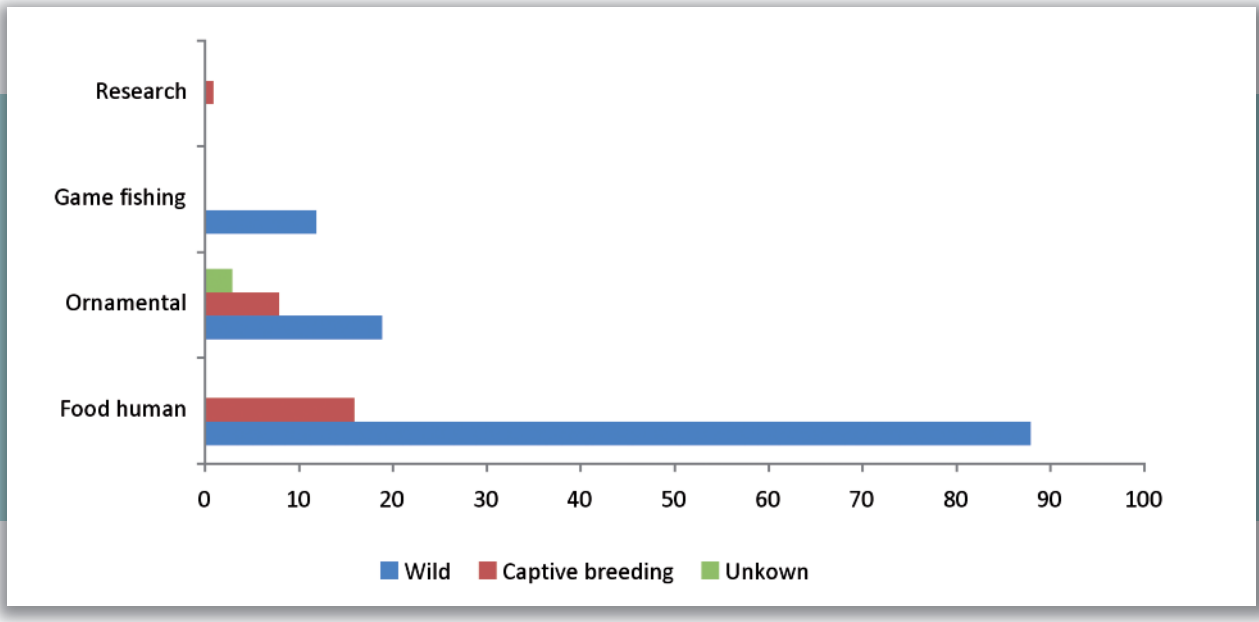

Figure 3.2. Origin of the resource for four major end uses of fish (source: IUCN Freshwater Biodiversity Unit). Note that a single species might be sourced from the wild or from captive breeding and also used for several purposes.

by local fishermen in Tunisia and Algeria and are also raised in captivity for the international aquarium trade. The European Eel (*Anguilla anguilla* EN[RG]) is a threatened species that is of high commercial value. Both the elvers (juvenile eels) and adults are collected by local fishermen. As the captive breeding of Eels is still in its early stages (PRO-EEL, 2011), the industry relies on the harvest of elvers, which are either processed for food (considered a delicacy) or raised in captivity to be sold as adults for food (see Case study 3.1).

Most freshwater fish, in terms of the number of species used for food (consumed directly by local people and/or sold in the markets) are sourced from the wild. It is important to stress that, except in poor and remote areas of Algeria, Morocco and Tunisia, fish are normally harvested by professional fishermen and traded in local or national markets. The aim of these fisheries is to obtain money from a harvested crop but part of the catch may be directly consumed in fishermen's households. Species that are grown for food in fish farms (aquaculture), although fewer in number, are of high socio-economic value as will be discussed in Section 3.2.3—these include several species of *Oreochromis* and Catfish (e.g. *Clarias gariepinus* LC[RG]) and the African Bonytongue (*Heterotis niloticus* RE[RG]).

This study also determined if a species is used primarily for subsistence, and whether it is traded locally, or is of national or international commercial value. A species may be valued locally and found in local markets but also traded internationally for the aquarium trade. *Micralestes acutidens* (RE[RG]), for example, is found in the international aquarium trade and is also used in the Nile Basin as bait to catch the Tiger Fish (*Hydrocynus vittatus* DD[RG]). **Results show that most utilized species have subsistence and local economic value (90% and 86% respectively) and that 71% of species that are used are traded at a national level while one quarter (25%) are traded internationally**, the latter being mostly ornamental species (see Section 2.2.2).

Nearly all fish families have at least one species that is used in the region. Five families have a higher number of utilized species and are considered of high socio-economic value (Figure 3.3). These are Cyprinidae (Cyprinids), Cichlidae (Cichlids), Mochokidae (Catfishes), Mormyridae and Alestidae (Tetras).

Cyprinidae is the family with the highest number of species utilized in the NAR. It also comprises the greatest number of species. Of the 34 species of Cyprinids known in northern Africa, at least 16 are used, including four species endemic to the Maghreb countries (*Barbus callensis* LC[RG], *Barbus figuiguensis* LC[RG], *Barbus moulouyensis* LC[RG] and *Barbus nasus* NT[RG]). These may not be highly productive species but can be an important source of protein for people in remote rural areas where livelihood strategies are based on several sources of food, of which these fish are one. One example is the Algerian Barb (*Barbus callensis*), which is endemic to the NAR and has been assessed as Least Concern. It is commonly present in reservoirs, small lakes and rivers in these countries, where, although not a primary source of food, it represents one of several food options for people in rural communities.

Cichlidae is probably the most important family from a socio-economic point of view. It includes globally important species used as a source of food, for the ornamental trade or for aquaculture production. There are only two species for which a use has not been recorded (*Tilapia ismailiaensis* and *Oreochromis ismailiaensis*); both are listed as Data Deficient mainly due to taxonomic uncertainties and they possibly represent the same

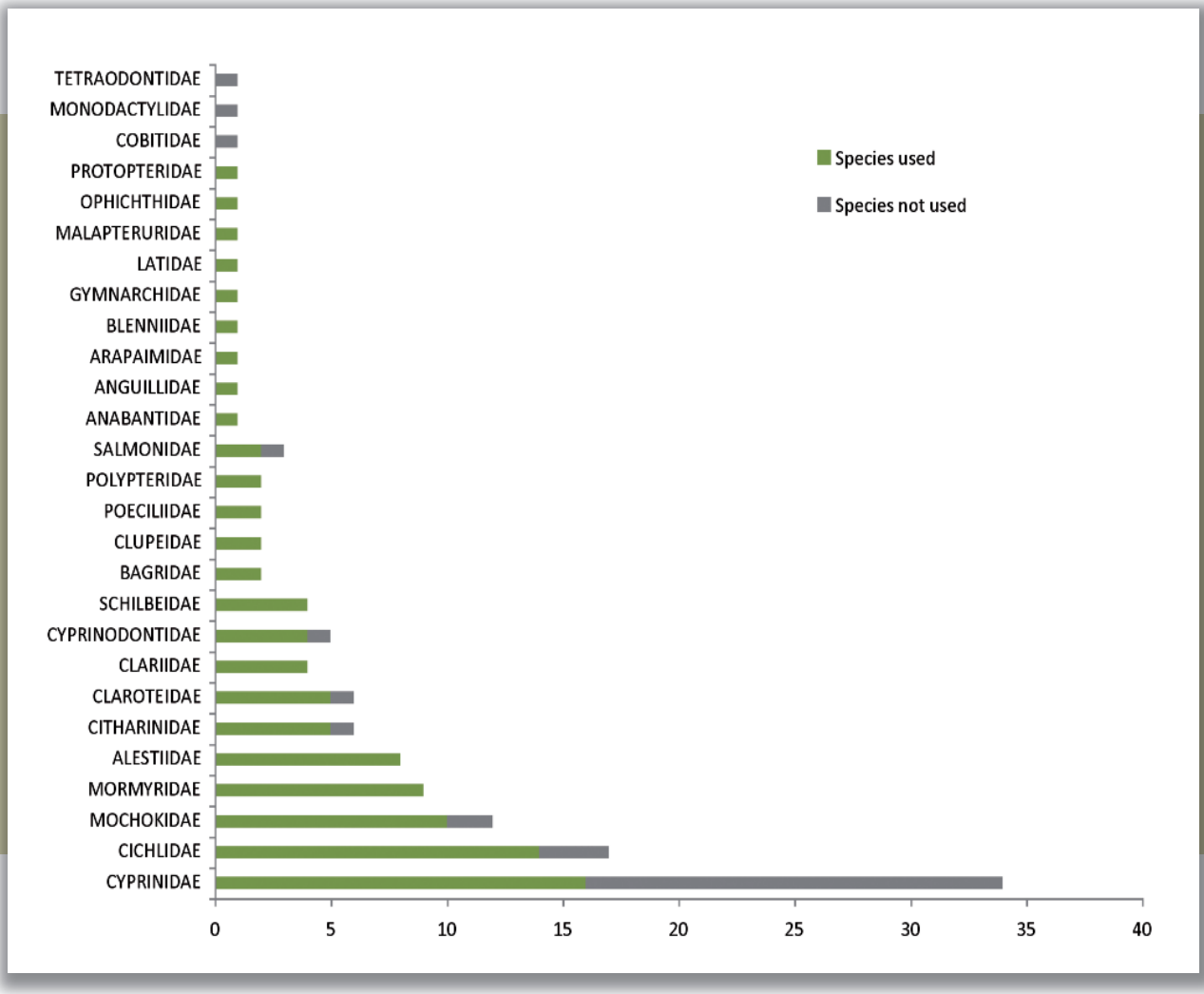

Figure 3.3. Number of species used in each freshwater fish family (source: IUCN Freshwater Biodiversity Unit).

species. Most species in this family have two or three uses. For example, *Astatotilapia bloyeti* VU[RG], *Hemichromis bimaculatus* EN[RG], Tilapia guineensis DD[RG] and Sarotherodon melanotheron melanotheron DD[RG] are all used as a source of food, for the aquarium trade and for aquaculture. The family includes the group known as Tilapias of which the Nile Tilapia (*Oreochromis niloticus*), native to the Nile Basin, is a highly valuable species. It is extensively farmed in Egypt and throughout the world, but it is also considered an important food source in subsistence fisheries in Africa (See Case study 3.2).

3.2.1. Inland fisheries

Globally the most important continents for inland capture fisheries in terms of tonnage are Asia, with 66.4% of all capture fisheries production, and Africa with 24.5% (FAO, 2010). Within northern Africa, in terms of quantity, there is an important distinction between inland fisheries in Egypt and those in the other countries included in this study: Algeria, Libya, Morocco and Tunisia. Egypt contains a significant portion of one of the largest river basins in the world: the Nile, and it is here where inland fisheries are more developed and where many fishermen live on the money obtained from selling their catch or working for fishing companies. **Egypt is ranked as the fourth largest inland fishery producer in Africa and the 11th in the world in 2008 (FAO, 2010)**. While inland fisheries do exist in the other countries, they are on a much smaller scale. For example, the inland freshwater fish catch in Egypt was 237,500 tonnes in 2009, while only 6,020 tonnes were landed in Morocco and 1,191 tonnes in Tunisia in the same year (FAO, 2009). However, FAO data do not account for artisanal and subsistence inland fisheries, which are generally not recorded, so these figures should be taken with caution. More detail on the fisheries and people involved in this activity is given in Section 3.3.

Table 3.2 Prices of selected fish species

Fish species/group	EGP wholesale	EGP Retail	USD wholesale	USD retail
Eel (*Anguilla*)	39.36	62	6.56	10.3
African Catfish (*Clarias spp.*)	6.78	7.25	1.13	1.2
Labeo spp.	6.4	7.25	1.1	1.2
Nile Perch (*Lates niloticus*)	15.65	32	2.6	5.3
Bayad (*Bagrus bajad* and *B. docmak*)	15.15	18	2.25	3
Synodontis spp. (mainly *S. schall*[2])	8.30	11	1.43	1.83
Alestes spp.	3	3.5	0.5	0.6
Barbus spp.	5.6	7	0.93	1.16
Tilapias[1] (*Oreochromis* spp., *Sarotherodon* spp. and *Tilapia* spp.)	6.07–9.99	7.5–12	1–1.7	1.25–2

Extracted from the table of fish prices at Cairo (El Abour) wholesale market, as shown in the Arabic edition of the GAFRD statistical year book for 2009 (published July 2010). Exchange rate: Egyptian Pound (EGP) 1 = USD 0.166.

[1] Price varies with size (three size classes: 1–5 fish/kg, 6–10 fish/kg and 11–15 fish/kg).

[2] As listed in GAFRD 2010.

Table 3.2 shows market prices for some freshwater fish in Egypt. Several species listed as regionally threatened are found and sold in local markets. The most highly priced species is the European Eel *Anguilla anguilla* (CR and EN[RG]), which is also economically important in other NAR countries. In a recent study of the trade in European Eels, carried out by TRAFFIC, Norway, Tunisia, Morocco and Algeria were identified as the top non-EU exporters of live Eels (Crook, 2010). The socio-economic importance of the European Eel in the NAR is presented in more detail in **Case study 3.1.** *Lates niloticus*, Tilapia species and *Synodontis clarias* (a catfish known as Shilane in northern Africa) are also among the most valued fishes. The last is listed as VU[RG] due to pollution and river flow alteration caused by dam construction in the lower Nile. *Alestes dentex* has been globally assessed in continental Africa as Least Concern; however, it is at risk of extinction in northern Africa (VU[RG]) due to its restricted range in the area following the construction of the Aswan Dam, which has also been identified as the one of the reasons for the regional extinction of a number of other fish species that used to be found downstream of the dam (see Table 3.7).

3.2.2. Ornamental fish

Globally, more than 4,000 species of ornamental freshwater fish are traded internationally each year (Whittington & Chong, 2007). There are around 882 ornamental freshwater fish species native to Africa, 21.5% of which are threatened with extinction (Gricar and UNEP–WCMC, 2011). Half of these species belong to the family Cichlidae and 19% to the family Nothobranchiidae (Killifishes). Capture and sale of ornamental fish is not a well-developed activity in Africa, at least not at the scale seen in other parts of the world such as Asia, which is the major exporter of ornamental freshwater fish. However, some of the most valuable traded fish species are African, with an average wholesale value of up to USD 2.42 per fish (Brummet, 2005a). According to FAO (2011), exports of ornamental fish from Africa amounted to 242 tonnes in 2008, with a value of USD 3,368,000. FAO data records document the trade in freshwater ornamental fish for some countries in northern Africa. For example, in 2008, five tonnes of ornamental fish were exported from Egypt and half a tonne from Tunisia—there are no recorded exports from other NAR countries (FAO, 2011). These data should be taken with caution as it has not been possible to test the accuracy of the quantities or whether these are all indeed freshwater fishes, and whether they are taken from the wild or are bred in captivity. As Figure 3.2 shows, most ornamental fish recorded are thought to be collected from the wild, although a small proportion might be captive bred. In contrast, globally, only 9–10% of freshwater ornamental fish are taken from the wild (Brummet, 2005b).

Thirty-two species were identified as being used as ornamental species, accounting for one third of all utilized species. Of these, three species are used for display in large public aquaria and are not known to be traded internationally as ornamentals. In this study only eight species were confirmed to be bred in captivity and an unknown origin was recorded for three species. *Hemichromis bimaculatus*, known as the Jewelfish, is a common aquarium species of high economic value. It is considered rare in northern Africa, where it is assessed as Endangered due to habitat loss and degradation caused by water pollution, the construction of dams and water over-abstraction. It is, however, regarded as Least Concern in sub-Saharan Africa, where it is more widespread. *Aphanius saourensis* is a Critically Endangered species endemic to Algeria that is also used for aquaria. It has been confirmed that both species (*Hemichromis bimaculatus* and *Aphanius saourensis*) are captive bred. In contrast, *Auchenoglanis biscutatus,* the Yellow Giraffe Catfish, is a threatened species that is collected from the wild. It is listed as Vulnerable in northern Africa, where it is affected by the same threats as the other two species, but no threats from over-harvesting for the aquarium trade have been reported.

Eight of the 32 ornamental species in northern Africa have been assessed as regionally threatened. None of these has been identified as threatened or potentially threatened by the ornamental fish trade in the region, as explained above. The picture is very different for sub-Saharan Africa, however, where 23.7% of the threatened and Near Threatened species are affected by the aquarium trade and nearly 30% are threatened by fishing activities such as subsistence and large-scale fishing (Gricar and UNEP–WCMC, 2011). The ornamental fish trade in northern Africa needs further study in order to quantify its scale and to identify the source of all species traded internationally for use in aquaria. Ornamental fish can be an excellent option within livelihood strategies in Africa if based on principles of sustainable harvesting. Brummet (2005b) describes a successful example of a locally managed ornamental fishery in the Brazilian state of Amazonas. Here, during the years 2000 and 2001, 30–50 million ornamental fishes were traded and local communities earned up to USD 250,000 per year, 60% of the total income for the region (Chao & Prang, 2002).

3.2.3. Aquaculture

Aquaculture production of freshwater species accounts for 59.9% of world aquaculture by quantity and 56.0% by value (FAO, 2010). In northern Africa aquaculture is a key economic activity in Egypt. Indeed, Egypt is the largest aquaculture producer in Africa and the 11th in the world, and produces 99% of the freshwater fish from aquaculture in the NAR (Table 3.3). The Egyptian General Authority for Fisheries Resources Development (GAFRD) reported 693,815 tonnes of total aquaculture production in 2008 and 705,490 tonnes in 2009. Freshwater fishes comprised 69.5% and 68.5% of all aquaculture production in Egypt in 2008 and 2009 respectively. Although freshwater fish farming is not considered to be a major activity in other countries of northern Africa, FAO data from 2009 reveal that it had increased in the previous five years in Morocco, Algeria and Tunisia, with a slight decrease in 2009 (Table 3.3). FAO data, however, include introduced species that are also used for aquaculture production; an important example is the Common Carp *(Cyprinus carpio).*

The most important aquaculture species in northern Africa, and probably one of the most important in the world, is *Oreochromis niloticus* (LC), the Nile Tilapia. Its socio-economic significance in Egypt is discussed in some detail in Case study 3.2.

Of the 11 species native to northern Africa known to be used for aquaculture six are Cichlids (Table 3.4). One species *(Heterotis niloticus)* has been listed as RE in northern Africa. It is important to stress that this means this species is extinct in the wild throughout its original range within the project area, i.e. downstream from Lake Nasser. Grey Mullet *(Mugil cephalus LC)* and Thin-lipped Grey

Table 3.3 Aquaculture production (tonnes) of freshwater fish in the NAR from 2005 to 2009

Country	2005	2006	2007	2008	2009	% of total production in 2009
Egypt	370,983	362,177	380,835	473,348	482,310	99,17%
Algeria	353	263	354	2,718	2,091	0.43%
Morocco	737	820	1,145	1,085	1,105	0.23%
Tunisia	710	725	705	752	816	0.17%
Libya	10	10	10	10	10	<0.1%
Total	**372,793**	**363,995**	**383,049**	**477,913**	**486,332**	**100%**

Source: FAO, 2009

Mullet *(Liza ramada LC)* are also important native aquaculture species, but they were not included in this study as they have not yet had their extinction risk assessed at the regional level.

Table 3.4 Farmed freshwater fishes in northern Africa and their Regional Red List Categories

Family	Species	Red List Regional Category
ARAPAIMIDAE	*Heterotis niloticus*	RE
CICHLIDAE	*Hemichromis fasciatus*	DD
CICHLIDAE	*Oreochromis aureus*	LC
CICHLIDAE	*Oreochromis niloticus*	LC
CICHLIDAE	*Sarotherodon melanotheron melanotheron*	LC
CICHLIDAE	*Tilapia guineensis*	DD
CICHLIDAE	*Tilapia zillii*	LC
CLARIIDAE	*Clarias gariepinus*	LC
CLARIIDAE	*Heterobranchus longifilis*	VU
CLAROTEIDAE	*Chrysichthys nigrodigitatus*	DD
LATIDAE	*Lates niloticus*	DD

Fishing for Tilapia in the Northern Delta Lakes of Egypt. Photo © Magdy Saleh.

3.3. THE IMPORTANCE OF FRESHWATER FISHES TO LIVELIHOODS IN NORTHERN AFRICA

The diverse uses of freshwater fishes, the extent of trade and the economic importance of these uses have been presented above. This part of the study aims to answer the following questions: i) how important are these freshwater fishes in the livelihoods of local communities, and ii) what is the level of reliance on these resources?

Across the developing world inland fisheries deliver nutritional security and income to hundreds of millions of people. Over 60 million people in developing countries are known to work in small-scale inland fisheries, an activity than can generate high monetary value for national economies (UNEP, 2010). For example, annual production in the Mekong river basin can amount to 2.1 million tonnes of freshwater fish, worth USD 2.1–3.8 billion, and it is the main source of income for 22 million people in Cambodia and Lao PDR (UNEP, 2010). In Africa the picture is similar. There are several African countries, such as Ghana, Sierra Leone, Gambia and Equatorial Guinea, where fish protein accounts for at least 50% of all animal protein consumed (FAO, 2008). In Sierra Leone for example, fish can contribute up to 75.7% of total animal protein consumption; in the Democratic Republic of Congo the figure is 42% and in Uganda 34% (Kawarazuka, 2010). In the Great Lakes of Kenya, Tanzania and Uganda, inland fisheries employ 226,000 people full time, 19,000 of whom are women (FAO & WFC, 2008). It is a diversified activity that can take complex forms within the livelihoods of rural communities, especially in the case of small-scale fisheries. Much of the catch from inland fisheries is unrecorded and in some countries information is lacking partly because of the diffuse nature of individual fisheries, but also because a proportion of the catch goes directly to domestic consumption and is never reported (Welcomme, et al., 2010). Subsistence food production is therefore likely to be more significant than official statistics suggest (IBRD, 2010). In

Nigeria, 19–33% of fish caught by household members was used for household consumption and 67–81% was sold for cash to purchase other food or for investment in farming activities (Neiland, et al., 2000).

In northern Africa inland fisheries also represent an important economic activity. However, the scale and the structure of the sector are radically different between Egypt and the Maghreb countries (Algeria, Libya, Morocco and Tunisia).

3.3.1. Egypt

Egypt has a well developed fisheries sector upon which hundreds of thousands of people rely, either through working as fishers, processors or fish sellers, or through direct consumption of part of the catch. Many others work in aquaculture production.

Aquaculture is an extremely important economic activity in Egypt, which is the top producer in Africa and the 11th in the world. It produced 694,000 tonnes of fish in 2008 (FAO, 2010; GAFRD, 2010), 69.5% of which consisted of freshwater species. As **Case study 3.2** reveals, more than 300,000 people depend on aquaculture production as their single source of income in Egypt. As the majority of fish farming is of Nile Tilapia (as a basic product) associated with mullet and/or carp, almost all of these people can be said to depend on the production of a single species. If Nile Tilapia farming ceased, the livelihoods of many people would be seriously impacted. Moreover, this activity is highly reliant upon the conservation of wild stocks of Nile Tilapia as an essential source of genetic variability and therefore a requirement for the long-term functioning of the industry.

Auchenoglanis occidentalis is listed as Vulnerable in northern Africa. Photo © L. de Vos.

Inland fisheries are also a key source of income and food for local livelihoods. Egypt is one of the largest inland fisheries producers in the world, occupying 11th place with 237,000 tonnes produced in 2008 (FAO, 2010). At least 78,000 fishers and 25,000 boats are known to be involved in inland fisheries in Egypt, including those in Lake Nasser (GAFRD, 2010). There are 49 fishery associations and six aquaculture associations registered representing a capital of USD 145,100 and 26,520, respectively (GAFRD, 2010). Cichlids are the most frequently targeted species, representing 47% of overall catches. There are, however, many species from other families that are harvested in Egyptian fresh waters to provide an income or food; these account for 117,000 tonnes annually (Table 3.5). Most fish listed in Table 3.5 are caught by traditional fishers and sold for cash, only a small proportion (not more than 10%, especially in very small-scale fisheries) is consumed directly by the fishers and their families (M. Saleh, unpublished data, 2011). As mentioned above, the sources of FAO data are known to be inaccurate in terms of recording small-scale and artisanal fisheries, so these figures are likely to be underestimates. **Overall, including inland fisheries and aquaculture, at least 378,000 people in Egypt depend directly on activities related to the harvesting and farming of freshwater fishes.**

Based on the prices listed in Table 3.2 and the quantities harvested in Table 3.5 it can be estimated that inland fisheries in Egypt accounted for a total of USD 355.7 million in the year 2009.

This is just the direct market value of the fisheries resource and does not account for associated industries and jobs such as processing, transport or aquaculture. The species that created the greatest revenue were the Tilapias (*Oreochromis* and *Tilapia* species), representing 47% of the overall value, Nile Perch (*Lates niloticus*: 23%), African catfishes from the genus *Clarias* (9.8%) and the European Eel (3.5%) (Table 3.6).

Algerian Barb (*Barbus callensis*). *Barbus* species have been recorded as the second most fished species in inland waters in Morocco. Photo © A. Azeroual.

Table 3.5 Catch of freshwater species (tonnes) in Egypt in 2009

Fish species-group	Estimated species composition and regional Red List Category	Nile	Lake Nasser	Inland lakes	Northern lakes	TOTAL	%
Tilapias	*Oreochromis niloticus* (LC^{RG}), *O. aureus* (LC^{RG}), *Sarotherodon galilaeus* (LC^{RG}) and *Tilapia zillii* (LC^{RG})	26,101 1	22,854	5,787	48,972	**103,714**	**46.98**
African Catfishes	*Clarias anguillaris* (DD^{RG}) and *Clarias gariepinus* (LC^{RG})	15,345	NR[1]	NR	22,461	**37,806**	**17.12**
Grass Carp	*Ctenopharyngodon idella*	19,235 5	NR	528	6,292	**26,055**	**11.80**
Nile Perch	*Lates niloticus* (DD^{RG})	4,658	10,744	333	NR	**15,735**	**7.13**
Mullets	*Chelon labrosus, Liza aurata, L. ramada, L. salinus, Mugil cephalus* and *Valamugil seheli*	49	NR	869	12,491	**13,409**	**6.07**
Bayad	*Bagrus baiad* (LC^{RG}) and *B. docmak* (LC^{RG})	7,202	NR	143	4,31	**11,655**	**5.28**
Atherina boyeri	*Atherina boyeri*	4,176	NR	NR	1,124	**5,300**	**2.40**
Other Catfishes	*Synodontis schall* (LC^{RG}), *S. clarias* (VU^{RG}), *S. frontosus* (DD^{RG}), *Shilbe mystus* (LC^{RG}), *S. uranoscopus* (VU^{RG}), *Auchenoglanis biscutatus* (VU^{RG}) and *A. occidentalis* (VU^{RG})	2,297	NR	NR	NR	**2,297**	**1.04**
Labeo spp.	*Labeo coubie* (EN^{RG}) and *L. niloticus* (LC^{RG})	2,161	NR	NR	NR	**2,161**	**0.98**
European Eel	*Anguilla anguilla* (EN^{RG})	442	NR	NR	786	**1,228**	**0.56**
Barbus spp.	*Barbus bynni* (LC^{RG}), *B. anema* (RE^{RG}), *B. neglectus* (RE^{RG}), *B. perince* (VU^{RG}), *B. stigmatopygus* (DD^{RG}) and *B. yeiensis* (DD^{RG})	719	NR	NR	NR	**719**	**0.33**
Alestes spp.	*Alestes baremoze* (RE^{RG}), *A. dentex* (VU^{RG}) and *Hydrocynus vittatus* (DD^{RG})	NR	698	NR	NR	**698**	**0.32**
	Total:	**82,385**	**34,296**	**7,660**	**96,436**	**220,777**	**100.00**

Source: General Authority for Fish Resources Development (GAFRD), 2010 statistics yearbook. Species composition estimated by M.A. Saleh. Note that species listed as Regionally Extinct (RE) in the NAR may still be fished for in Egypt but outside the project area (i.e. upstream of the Aswan Dam).

[1] NR: not reported.

Table 3.6 Estimated value of freshwater fishes in Egypt in 2009

Species group[1]	Captures[1] (t)	Average wholesale price[2] (USD/kg)	Average retail price[2] (USD/kg)	Total price 2009 (wholesale) USD	Total price 2009 (retail) USD
Tilapias (*Oreochromis* spp., *Sarotherodon* spp. and *Tilapia* spp.)	103,714	1.35	1.625	140,013,900	168,535,250
African Catfish (*Clarias* spp.)	40,103	1.13	1.2	45,316,390	48,123,600
Nile Perch (*Lates niloticus*)	15,735	2.6	5.3	40,911,000	83,395,500
Bayad (*Bagrus bajad* and *B. docmak*)	11,655	2.25	3	26,223,750	34,965,000
Other Catfishes (mainly *Synodontis schall*)	2,297	1.43	1.83	3,284,710	4,203,510
Labeo spp.	2,161	1.1	1.2	2,377,100	2,593,200
European Eel (*Anguilla anguilla*)	1,228	6.56	10.3	8,055,680	12,648,400
Barbus spp.	719	0.93	1.16	668,670	834,040
Alestes spp.	698	0.5	0.6	349,000	418,800
Total	**178,310**	**1**	**1.99**	**267,200,200**	**355,717,300**

[1] From Table 3.5.
[2] From Table 3.2.
Introduced or brackish-water fishes have been excluded.

Many important species caught in inland fisheries are already threatened or Data Deficient. For example, the Catfishes (Mochokidae) in Egypt include species in the genera *Bagrus and Clarias*. These generated an income of at least USD 56 million in 2009 (Table 3.6). Species such as *Synodontis uranoscopus* (VU^{RG}), *Auchenoglanis biscutatus* (VU^{RG}), *Auchenoglanis occidentalis* (VU^{RG}) and *Synodontis clarias* (VU^{RG}) are also threatened. The main threats to these species in northern Africa are very similar, as they are all affected by dams, water pollution (agricultural, domestic, and industrial), groundwater extraction and drought. The European Eel alone generated at least USD 12.6 million in Egypt in 2009. The main threats to this species in northern Africa are overfishing, estuary pollution and the construction of dams which block migration routes. This species is also economically important in the Maghreb countries (*see* Case study 3.1).

Of the 86 species of freshwater fishes known to occur in Egypt, 28 are of socio-economic importance and form the main components of Egypt's fisheries. Eight of these are threatened in the northern Africa region. **This means that 28% of species composing the fisheries of Egypt are at risk of extinction**. It is also important to note that three species important to these fisheries have been listed as Regionally Extinct (García, et al., 2010).

3.3.2. Maghreb countries

Inland fisheries and farming of freshwater species occur on a much smaller scale in the Maghreb countries than in Egypt. The exact number of people involved in these activities and their economic importance, in terms of value and scale, are not well documented. Most fishery studies focus on the marine and offshore fisheries, which are of greater economic importance. There is precise information on the European Eel, however, mainly because of its global (CR) and regional (EN^{RG}) threatened status and its listing in CITES, requiring its international trade to be regulated (Crook, 2010). A few studies of the socio-economic importance of wetlands are also available (Benessaiah, 1998; Khattabi, 1997; Khattabi, 2006)

and, although they mainly focus on coastal wetlands and coastal lagoon systems, they provide useful insights into the importance of some freshwater fish species in the region for the lives of local communities.

In Algeria, Morocco and Tunisia thousands of people rely on income provided by the catching and farming of the European Eel (*Anguilla anguilla*). This is an important species in terms of quantity and value in the NAR. The socio-economic importance of this species in the northern African countries is assessed in detail in **Case study 3.1.**

Inland fisheries in Morocco have their place in local economies, and are sometimes the only source of income for local people. Fisheries can be of three types: small-scale, industrial large-scale and recreational or sport fishing, and take place in coastal lagoons (where some species included in this study are found), inland lakes, dam reservoirs, and rivers (Khattabi, 2006). For example, a study of the socio-economic value of the Atlantic coastal lagoon Merja Zerga revealed that around 15% of households practised fishing as a principal or secondary activity and that wetland products contributed 30% of overall household revenue, 38% of which came from fishes (Khattabi, 1997). The European Eel has been reported to compose 20% of the fisheries in Merja Zerga (Kraiem, et al., 2009). Fishing is common in reservoir dams and rivers. In 2003, 200 licences were issued for fishing in Morocco, 52% of which for reservoirs and 48% for rivers. It has, however, been recognized that the number of licences does not necessarily reflect the actual number of people involved in this activity, which remains unknown (Khattabi, 2006). In the Moulouya river basin in Morocco, several freshwater fishes have been identified as being important for the local economy (Melhaoui, 2011), although the specific value of these species and the number of people involved have not been quantified. They include some NAR endemic species such as *Barbus callensis* (LC^{RG}), *Barbus molouyensis* (LC^{RG}) and *Salmo trutta macrostigma* (DD), and the Critically Endangered European Eel, all of which are reported to be threatened by habitat loss and degradation through human activities.

In Tunisia, freshwater fishes represent 47% of total fish consumption (MEDD, 2010). Inland fishing takes place mainly in the many artificial reservoirs across the country, but the overall scale of fishing has not been systematically quantified. Aquaculture is also carried out in reservoirs, where species are introduced artificially. Figure 3.4 shows the freshwater fishes that are harvested and their relative importance in total catch (MEDD, 2010). Most of these species, such as Mullets, Zanders, Carps and Common Rudd, have been introduced in reservoirs and are not native to the NAR. The total production of freshwater fishes was 1,600 tonnes in 2009.

There is very little fishery activity recorded from **Algeria and Libya**. Aquaculture production from Libya has been recorded by FAO (*see* Table 3.3) but there is no detail available on number of people involved in this activity and any estimate would be very imprecise. In Algeria, the European Eel is exploited at a small scale but there is no detailed information on the number of people involved on inland fisheries or the importance of this activity in local livelihoods. The only reliable data of people involved in fisheries for Algeria and Tunisia are provided by eel fisheries which are dealt with detail in **Case study 3.1.**

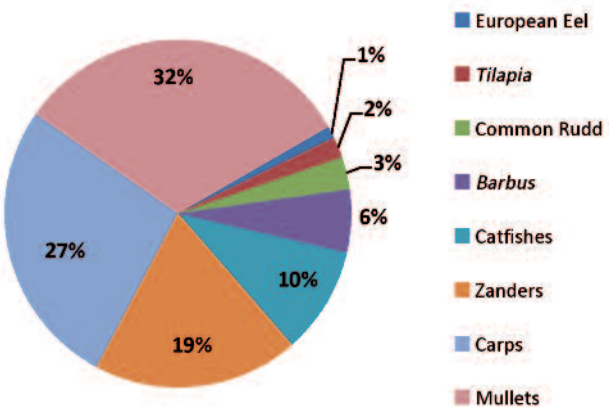

Figure 3.4. Proportion of freshwater fish catches in Tunisia in 2009 (source: MEDD, 2010).

Women washing their clothes in a river in the Atlas mountains in Morocco. Photo © Alan Bachellier.

The Maghreb region is also home to an interesting species diversity of barbels (*Barbus* spp.), the most common genus in the region. *Barbus* species represent more than 20% of the total number of freshwater fish species, as well as 59% of the total endemics. Eleven of the 26 barbels assessed (42.3%) are known to be harvested in small quantities. Most of these species thrive in distant mountainous areas but are also common in small water bodies and reservoirs across the region. Although the exact scale of this activity is not known, *Barbus* species have been recorded as the second most fished species in inland waters in Morocco, accounting for 27% of total catches (Khattabi, 2006). The most heavily fished species (38%) is the Common Carp (*Cyprinus carpio*), which is not native to northern Africa. Among the barbels there are several threatened species, such as *Barbus harterti* (VU) (restricted to the Oum er-Rbia basin in central Morocco) and *Barbus issenensis* (VU) in the Souss and Massa basins in Morocco. These species are not known to be targeted for fishing, although similar species such as *Barbus callensis* (LC), *Barbus moulouyensis* (LC) and *Barbus nasus* (NT) are, and it is likely they are included in catches where they occur. *Barbus nasus* is restricted to Morocco; it has disappeared from the lower reaches of Wadi Tinsift and Oum er-Rbia, and is now very restricted in the upper catchments in the Atlas Mountains. The main threats to these species are intensive groundwater extraction and pollution from agricultural, industrial and domestic sources. Of the freshwater fishes included in this study, 42 occur in the Maghreb region. At least 50% (21 species) are known to be of socio-economic value. Three of these species are already Regionally Extinct, although they used to be fished before disappearing (*see* Table 3.7). Another four of these utilized species (19%) are known to be threatened (*Anguilla anguilla* EN^{RG}, *Aphanius saourensis* CR, *Hemichromis bimaculatus* EN^{RG} and *Salmo akairos* VU). The major threats to these species are varied: they are mainly affected by habitat loss and degradation caused by water pollution (agricultural, domestic and industrial), groundwater extraction and droughts.

3.3.3. Conclusion

The daily livelihoods of many thousands of people in northern Africa depend on freshwater fishes, either through involvement in the economic activities associated with their use (such as small- and large-scale inland fisheries, aquaculture, the ornamental fish trade, game fishing and tourism), or through use of part or all of the catch for household consumption. At least 380,000 people rely on freshwater species in the region, 99% of whom live in Egypt. These figures are likely to underestimate the actual scale of the activity especially for the Maghreb countries, where the number of people involved in inland fisheries is difficult to determine. It should also be noted that marine fisheries play a central role in the culture and livelihoods of people in the Maghreb countries and therefore most studies focus on this sector. Production of the European Eel is an important economic activity in Algeria, Morocco and Tunisia and it generates income and thousands of jobs in the region, as Case study 3.1 demonstrates. In northern Africa, and particularly in the Maghreb countries, the main livelihood of people in remote rural communities is based on crop and livestock farming, with occasionally reliance on freshwater fish from rivers and reservoirs as a secondary source of food. People in these areas may also benefit from the economic activity generated by recreational fishing in the Nile and in the principal

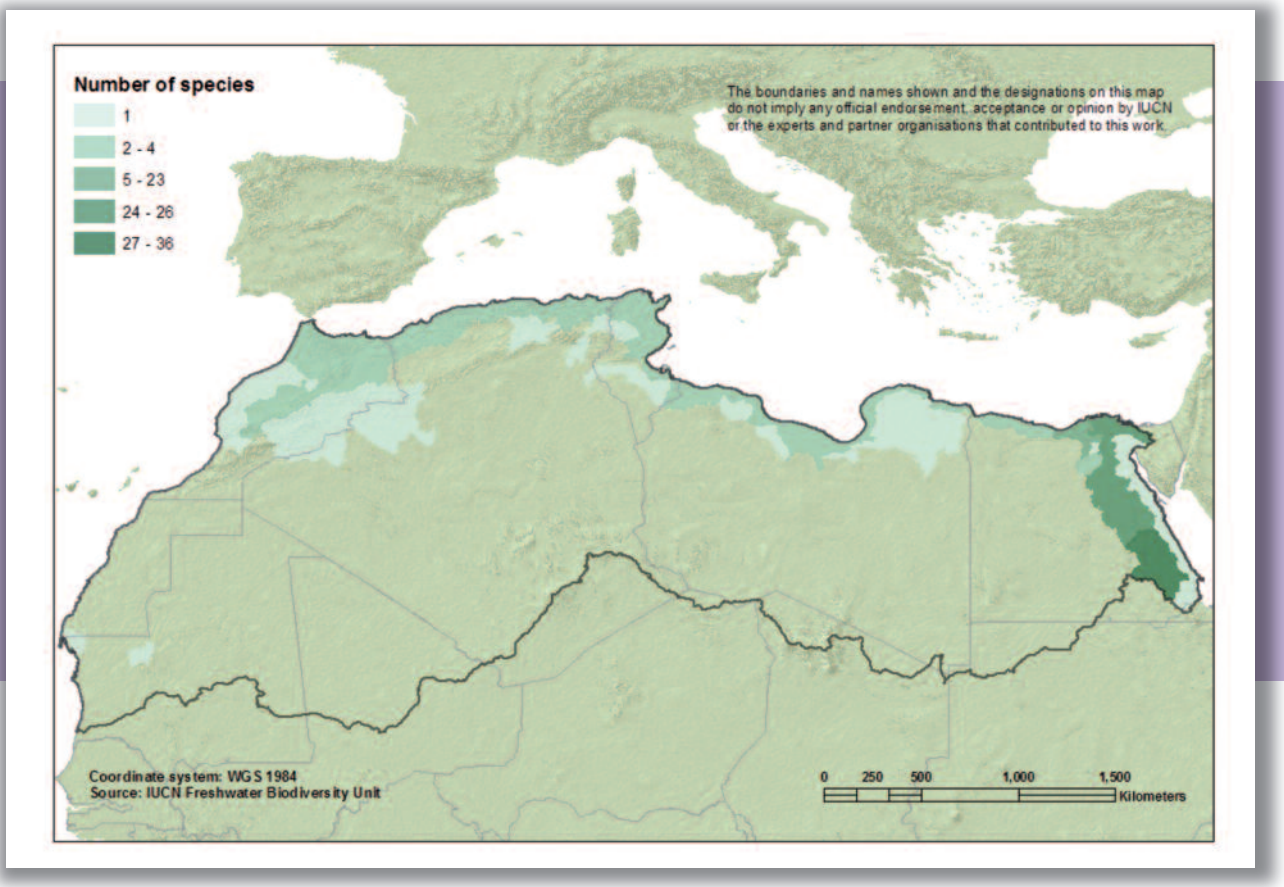

Figure 3.5. Distribution of freshwater fishes of socio-economic value in northern Africa.

Maghreb mountain ranges. Nevertheless, in contrast to sub-Saharan Africa, there seems to be a lack of studies that focus on the role of freshwater fish in the livelihoods of northern African people.

3.4. PATTERNS OF DISTRIBUTION

In order to identify areas where the largest numbers of utilized species are found the spatial distribution patterns of species were mapped. Figure 3.5 reveals that species of socio-economic value are concentrated in the Nile basin. This is consistent with species richness patterns in northern Africa, where the most diverse system is also the Nile basin. It is notable, however, that freshwater fish used by people are also found throughout the Mediterranean and Atlantic coastal areas of northern Africa.

The proportion of species of socio-economic value in each catchment (Figure 3.6) reveals high levels of use in the Nile basin, but other interesting areas where the proportion of utilized species is high are now highlighted. **Tunisia and Libya, for example, are countries where there are few freshwater species but almost all are used. This is an important finding as these countries will have potentially fewer harvest options should the few species that are used be lost**. Species that are used in these areas include the European Eel and the Algerian Barb (*Barbus callensis*). The Moulouya River basin in eastern Morocco also stands out as a place where a high proportion of species is used. The area of central-western Algeria towards the Moroccan border is highlighted because the single species present, *Barbus figuiguensis*, is known to be used occasionally although it is of low economic importance.

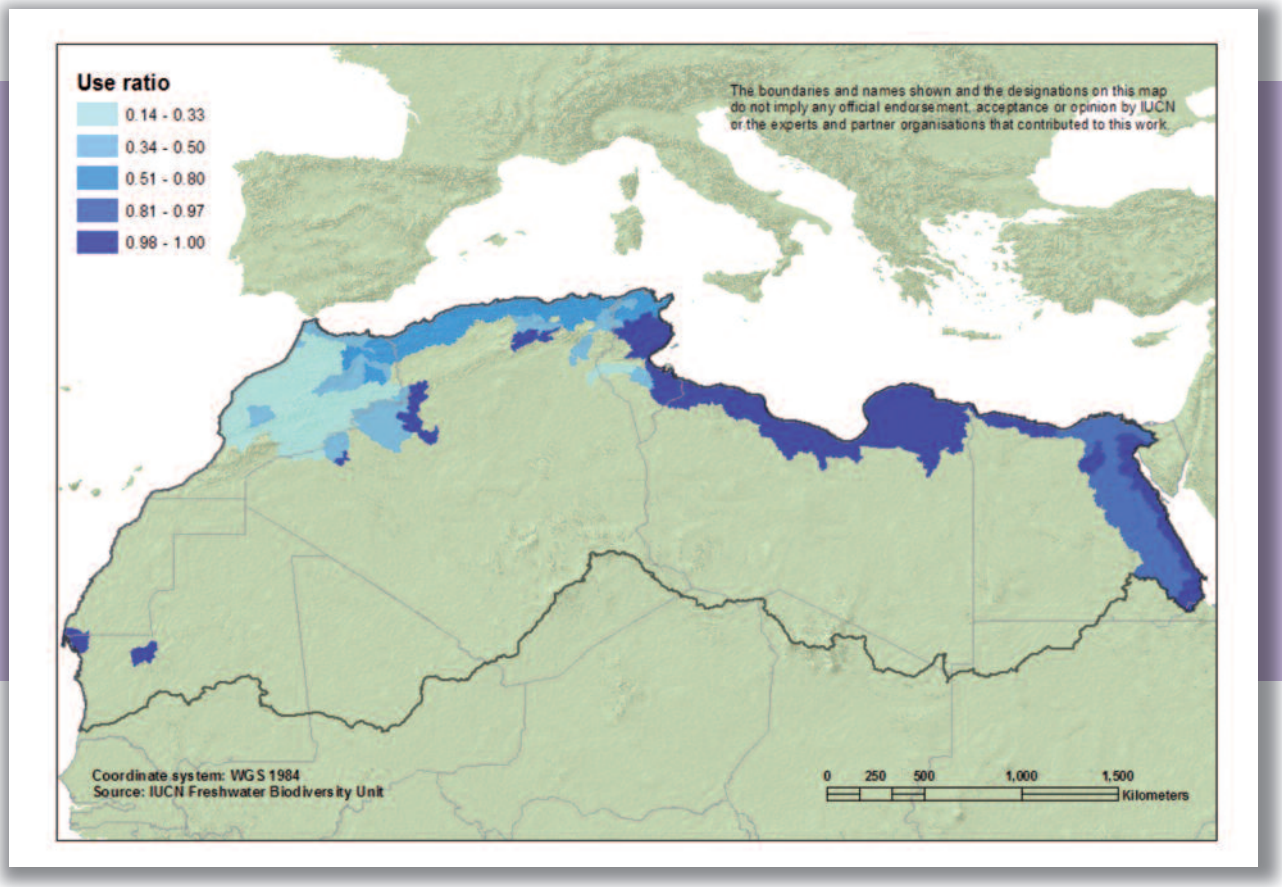

Figure 3.6. Proportion of utilized freshwater fish species in northern Africa. The use ratio was calculated by dividing the number of species used by the total number of species present, a maximum value of one indicating that all species in the catchment are used.

The spatial relationship between utilized and threatened species was mapped in order to identify potential priority areas for conservation (Figure 3.7). Conservation action is needed in the areas where utilized species are under threat in order to: i) save species from exctinction, and ii) protect a resource that is valued and used by local people. Management strategies that include habitat protection and sustainable harvesting programmes are esssential to protect the resource while still benefiting people's livelihoods.

The Critically Endangered European Eel (*Anguilla anguilla*) is confirmed as a priority species for conservation across most of the North African coastal region, where it is the only threatened utilized species in coastal Morocco, Tunisia, Algeria and Libya. The number of threatened utilized species increases southwards up the Nile to the Aswan Dam and Lake Nasser. The lower Nile stands out as an area where many utilized species are threatened, but it is also the most diverse area in terms of overall species richness. Here there are up to 20 species that are both threatened and of socio-economic importance including key species in the Cichlidae family. Further south, outside the study region, up to 19 threatened and exploited species are found in Lake Nasser. Construction of the Aswan dam in 1970, which created lake Nasser, may be the main cause of decline of many of these species.

3.5. THREATS TO SPECIES OF SOCIO-ECONOMIC VALUE

More than a third (35.59%) of utilized fish in northern Africa are regionally threatened. Overharvesting has been identified as a major

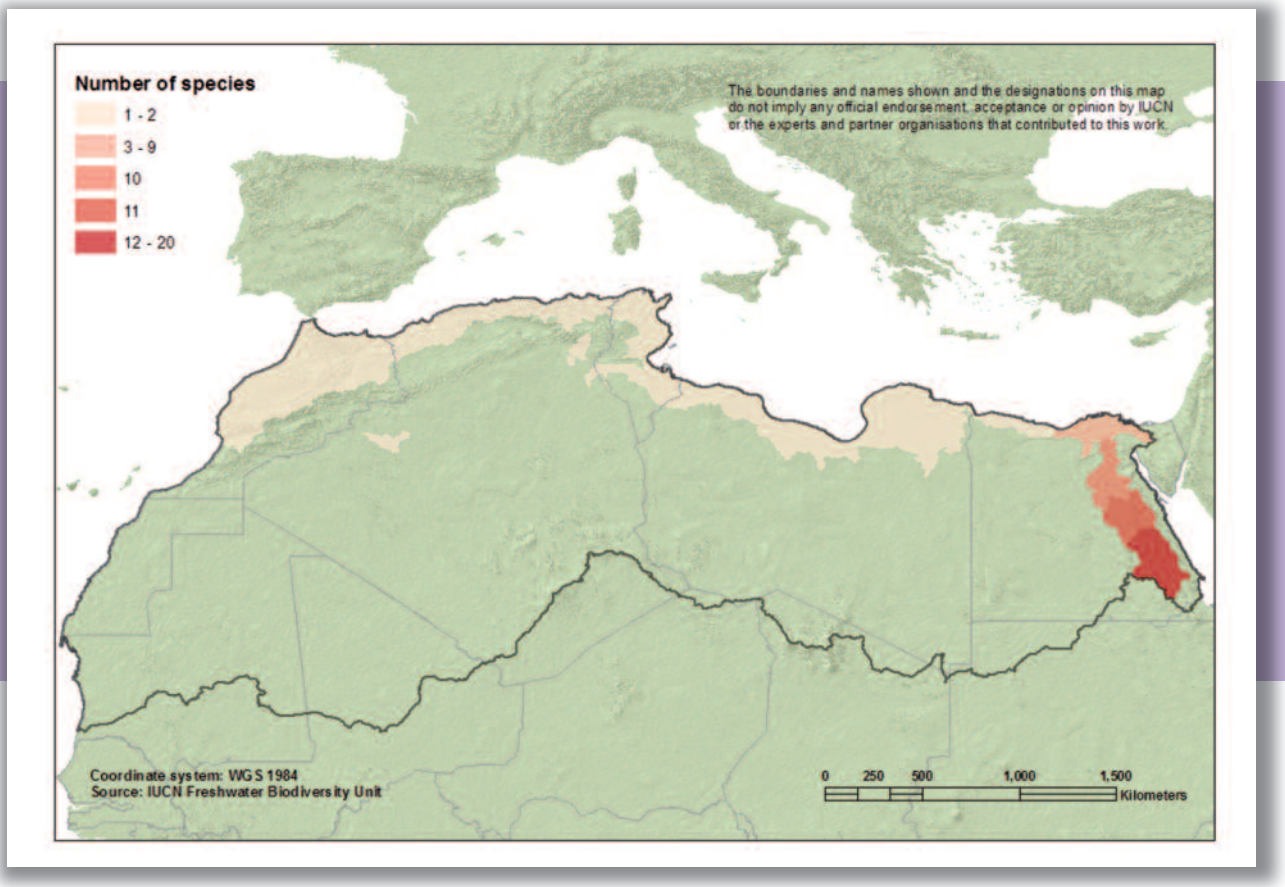

Figure 3.7. Distribution of threatened fishes that are of socio-economic value in northern Africa.

threat for *Anguilla anguilla* (EN^{RG}), *Alestes dentex* (VU^{RG}), *Barbus bynni bynni* (LC^{RG}), *Hydrocynus forskahlii* (LC^{RG}) and *Lates niloticus* (DD^{RE}), representing 4.8% of all the fish species in the region. The European Eel is a good example of the complexity of the impact as it suffers from a number of interrelated threats (see Case study 3.1).

Major threats to freshwater fish in northern Africa are habitat loss and degradation due to human activities, affecting more than 60% of freshwater fish species (García, et al., 2010). These activities include groundwater extraction, water pollution and dam construction. Drought and temperature extremes are also an important threat to fishes in northern Africa and affect almost two-thirds of freshwater fish species. Indications are that the main threat to freshwater fish is human activities that degrade and destroy their habitats rather than consumption of the resource itself. Although harvest management needs to be planned and controlled to allow for sustainable exploitation, this measure needs to be part of an integrated management strategy addressing the many other threats at the catchment scale.

As mentioned above, 23 freshwater fish species have already been listed as Regionally Extinct (RE). Almost all of them (22) are still caught in sub-Saharan Africa and at least 16 are known to have been fished for along the Nile before becoming locally extirpated (Table 3.7). Although Lake Nasser now provides several species that are caught, traded in markets and consumed by local people, the creation of the lake may have decreased species richness and fishery options for people living downstream if the 23 RE species are taken into account.

Table 3.7 Regionally extinct freshwater fish species that used to be harvested in northern Africa

Family	Species	Family	Species
ALESTIIDAE	*Alestes baremoze*[1]	CYPRINIDAE	*Barbus anema*[2]
ALESTIIDAE	*Brycinus macrolepidotus*[2]	CYPRINIDAE	*Barbus neglectus*[1]
ALESTIIDAE	*Hydrocynus brevis*[1]	MOCHOKIDAE	*Synodontis batensoda*[2]
ALESTIIDAE	*Micralestes acutidens*[1]	MOCHOKIDAE	*Synodontis membranaceus*
ARAPAIMIDAE	*Heterotis niloticus*[1]	MORMYRIDAE	*Hyperopisus bebe bebe*[1]
CLAROTEIDAE	*Clarotes laticeps*[1]	MORMYRIDAE	*Mormyrus hasselquistii*[2]
CITHARINIDAE	*Distichodus engycephalus*[1]	MORMYRIDAE	*Mormyrus niloticus*[2]
CITHARINIDAE	*Distichodus rostratus*[1]	MORMYRIDAE	*Petrocephalus bovei bovei*[2]
CITHARINIDAE	*Ichthyborus besse besse*[1]	POECILIIDAE	*Micropanchax loati*[1]
CLUPEIDAE	*Alosa alosa*[3]	POLYPTERIDAE	*Polypterus bichir bichir*[2]
CLUPEIDAE	*Alosa fallax*[4]	SCHILBEIDAE	*Siluranodon auritus*[1]

[1] Formerly caught in Egypt—currently fished for south of the Aswan dam.
[2] Formerly found in the Nile Delta—currently fished for south of the Aswan dam.
[3] Formerly caught in Algeria, Morocco and Tunisia.
[4] Formerly caught in Algeria, Egypt, Morocco and Tunisia.

3.6. TEN CONCLUSIONS AND RECOMMENDATIONS

1. Of the 128 freshwater fishes included in this study at least 59 (46.09%) are of socio-economic value and are utilized in northern Africa, and 99 (77.34%) are utilized elsewhere in continental Africa. Twenty-three species of fish previously valued within fisheries are now Regionally Extinct.
2. Freshwater fish in Africa are mainly used for food, either directly or bought in markets, whether sourced from the wild or from fish farms. The ornamental fish trade is the second most common use of species, although it is not clear whether this trade is sourced from the wild or through captive breeding.
3. One third (35.59%) of utilized fish in northern Africa are threatened. The main threats are habitat loss and degradation due to human activities, such as over-abstraction of groundwater, water pollution and construction of dams. Five per cent of all freshwater fish are threatened by overharvesting for food.
4. Inland fisheries and freshwater fish farming are of paramount importance to Egypt's economy, employing around 378,000 people. Twenty-eight per cent of the species caught in Egypt's inland fisheries are already at risk of extinction.
5. In the Maghreb countries, inland fisheries and aquaculture operate at a smaller scale than in Egypt but still provide an important input to the livelihoods of many thousands of people. Here, there are few freshwater fish species so there will be limited alternative options should any of these species be lost.
6. Nile Tilapia (*Oreochromis niloticus*) and European Eel (*Anguilla anguilla*) are the most economically valuable species in northern Africa.
7. Nile Tilapia is a very important species in Egypt's economy, comprising most of the

catch of inland fisheries and the main aquaculture species.

8. The European Eel is at serious risk of extinction due to a complex and interrelated number of threats. Limiting harvesting to minimum or even zero levels has been recommended as an important step in helping to stop this decline. This may however impact the livelihoods of thousands of people in the Maghreb countries.
9. Potential priority areas for conservation identified by this project are those that hold a high proportion of threatened species of socio-economic value. They include the Lower Nile and Nile Delta.
10. Conservation initiatives should be focused at the catchment and/or sub-catchment scale in order to address the high levels of connectivity and the consequent rapid and widespread impact of threats throughout catchments.

Oued Za à Ain Beni Mathar, in Morocco. Photo © Jean-Pierre Boudot.

Case study 3.1 The European Eel: a northern African perspective

by Juffe-Bignoli[1], D.

The European Eel (*Anguilla anguilla*) has a complex life cycle that includes marine, brackish and freshwater environments. It is also a species of significant socio-economic value, directly linked to the livelihoods of thousands of people across Europe and the Mediterranean (Bevacqua, et al., 2007; Table 1). For example, European Eel artisanal fisheries accounted for 70% of total revenues of professional fishers along the Mediterranean coast of France in 2007 (Bevacqua, et al., 2007), although the eel fishing fleet has been diminishing annually in recent years. Global exports of all *Anguilla* species commodities generated an income of USD 11 billion between 1997 and 2007, with smoked eels (60% of the trade) and live eels being the most important (Crook, 2010). However, the species faces a number of threats and its recruitment levels have declined at an alarming rate over the past 30 years, leaving the eel facing an extremely high risk of extinction (Dekker, 2003a; FAO/ICES 2010; Freyhof & Kottelat, 2010; Bevacqua, et al., 2007).

The European Eel is considered to be currently outside safe biological limits and its recovery could take several decades (Astrom & Dekker, 2007; FAO/ICES, 2010). IUCN have listed the species as Critically Endangered on the IUCN Red List based on a steep decline (up to 95 to 99% in some catchments in Europe) in the recruitment of glass eels since 1980 (Freyhof & Kottelat, 2010). Although the causes of this steep decline are not well understood, many threats to this species have been identified (Dekker, 2003b; Dekker, 2007). These include climatic changes potentially affecting the currents that bring eel larvae to European waters from the breeding grounds in the Sargasso Sea (Miller, et al., 2009), a parasitic nematode (*Anguillicoloides crassus*) that was introduced to Europe when Japanese Eels (Anguilla japonica) were imported for aquaculture, dams blocking migratory routes, and overharvesting (Azeroual, 2010; Farrugio, 2010; Freyhof & Kottelat, 2010). As a result of its critical situation, the species was listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in June 2007, and this listing came into force in March 2009. In December 2010, EU imports and exports of European Eel from all other countries were banned as the trade was considered to be having a harmful effect on the species' conservation status (see Crook, 2011, for details of this ban), although internal trade within the EU is still allowed. A European Council Regulation establishing measures for the recovery of the stock of European Eels was published in September 2007 (Council of the European Union, 2007). The key objective is to achieve a 40% escapement to the sea of adult silver eel biomass from each river basin of the European Union (EU), based on historic levels.

In northern Africa, where eel recruitment has declined by an estimated 50% in the past 10 years, and catches have declined by between 10 and 25% since 1980 (Azeroual, 2010), the species faces many additional threats including pollution of estuaries and rivers, water abstraction from surface and ground waters, drought and extraction of gravel (Azeroual, 2010). Harvesting of glass eels (juveniles usually found in coastal areas), yellow eels (yellow pigmentation, mainly found in rivers and lakes) and silver eels (the mature form that leaves freshwater systems for the sea) takes place across northern Africa in coastal areas, lagoons and inland waters. There is also farming of eels in the region (juveniles are harvested from the wild

[1] Freshwater Biodiversity Unit, IUCN Global Species Programme, Cambridge, UK.

and grown out in aquaculture facilities), though the precise amount that is produced is hard to determine. Fisheries and aquaculture are regulated by law in all northern African countries, restricting quantities to be captured and defining an eel fishing season.

Data from FAO on aquaculture production and capture fisheries of this species exist for some northern African countries (Table 2), although these figures are known to be unreliable as they usually do not account for small-scale artisanal fisheries (Béné, et al., 2010; Welcomme, et al., 2010). For example, according to FAO there are no capture fishery data and just 14.2 tonnes of aquaculture production reported from Algeria in 2009. However, the average annual production in the past 10 years in the northern region of El Kala (north-eastern Algeria) was estimated to be 80 tonnes, all exported to Italy (GFCM, 2010). In Morocco, at least 200 boats catching around 40 tonnes of silver eels per year were known to operate in the Nador lagoon in 2010 (GFCM, 2010). Although there is little information about the scale of this activity in other areas, this is not the only place where the species is harvested in Morocco. The main sites of production and marketing of eels in Morocco are on the Atlantic (Oued Sebou, Oued Oum er-Rbia and Oued Loulous) and Mediterranean coasts (Moulouya river and Nador lagoon). According to FAO data, Egypt was the largest producer with 940 tonnes in 2009 (all from capture fisheries), three times more than the total production from the Maghreb countries (Table 2). However, Egypt's General Authority for Fish Resources Development (GAFRD) reports a higher figure: 1,238 tonnes of European Eel harvested in 2009, which was made up of 765 tonnes from Lake Burullus, 21 from

Table 1 Number of people involved in European Eel fisheries in northern Africa

COUNTRY	LOCATIONS	BOATS/FISHERS	ADDITIONAL NOTES
Algeria	Tonga and Oubeira lakes, the Mafragh estuary and the El Mellah lagoon	Four aquaculture farms and 13 boats are known to be operating in these areas.	From MPRH, 2010.
Egypt	Nile Delta	1,587 fishers	Total number of eel fishers is unknown as eels are not the main target of fishers in either the Nile Delta or the lakes. Estimates are based on the number of licences plus the number of boats in Egypt in 2009 (GAFRD, 2010), taking each boat to hold a minimum of 3 fishers.
	Lake Manzala	9,723 fishers	
	Lake Burullus	6,619 fishers	
Morocco	Nador lagoon	200 boats, each with a minimum of 2 fishers (GFCM, 2010)	Small-scale eel fishing occurs in inland waters as well as on the Atlantic and Mediterranean coasts (GFCM, 2010).
	Merja Zerga	Around 2,500 households obtain part of their income from the resources of is tidal lagoon (Benessaiah, 1998).	The European Eel represents 21% of the catch in Merja Zerga (Kraiem, et al., 2009).
Tunisia		225 inland boats registered, with only 2 fishers per boat allowed. Plus 113 authorized fishers in coastal lagoons (MEDD, 2010).	The coastal marine fleet consists of 10,000 boats. Although eels are not the main target of fishers, an average of 100 tonnes is captured from this source every year (MEDD, 2010). 448 fixed fishing units are reported. These include using gill nets, trammel nets, bottom longlines, traps and Charfias (MEDD, 2010).

Table 2 Main production figures for the European Eel in northern Africa in 2009

COUNTRY	CAPTURES (t)[1]	CAPTURES (USD)	AQUACULTURE (t)[2]	AQUACULTURE (USD)	TOTAL (t)	TOTAL (USD)
Algeria	No data	No data	14	26,000	14	26,000
Egypt	940	6,138,200[3]	No data	No data	940	6,138,200
Morocco	40	129,200[4]	60	746,000	100	875,400
Tunisia	108	348,840[4]	67	67,000	175	415,540
Total	**1,088**	**6,616,240**	**141**	**839,000**	**1,229**	**7,455,140**

[1] Captures of European Eel in marine, brackish and freshwater systems, from FAO Fishstat database (FAO, 2011).
[2] From FAO Fishstat database (FAO 2011).
[3] Average price per kg at Cairo Wholesale Market (El Abour), EGP 39.36 = USD 6.53 (GAFRD, 2010).
[4] Average price per kg at the Bir El Kassaa wholesale market in Tunisia, TND 4.8 = USD 3.2 (MEDD, 2010). This value was used for Morocco due to lack of reliable data for 2009.

Manzalla, 10 from Lake Qaroun and 442 tonnes from the Nile (GAFRD, 2010).

In northern Africa the exploitation of eels has long been considered a profitable activity due to the fish's economic value. The number of people involved in eel fisheries in the region is not known (see Table 1), but is likely to be in the thousands. For example, in Egypt the eel is often not the target species for fishers, so the number of people harvesting eels is unknown. However, in 2009 there were 1,587 licensed fishers in the Nile Delta, which is one of the major eel harvesting areas. In Merja Zerga on the Atlantic coast of Morocco the European Eel represents 21% of the fish harvest (Kraiem, et al., 2009), and a minimum of 2,500 households derive at least part of their income from this tidal lagoon (Benessaiah, 1998). Based on Table 2, capture fisheries and aquaculture production of European Eels generated a total income of at least USD 7.4 million in 2009 in northern Africa (Table 2). Before the current trade ban came into force, Morocco, Algeria and Tunisia were the largest exporters of European Eel to the EU, after Norway (Crook, 2010). In Algeria and Tunisia 80–90% of eel production is exported, as there is little tradition of eel consumption in these countries (MEDD, 2010; MPRH, 2010).

Given the critical situation of the European Eel, it is vital to address all threats that are contributing to the steep decline in recruitment that has been observed (Astrom & Dekker, 2007; Bevacqua, et al., 2007; FAO/ICES, 2010). These include reducing harvesting to minimum levels and/or imposing more sustainable fishing practices, but also preventing habitat loss and degradation caused by anthropogenic activities. Saving the European Eel is important, not only to safeguard biodiversity but also because, as this case study shows, it plays an important role in the livelihoods of thousands of people across northern Africa.

Case study 3.2 The Nile Tilapia *Oreochromis niloticus* in Egypt

by Saleh[2], M.A.

Tilapias, a name that refers to species of the Cichlidae family belonging to the genus *Oreochromis*, *Sarotherodon* and *Tilapia*, are a very important group of fish in Egypt. The total production of these fish in 2009 was 495,300 tonnes, representing 45.3% of the total fish production of Egypt (GAFRD, 2010). This figure is the sum of both captures (inland fisheries) and farm production (aquaculture) of tilapia. The total market value of this production was USD 752.2 million in 2009.

Most wild-caught tilapia comes from the Northern Delta lakes (78,900 tonnes), followed by the Nile river and the extensive irrigation canal system (26,100 tonnes). The Nile Tilapia *Oreochromis niloticus*, listed regionally as Least Concern in continental Africa, makes up most of the tilapia caught in the Nile system and, to some extent, in the Egyptian lakes (60–70%, according to unpublished GAFRD catch records for different landing sites). This mainly diurnal, herbivorous fish occurs in a wide variety of freshwater habitats such as rivers, lakes, canals and irrigation channels. Although IUCN regional assessments have not identified any major widespread threats to this species, native populations may be affected locally by overfishing, habitat loss and hybridization, as are other *Oreochromis* species. The Red Belly Tilapia (*Tilapia zillii* LC[RG]) comes next in importance (15–20% of captures), especially in the lakes, while the percentage of Blue Tilapia (*Oreochromis aureus* LC[RG]) and Mango Tilapia (*Sarotherodon galilaeus galilaeus* LC[RG]) in the catch varies as one goes north. The Nile Tilapia is therefore of paramount importance for inland fisheries in Egypt, where thousands of people depend on the industry (see Section 3.2.1).

Stocking fingerlings of Nile Tilapia (*Oreochromis niloticus*) in earth pond in the Wilaya of Ouargla, Algeria. Photo © FAO Aquaculture photo library / V. Crespi.

[2] Fisheries and Aquaculture Independent Consultant, Cairo, Egypt.

Tilapias, like this fish of the *Oreochromis* genus, are a very important group of fish in Egypt. Photo © Drriss.

The Nile Tilapia also constitutes the bulk of the farmed tilapia produced in Egypt, where 390,400 tonnes were harvested in 2009. Most cultured Nile Tilapia are produced semi-intensively in earthen ponds in the Northern Delta Region and in floating cages in the Nile. Most of the aquaculture facilities in the country get their seed requirements from fish hatcheries, where mono-sex Nile Tilapia is the only tilapia species produced (Saleh, 2007). It is estimated that more than 90% of cultured tilapia is *Oreochromis niloticus*, the rest being Blue Tilapia (5–7%) and a mixture of Red Belly Tilapia and Mango Tilapia. Brood stocks in all hatcheries are sourced originally from the wild (the Nile and lakes) and no interbreeding of species or hybridization is applied. A line of selected fish is usually kept back in the hatcheries to serve as future brood stock (brood stock from hatchery-bred tilapia is much easier to handle than wild fish). Additionally, most hatcheries from time to time introduce new blood into their system to improve the genetic pool by adding wild fish. Introduction of exotic tilapia (of whatever species) is strictly forbidden in order to preserve the local strains from the probable negative effects of genetic distortions.

According to the figures given above, the production of Nile Tilapia alone in Egypt may be in the region of 414,600–425,200 tonnes, representing about 38.6% of the total fish production of Egypt.

The development of Nile Tilapia farming has facilitated the growth of important supportive industries, which may employ 20,000–30,000 people (M. Saleh, unpublished data, 2011). The number of feed mills specializing in producing tilapia feed has increased greatly to meet demand. More than 14 large feed mills and a large number of small processing units are presently operating in the country, producing about one million tonnes of feed each year. The activity also supports the large handling, processing, packing and marketing chain in the country.

The Nile Tilapia *Oreochromis niloticus* can accordingly be considered of very important economic value to the country. Production of this species creates a large number of jobs, as more than 300,000 persons depend on the production of Nile Tilapia in aquaculture as their main source of income. This figure is estimated from the total number of people working in aquaculture, as reported in the 2009 GAFRD Year Book of Fishery Statistics, considering that most fish farming in Egypt produces Nile Tilapia (as its basic product) together with mullet and/or carp. If Nile Tilapia is not cultured, the activity will become inviable and disappear.

4 THE SOCIO-ECONOMIC VALUE OF AQUATIC PLANTS

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Collection of reed in the River Nile. Photo © Jon Savage.

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[3] Tour du Valat, Le Sambuc, 13200, Arles, France.

Loukkos marshes, Larache, Morocco. Photo © S.D. Muller.

Ouzoud Waterfalls are located 150 km north-east of Marrakech, in Morocco. Photo © Jean-Pierre Boudot.

Aquatic plants were commonly used in Ancient Egypt and were also culturally important. This picture shows men pulling tight knotted Papyrus (*Cyperus papyrus*) and Egyptian Lotus (*Nympha* spp.) around a windpipe. This symbolized the unified kingdom of ancient Egypt: the papyrus represents Lower Egypt and the lotus represents Upper Egypt. Photo © K.Green.

This chapter presents information on the socio-economic value of aquatic plants in the northern African region. In Section 4.1, the conservation status of aquatic plants is described and, in Section 4.2, their socio-economic value is evaluated to determine which species are utilized, how are they being used, which part of the plants are used and where they are collected. Those taxa identified as being of high importance are described in more detail in Section 4.3. The role of crop wild relatives in the plant conservation agenda and the socio-economic significance of this group in the NAR are discussed in Section 4.4. Patterns of distribution of utilized and threatened species are presented in Section 4.5 and the nature of the threats is addressed in Section 4.6. Finally, some conclusions and recommendations are presented.

4.1. CONSERVATION STATUS OF AQUATIC PLANT SPECIES

A total of 496 species and 22 subspecies of plants occurring in freshwater ecosystems are included in this study. All the species are native to northern Africa and have previously been assessed for their risk of extinction in the NAR (García, et al., 2010) or the Mediterranean basin (IUCN, 2010). Only species found in NAR countries were selected from the Mediterranean assessment. The 22 subspecies included in the dataset are unique to the region.

Of the 518 species and subspecies included in this study, 24.5% are threatened with extinction in northern Africa (Table 4.1). Eighty-six of these aquatic plants are endemic to the region, 38 of which (44%) are threatened, and therefore globally threatened too. This level of threat is much higher than in other regional assessments carried out, such as the western African assessment, where the regional level of threat was 1.5% (Smith, et al., 2009) but it is closer to the 23% of threatened aquatic plants listed in the Central African assessment (Brooks, et al., 2011). At a continental level it is also higher than the average. Twenty per cent of aquatic plants in continental Africa are at risk of extinction and 25% of endemic plants are listed as threatened (Juffe-Bignoli, 2011).

Levels of threat are therefore high in this region, which is regarded as a global conservation priority as it lies within the Mediterranean Basin Biodiversity Hotspot, which is well known for the high diversity and level of endemism of its flora (Mittermeier, et al., 2004). This highlights the need for action in the area from a species conservation perspective but, as this chapter will demonstrate, action will be positive not only for species but also for people who benefit directly from these resources.

Table 4.1 Number of aquatic plants in each regional Red List Category in the northern African region

IUCN Red List Category	All Plants	%	Endemic Plants	%	
Regionally Extinct (RE)	1	0.2%	0	0%	
Critically Endangered (CR)	30	5.8%	13	15%	Threatened categories
Endangered (EN)	27	5.2%	7	8%	
Vulnerable (VU)	70	13.5%	18	21%	
Near Threatened (NT)	73	14.1%	26	30%	
Least Concern (LC)	265	51.2%	17	20%	
Data Deficient (DD)	52	10.0%	5	6%	
Total number assessed	**518**	**100%**	**86**	**100%**	

4.2. SOCIO-ECONOMIC VALUE

Results of this study reveal that at least a quarter of all the aquatic plants in the NAR are known to be used (Table 4.2). However, if uses reported from around the world are taken into account, 42.7% of the species in northern Africa should be considered to be of economic value. The reason for this discrepancy is that in many cases it has been possible to confirm that a plant is used in a specific northern African country, whereas for other species it has only been possible to verify use in sub-Saharan Africa or non-African countries. Recorded uses per NAR country are shown in Table 4.2. Of the 86 species endemic to northern Africa that are included in this study, 11 (12.8%) are known to be used.

The use of plants is diverse and complex as Figures 4.1, 4.2 and 4.3 reveal. Almost all parts of plants at different life stages are known to be utilized. Plants have a wide range of uses and for almost half of the plants more than one use has been recorded, as Figure 4.2 shows. For example, six different uses for *Typha domingensis* have been recorded. This species is used in Algeria, Egypt, Morocco and Tunisia and also in sub-Saharan Africa. Its flowers, stems, roots and pollen are edible and it has also been used as a medicinal plant, for handicrafts, fuel, fibre and animal feed, and as construction material. For example, ash made from its rhizomes is applied to wounds in Morocco. Its leaves are used for weaving and making string, chair seats, mats, etc., across Africa. Like other *Typha* species, the plant produces considerable biomass and can be used as fuel in cold winters. None of the species in this family (Typhaceae) are threatened, although one species, *Sparganium erectum*, has been listed as NT^{RG}. This species, like aquatic plants in general in northern Africa, is suffering habitat decline due to wetland drainage for agricultural use, water pollution and development.

The five main uses of aquatic plants are for medicines, food for humans, animal feed, ornamental or horticultural use, and as a source of non-medicinal chemicals (Figure 4.1). A significant number of plants have also been recorded as being used for making handicrafts and household goods, and as construction and structural materials. Although a third of these plants are cultivated, 70% of the species are collected from the wild, according to this study. Ornamental species are an exception as they are generally cultivated for sale in the aquarium trade or for use in gardens and ponds. Eleven species are known to be used in aquaria and most of them are cultivated.

In many cases the harvesting of plants is non-lethal. The collection of leaves, young shoots, bark, flowers, pollen, fruits or seeds is common and generally does not harm the species or population if done seasonally and sustainably. Figure 4.3 reveals that, although for almost half of the species the whole plant is used, for the remainder only parts of the plant are used. In many cases several different parts of one single species are used. The

Table 4.2 Number of aquatic plant species known to be of economic importance in the northern African region

COUNTRY OF USE	SPECIES USED	% TOTAL SPECIES
Morocco	84	16,22%
Egypt	46	8,88%
Algeria	43	8,30%
Libya	23	4,44%
Tunisia	18	3,47%
Total NAR	**143**	**27,61%**

Note that the same species may be used in several different countries

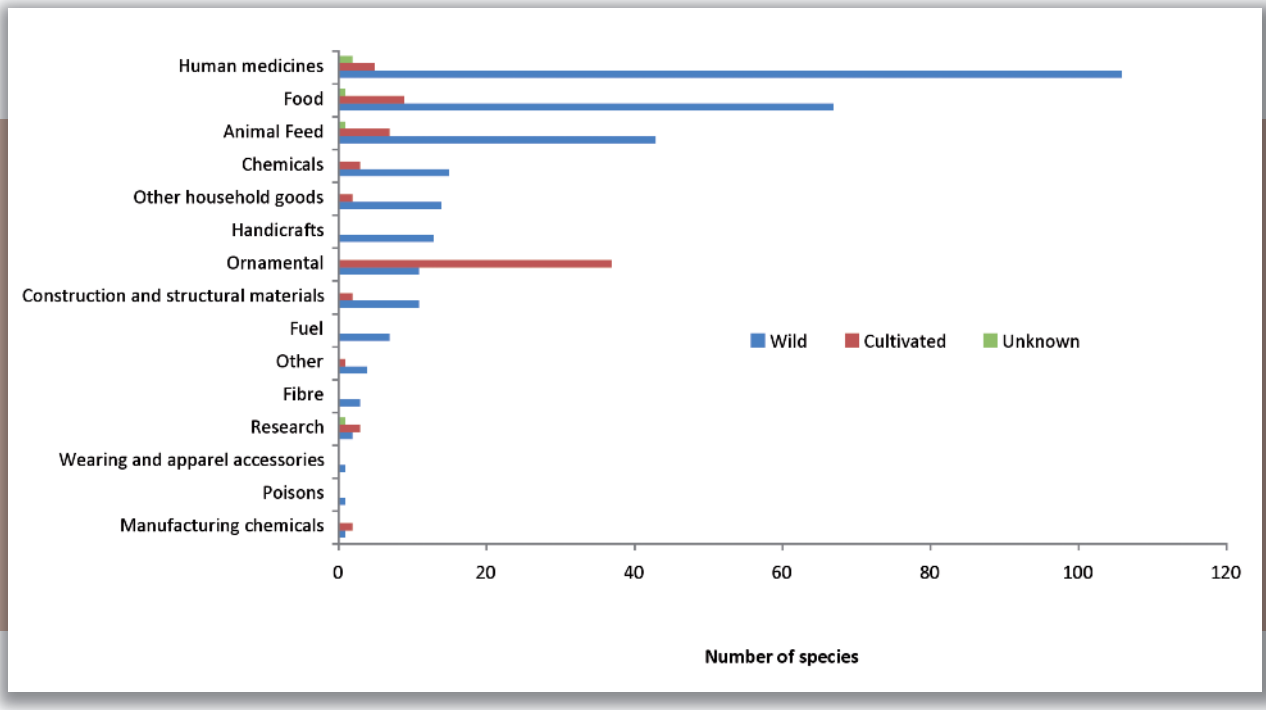

Figure 4.1. Recorded uses for aquatic plants and where are they sourced from (source: IUCN Freshwater Biodiversity Unit). Note that a single species may be both collected from the wild and cultivated for different uses.

fully aquatic water Lily *Nymphaea alba* (VU[RG]), which is utilized in Morocco, Algeria and Libya (and also in Europe and the Mediterranean basin, where it is listed as LC[RG]), has several parts of its plant used for different purposes: whole plant (ornamental), rhizome (black dye for wool, medicine and food), flowers (medicine and ornamental), seeds and fruits (food). In northern Africa, it is threatened by habitat loss due to agriculture, which has destroyed most of its wild range.

A breakdown of **utilized plants by families** reveals that 47 of the 66 families included in this study contain at least one species of socio-

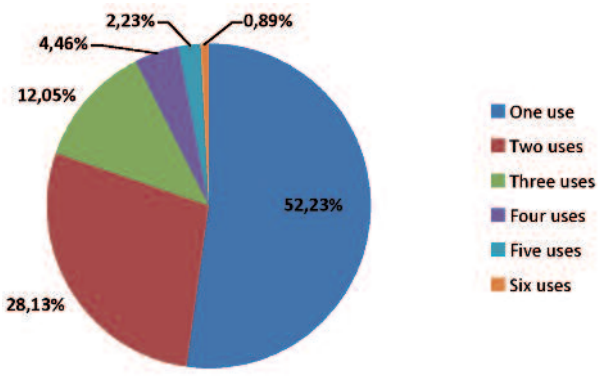

Figure 4.2. Proportions of aquatic plant species according to number of different uses (source: IUCN Freshwater Biodiversity Unit).

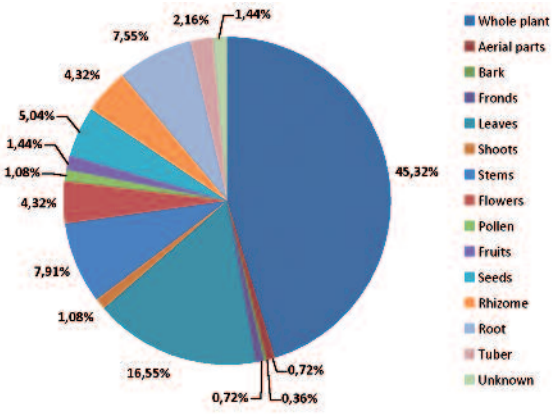

Figure 4.3. Parts of plants used and percentage of plant species recorded to be used for each part (source: IUCN Freshwater Biodiversity Unit). Note that these figures do not refer to the parts of the plant harvested but to the parts actually used.

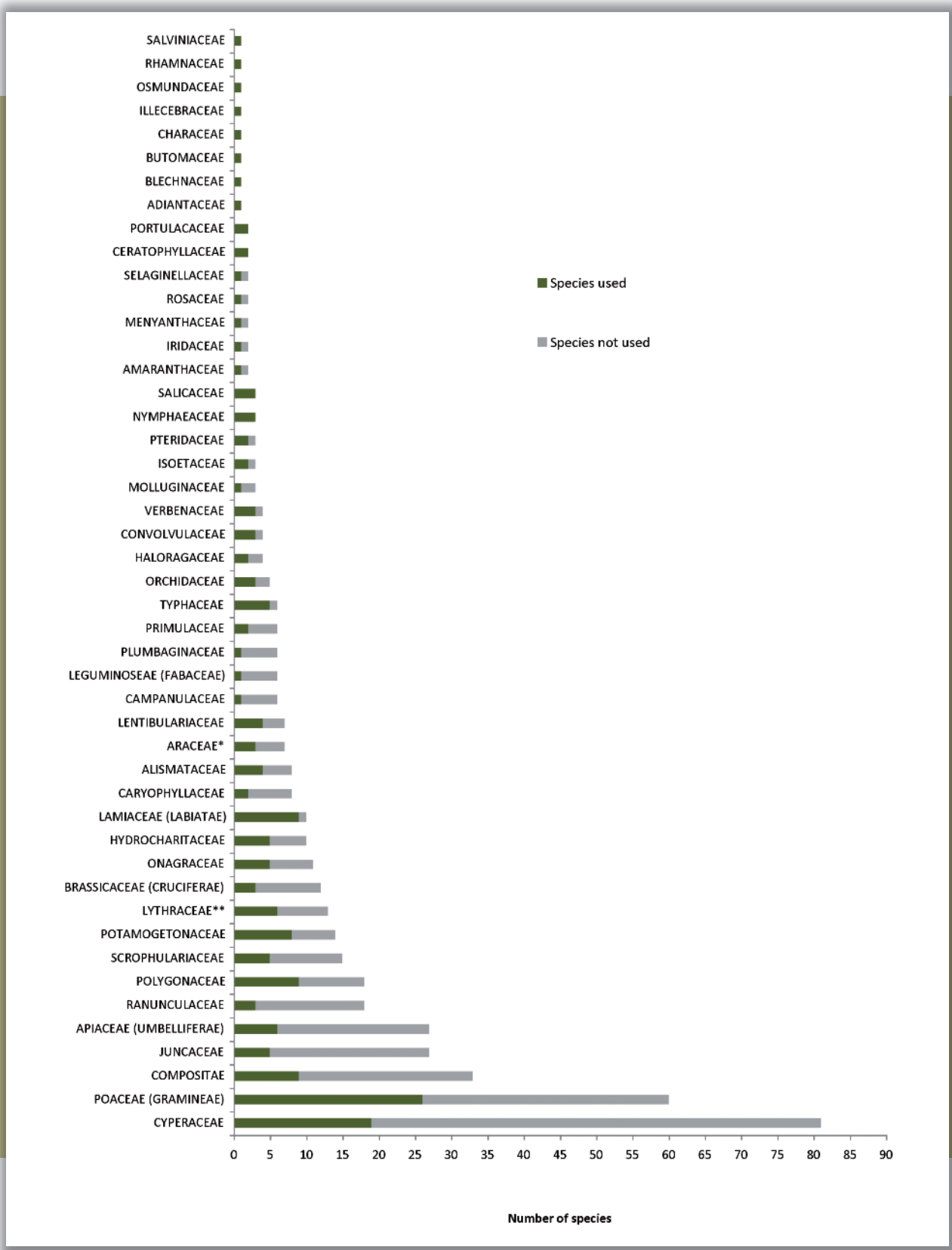

Figure 4.4. Number of species used in each plant family (source: IUCN Freshwater Biodiversity Unit). Families with only one species used have been excluded. Other commonly accepted names for some families are given in parentheses.

*Only species of the genera *Lemna*, *Landoltia*, *Wolffia* and *Wolfiella* (in Lemnaceae in García, et al., 2010).

** Including *Trapa natans* (in Trapaceae in García, et al., 2010).

economic importance (Figure 4.4). In terms of proportion of use (number of species used per number of species assessed), 30 families have at least 50% of their assessed species used. For 17 families, only one species is known to be used, and in eight families only one species was assessed. Nevertheless, whether the number of species or the proportion of species is analysed, these figures show the richness of uses of the region's aquatic flora, with most families contributing to some kind of use across the region.

The families with the largest number of species known to be utilized are Cyperaceae (Sedges) and Poaceae (Grasses), with 19 species (23% of the species in the family) and 26 species (44%) identified as being of socio-economic value, respectively. Compositae (Daisy family), Lamiacaeae (Mints), Polygonaceae (Knotweed family), Nymphaceae (Water Lilies) and Caryophyllaceae (Carnation family) have a significant number of species used. The Grasses and Sedges are extremely important groups with very varied uses (Figure 4.5), providing for all basic needs such as food, medicine, structural materials and household goods, as well as goods from which people can obtain an income, such as handicrafts, essential oils, and ornamental and horticultural plants.

4.2.1. Medicinal use

The most frequently recorded use for plants is **medicinal**. A total of 180 medicinal plants have been identified in this study (34% of the species) and at least 90 of these are used in northern Africa. The disproportionate number of species of medicinal use among used plants (more than the species known to be used in northern Africa) has two reasons. Extensive research has been conducted on the medicinal properties of plants for centuries and, even today, plants are still being studied for their potential applications in medicine. Moreover, medicinal plant use is very common in developing countries, where in many cases there is no easy access to modern medical facilities. Medicinal plants are normally used to deal with

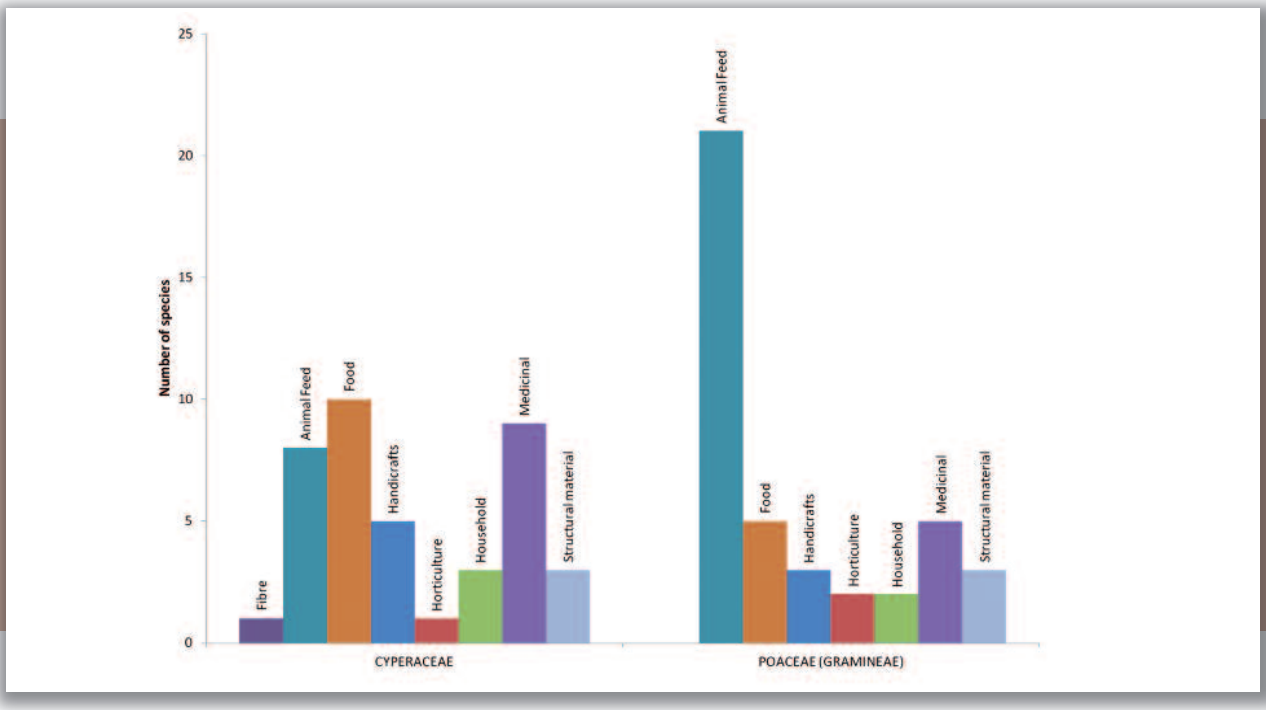

Figure 4.5. Uses recorded for Grasses (Poaceae) and Sedges (Cyperaceae) in northern Africa (source: IUCN Freshwater Biodiversity Unit). Note that more than one use may be recorded for the same species.

symptoms of colds and minor diseases, and also for pain relief (for headaches, wounds or stomach cramps); as diuretics (most *Mentha* spp.), astringents, purgatives, tonics or sedatives; to soothe wounds; or to cure bronchitis, fevers, etc. *Lythrum borysthenicum* (LC[RG]) has been recorded to be used in Morocco to heal wounds, as has *Persicaria senegalensis* (LC[RG]) in Egypt. *Apium graveolens* (Wild Celery, LC[RG]) is a common medicinal plant used throughout the NAR for the treatment of rheumatism, arthritis and gout. This plant is also used as food and is widely cultivated. In the wild the species grows in coastal salt marshes and salt springs and on lake shores. The whole plant of *Rumex crispus* (LC[RG]) is used as a tonic, purgative and astringent in Libya. The range of medicinal uses and of plants used for medicine is wide and, although they do not focus on aquatic plants, there are books and publications that list and describe medicinal plants within countries and/or regions (i.e.: Boulos, 1983; Kotb, 1985; Mimoudi, 1988; Bellakhdar, 1997; Batanouny, 2005; IUCN, 2005; Batanouny, 2006).

Use of *Juncus articulatus* and *Juncus maritimus* in Saidia, a touristic resort in north-eastern Morocco. Photo © M. Melhaoui.

4.2.2. Food

Plants that are **used as food**, or eaten or drunk for other non-medicinal purposes form the second largest group of utilized plants. Several species are regularly used as food in northern Africa. *Nasturtium officinale* (Water Cress, DD[RG] but LC[RG] in the Mediterranean) is a species in the Cabbage family (Brassicaceae) which is often used in salads in Morocco, Libya and Egypt; it is also cultivated. *Cyperus esculentus* (LC[RG]), whose fruit is known as Tiger Nut in Africa, is consumed in Egypt and Libya and is also used as a milk substitute, sweetener, and for infusions. Its tubers are used as a stimulant and aphrodisiac, and are also used to make flour of high caloric value; roasted tubers are used as a substitute for coffee and cacao. Minced rhizomes of a common aquatic plant, the Yellow Iris (*Iris pseudacorus*, LC[RG]), are mixed with couscous in a popular dish in northern Africa. *Trapa natans* (EN[RG]) is threatened by habitat loss and currently has a restricted range in NAR, but it produces a sweet and edible fruit that is taken from the wild in Africa and also planted in private gardens across Asia. Species in the genus *Mentha* (Lamiaceae) are very popular in northern Africa. They are used for seasoning, for making traditional mint tea and as medicinal plants; most species in the genus, including threatened and endemic species, are known to be of economic value in the area. This family is dealt with in detail in **Case study 4.1.**

Species used as **animal feed** are also numerous and are economically important as pasture for feeding livestock, especially in rural areas close to rivers and wetlands. These are species belonging mainly to the Grasses (Poaceae) but also to other families such as Cyperaceae (Sedges), *Rumex* species (Docks and Sorrels), and Typhaceae (Bulrushes). Four species of the genus of aquatic grasses *Glyceria* are used to feed cattle in northern Africa. These include *Glyceria fluitans* (EN[RG]) and *Glyceria declinata* (VU[RG]), both regionally threatened by drainage, small-scale agriculture and urbanization. *Panicum coloratum* (LC[RG]) is used in

Egypt to feed cattle. This species can be grazed by animals but also cut to make good-quality hay and silage (Cook, et al., 2005). *Typha latifolia* (LC[RG]) is a common species in northern Africa and has also been used to feed cattle in Egypt. *Cyperus esculentus* (LC[RG]), mentioned already in this chapter, is also used to feed cattle due to the high nutritional value of its tubers.

4.2.3. Other uses

Other uses such as for **construction materials, handicrafts and household goods** are equally important to local livelihoods. Many species of the Cyperaceae (Sedges), Juncaceae (Rushes) and Typhaceae families are commonly used for thatching (*Typha domingensis* DD[RG], *Arundo donax* LC[RG], *Juncus acutus* LC[RG]); weaving (*Typha* spp., *Juncus effusus* LC[RG], *Cyperus longus* LC[RG]); making mats (*Cyperus articulatus* LC[RG], *Schoenoplectus corymbosus* LC[RG], *Sparganium erectum* NT[RG]); forming windbreaks or parasols (*Arundo donax* LC[RG], *Phragmites australis* LC[RG], *Juncus acutus* LC[RG]); and making baskets (*Juncus acutus* LC[RG], *Juncus maritimus* LC[RG]), among many other uses. *Arundo donax* (Giant Reed) is a widely used and economically important hydrophyte grass. It is considered naturalized in the Mediterranean basin as it was introduced before 1500 BC, and it is also cultivated in America and Asia. The plant grows long, hard canes that are used for many purposes in Morocco, Algeria, Tunisia and Libya. It is used for making handicrafts, thatching, windbreaks in beach resorts and houses, and parasols. It is also valued as an ornamental species, can be planted in wet soils to reduce erosion, and its tubers are used for cases of chronic rheumatism. The aerial part of this species can also be used as fodder, although only young leaves are palatable. In the wetlands of north-western Morocco (Tangier and Tétouan), simple or braided panels of *Arundo donax* for use as ceilings or window curtains are sold at an average price of MAD 15.6 ± 9.9 /m² (USD 1.9 ± 1.2) (Ennabili, et al., 1996).

4.3. THE IMPORTANCE OF AQUATIC PLANTS TO LIVELIHOODS IN NORTHERN AFRICA

One of the aims of this study was to collect data related to rural livelihoods in northern Africa in order to reveal what role aquatic plants play in local economies.

Trade in wild plants is an important economic activity across the world. In terms of medicinal plants alone, global sales of herbal products totalled an estimated USD 60,000 million in 2002, with 80% of the population in developing countries relying largely on plant-based drugs for their health care needs. Bulk trading in these species still depends on wild harvesting. For example, in Bangladesh at least 90% of medicinal plants are taken from the wild (FAO, 2005). The same proportion (90%) of medicinal plants in Morocco is collected from the wild (Chemonics International, 2008; IUCN, 2011). Morocco was the eighth largest exporter of medicinal plants to the EU in terms of value, accounting for USD 13.5 million in 2002. In

the same year Egypt was the ninth main exporter to the EU at USD 9.8 million, and Tunisia was 32nd at USD 1.9 million (FAO, 2005). These exports were plants, parts of plants, seeds and fruit, used in perfumery or for medicines, insecticides, fungicides or similar purposes, fresh or dried, and whole or processed. The proportion of aquatic plants involved in this trade is, however, not known.

4.3.1. Morocco

In northern Africa, wetland vegetation can provide local people with a source of income through the production of household items and various utensils and craft products for sale to customers including tourists (Batanouny, 2006). Wild aquatic plants are also valued locally as medicines, foodstuffs (such as tea, salads and spices) or construction materials for thatching and hedging. They are not always traded in local markets and usually never leave the household, as plants are used directly by local communities and are therefore an important resource to improve people's daily lives. For example, a study of the socio-economic value of the Merja Zerga wetland in coastal Morocco examined the livelihoods of at least 2,500 households that lived on the resources provided by this wetland. The household income thus obtained was estimated at USD 803/year, 14% of which was obtained from the harvest of rushes (*Juncus* spp.) (Khattabi, 2006). The making of *Juncus* mats is a profitable business, especially for the poorest households. Mats measuring 3.5 x 1.75 m were sold for MAD 40 (USD 4.8) and provided a net annual income of MAD 1,014 (USD 121) per household in 1997 (Khattabi, 1997). Ennabili et al. (1996) carried out a socio-economic assessment of several wetlands in north-western Morocco, covering the provinces or prefectures of Tangier, Tétouan, Larache, Chefchaouen and parts of Kénitra and Al Hoceima. The authors carried out 469 surveys at 58 stations scattered over this area. Relevant results of this study are presented in Table 4.3. Employment rates directly linked to wetlands varied widely from one station to another, representing 19.8% ± 11.5% of seasonal workers and 6.0% ± 4.0% of those with permanent jobs. Similarly, the authors mentioned that artisans have only a summer season of three to four months with a potential daily net income in the range of MAD 46.7 ± 32.2/day/person (USD 5.24 ± 3.86).

Table 4.3 shows the importance of certain species to the local economy in terms of income generated for households and/or individuals in Morocco. These species are also used across the rest of the NAR, where they are expected to play a similar role in rural economies. *Sparganium erectum* (NT^{RG}), *Typha angustifolia* (LC^{RG}) and *Arundo donax* (LC^{RG}) are aquatic plants harvested to make handicrafts and household goods and to feed livestock. *Typha angustifolia*, for example, can produce up to 217 tonnes of fresh biomass per hectare in the wetlands of north-western Morocco, which results in an annual gross income of around USD 9,000 per hectare. *Portulaca oleracea* (LC^{RG}) is cultivated in rural areas near Rabat, where the annual harvest can bring in MAD 500 (USD 60) for an average household (Rhazi, unpublished data, 2011). *Phragmites australis* is a widely used and economically important species across the world (*see* Case study 4.2). Although these species are not at risk of extinction, they are known to be affected by habitat loss and degradation caused by agriculture, water abstraction, land reclamation and water pollution, all of which are anthropogenically derived threats.

The significance of some of these species is patent when revenues are compared to the per capita agricultural GDP (Gross Domestic Product) in Morocco, which was USD 726 in 2004 (IFAD, 2007). Indeed, some of these plants can provide an annual income that is even higher than the per capita agricultural GDP in Morocco (*see* Table 4.3).

Figure 4.6 summarizes information on who carries out harvesting, how plants are harvested, when they are harvested and whether they are traded. This information was extracted from the database created for this project by choosing the plants in Morocco for which the answer to the four questions was available. While this information should not be generalized to the whole region, it provides an

Table 4.3. Monetary value of selected aquatic plant species in some wetland areas in Morocco

SPECIES	AREA OF STUDY	VALUE	DESCRIPTION
Arundo donax	Wetlands of north-western Morocco	USD 3.97/person/day	Potential revenue from harvest. Annual gross financial product of harvesting is estimated at USD 8,929/ha. Harvested for use as construction and craft material.
Cladium mariscus	Wetlands of north-western Morocco	USD 10.8/person/day	Potential revenue from harvest. Harvested for basketry and thatching. Also used as a dye.
Iris pseudacorus	Morocco	USD 7.95/person/day	Net potential revenue from harvest. Harvested to be sold as an ornamental plant, and for medicinal use.
Juncus spp.	Merja Zerga	USD 121.68/household/year	Average net annual income from harvest. Harvested for making handicrafts and thatching.
Mentha pulegium	Benslimane	USD 120/household/year	Household revenue in rural temporary wetland areas. Harvested for food, medicinal use, for its aromatic properties and extraction of essential oils.
Phragmites australis	Wetlands of north-western Morocco	USD 6/person/day	Net potential revenue from harvest. Harvested for making handicrafts and thatching.
Portulaca oleracea	Rural areas near Rabat	USD 60/household/year	Estimated revenue from harvest in rural areas near Rabat. Harvested for food.
Sparganium erectum	Wetlands of north-western Morocco	USD 7,674/ha/year USD 5.52/person/day	Estimated annual gross financial product of local harvest is USD **7,674 /ha.** Harvested for making handicrafts (mats, baskets) and to be used as fodder.
Typha angustifolia	Wetlands of north-western Morocco	USD 10.66/person/day	Potential revenue from harvest. Estimated annual gross financial product of harvesting is USD **9,641/ha.** Harvested for making handicrafts.

Values in Moroccan dirham were converted to US dollars at the rate MAD 1 = USD 0.12

interesting *livelihoods snapshot* as these 58 species represent 40% of the aquatic plants known to be utilized in northern Africa. Aquatic plants are mainly collected by women, either alone or accompanied by men or children. This harvest is carried out manually or with the aid of simple tools such as sickles and mattocks. Most species are used for subsistence, although 33% of the species reach local markets. All species are harvested seasonally, mostly in spring and summer.

In addition to their economic value derived from direct use, some wetland plants provide water treatment, which is of great economic importance in northern Africa. For example, according to the National Office of Drinking Water in Morocco

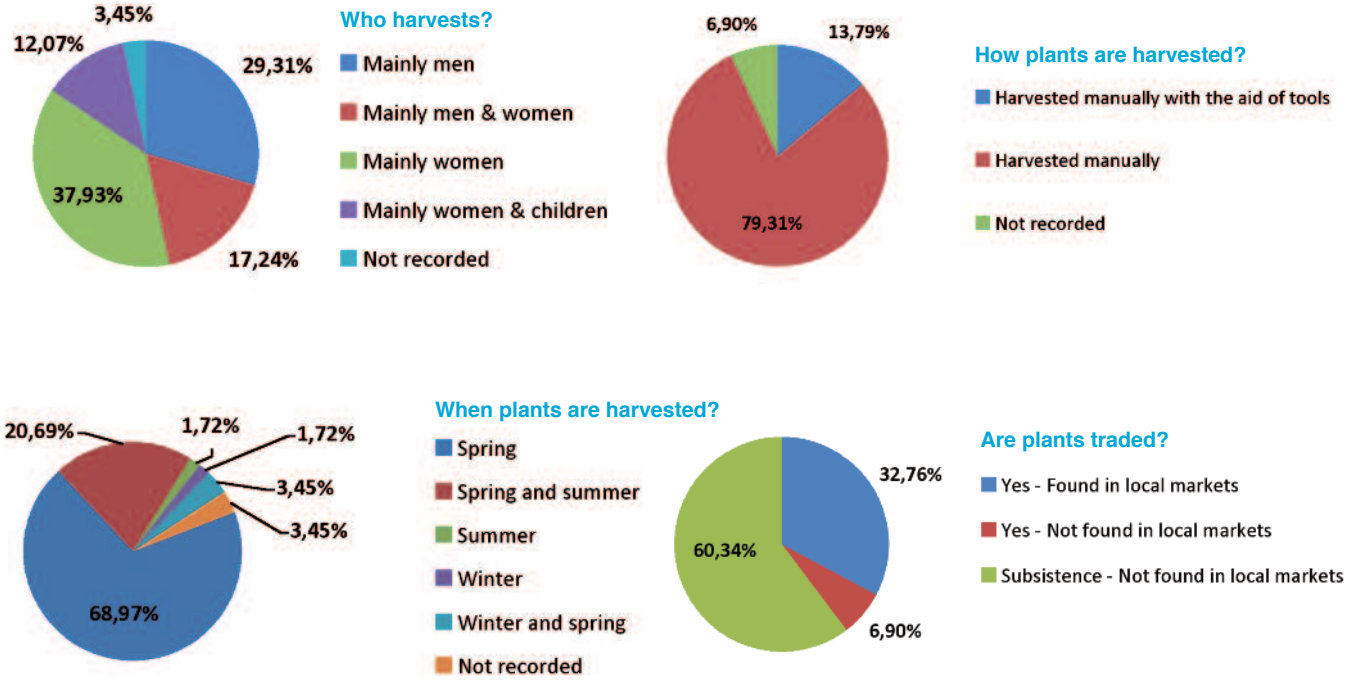

Figure 4.6. The harvest of 58 aquatic plants in Morocco (source: IUCN Freshwater Biodiversity Unit).

(ONEP), the volume of wastewater discharged into the Restinga Smir wetland in north-western Morocco is estimated at 215,570 m^3/year. The cost of cleaning the water by industrial processes is in the order of MAD 316,890/year (USD 38,027). Water purification provided by hygrophytes contributes up to 12% to the annual partial usage value of Restinga Smir, which amounts to MAD 2.6 million (USD 312,000) (Khattabi & Sefriti, 2005).

4.3.2. Other northern African countries

In Tunisia, freshwater plants are also an important resource for poor rural communities. The Garâa Sejenane is a vast, complex plain with a system of temporary ponds in the Mogods region in northern Tunisia, which covers 2,500 hectares and is known for its high botanical value (Ferchichi-Ben Jamaa, et al., 2010). The inhabitants of this region live in relatively isolated small villages known as *douars*. Their livelihoods are based on subsistence agriculture, including crop rotation and livestock farming. According to an ethnobotanical survey conducted in the area in 2010 (Ben Haj Jilani, et al., unpublished), all 518 households spread over eight douars used *Juncus acutus* (LC^{RG}), *Phragmites australis* (LC^{RG}) and *Typha domingensis* (DD^{RG}) to thatch the roofs of their houses. *Mentha pulegium* (LC^{RG}) was used as a medicinal plant to treat fevers and colds, or yielded pigments for painting. Threats to these species include habitat loss and degradation due to agriculture-related activities, water abstraction and pollution, and urbanization. Besides grasses, aquatic plants in the genera *Isoetes* (Quillworts) and *Rumex* (Docks) were recorded as being eaten by livestock. *Rumex tunetanus* (CR) is very rare and endemic to the Garâa Sejenane area in Tunisia; it was recorded as being grazed by cattle, along with other species of the same genus. Threats to this species are drainage, agricultural expansion, grazing and the development of road infrastructure.

The data presented in this section provide evidence that aquatic plants play a significant role in rural economies and are used and traded by people across northern Africa. The number of people involved in these activities is not known,

although some examples presented here demonstrate that aquatic plants contribute to annual household incomes and provide other products and services, such as structural materials for building homes, feed for livestock and medicines used by thousands of rural settlers across northern Africa. However, more detailed information, including specifically livelihood-targeted field research, will be required in order to obtain firmer and more conclusive results. Such research was beyond the objectives of this current desktop study.

4.4. CROP WILD RELATIVES—VALUE FOR THE FUTURE

Crop Wild Relatives (CWR) are wild species with a close genetic similarity to cultivated crops. The definition of CWR and the determination of different grades of CWR depending on the genetic proximity of the species are dealt with in detail by Maxted et al. (2006). Brehm et al. (2010) provide an example of CWR selection for a specific region. Interest in CWR has increased in recent years, as their value and growing use have been widely recognized by the global conservation community. CWR are now considered a critical component in the conservation of plant resources for food and agriculture (Maxted, et al., 2010). CWR provide genetic resources for the future, as they are a source of genes for crop improvement via both traditional breeding and biotechnology, which will allow agriculture to adapt to a changing world. There are many global initiatives and regional policy instruments that aim to conserve CWR. CWR are recognized in the CBD Global Strategy for Plant Conservation, the International Treaty on Plant Genetic Resources for Food and Agriculture, the European Plant Conservation Strategy, etc. (see Maxted, et al., 2010, for more information). From an economic perspective, global trade in CWR is worth an estimated USD 115 billion.

Some studies aiming to identify how many CWR there are have come up with significant numbers of species. For example, Kell et al. (2008) reported that 85% of the European Flora consists of crops and CWR species. Clearly, these numbers should lead to prioritization strategies in order to direct conservation efforts at the CWR that are most at risk of being lost and to identify the most relevant areas in terms of species richness and economic importance. CWR prioritization methods are being developed (Brehm, et al., 2010) and the identification of CWR around the world is under way.

In this study it was decided whether a species is a CWR or not without entering into detail about its genetic proximity to the crop. The aim of this approach was to highlight another important socio-economic value of wild plants: they are a genetic resource that enables future generations to ensure their food supply while providing the means to address agricultural issues that may arise (through resistance to disease, drought or climate change, for instance). In this respect, 342 species in this study were identified as CWR by the IUCN/SCC Crop Wild Relative Specialist Group (Lala & Maxted, 2011). If the number of aquatic plants of socio-economic value in northern Africa is recalculated once CWR have been included in the equation, the proportion is striking: 66% of aquatic plants in the region should be considered of socio-economic value. While the global importance of CWR is irrefutable, these results are presented separately in order to differentiate between potential and actual uses of aquatic plants. However, it should be stressed that 44.1% (151 species) of CWR identified are already being used in northern Africa or sub-Saharan Africa.

Given the difficulty of collecting and conserving all CWR, the preservation of CWR genetic reserves in situ is necessary and imperative. In this regard, Figure 4.7 maps the distribution of all wild relatives identified. This map reveals, not surprisingly, that the areas where CWR are most abundant coincide with patterns of species richness (Figure 4.8), i.e. the coastal plains and Rif mountain range of Morocco, the coastal mountain ranges of Algeria and Tunisia, and the Nile Delta and lower Nile in Egypt, all of which are important areas for CWR.

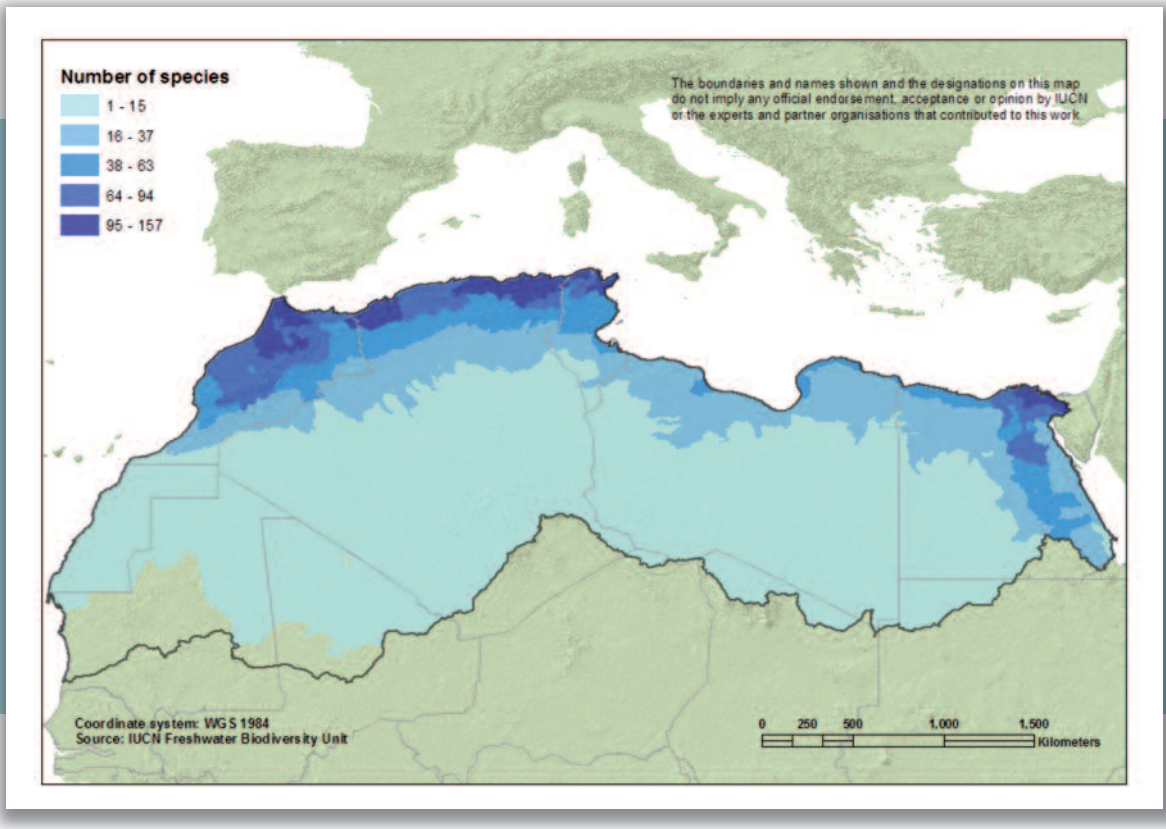

Figure 4.7. Distribution of Crop Wild Relatives in the northern African region.

4.5. PATTERNS OF DISTRIBUTION

Three regional biodiversity hotspots for aquatic plants (Figure 4.8) have been identified in northern Africa. These are the Betico-Rifan arc stretching across Morocco and western Algeria (1), the Middle Atlas and High Atlas mountains in Morocco (2), and the Kabylias–Numidia–Kroumiria complex (3) running from north-eastern Algeria to the Kroumiria region in Tunisia. These areas were obtained by combining catchments where at least 104 species occur or where at least 10 species endemic to northern Africa occur (for further information see Rhazi & Grillas, 2010). Species richness patterns for all plants also reveal other important areas, such as the lower Nile basin, including the Nile Delta, and the Atlantic plains of Morocco (Figure 4.9). The pattern of richness for plants of socio-economic value is shown in Figure 4.10. At first glance, areas where there are larger numbers of utilized species cover the three biodiversity hotspots described above, as well as the Nile Delta region. A closer look shows that the Rif and Middle Atlas mountain ranges are the main areas where a large number of species are utilized. Some of these plants are endemic to the region, such as *Mentha suaveolens* ssp. *timija* and *Mentha gattefossei*, which are strictly endemic to Morocco and globally listed as Near Threatened. In addition, the Atlantic plains of Morocco are not only significant areas in terms of species richness and endemism (Figures 4.8 and 4.9), but they also have a large number of species of socio-economic importance (Figure 4.10).

Other important areas are northern Tunisia and eastern Algeria, between the eastern Tell Atlas and the coastal area north of the Aurès Mountains. These also hold important conservation sites, including El Kala National Park, which is a Ramsar site in Algeria, and the Garâa Sejenane in the Mogods area in Tunisia, both identified as Important Plant Areas (IPAs).

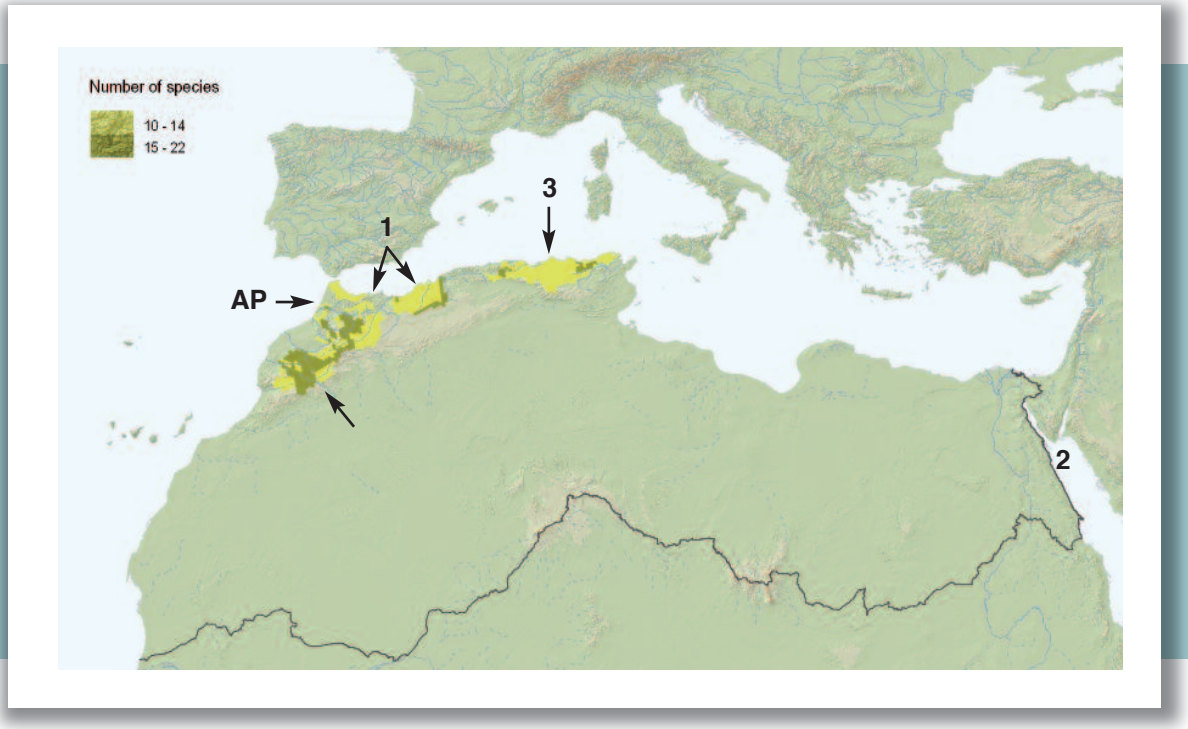

Figure 4.8. Map of the three regional biodiversity hotspots for endemic aquatic plants in northern Africa: (1) the Betico-Rifan arc; (2) the Middle and High Atlas; (3) Kabylias–Numidia–Kroumiria (source: Rhazi and Grillas, 2010).

AP: Atlantic Plains of northern Morocco.

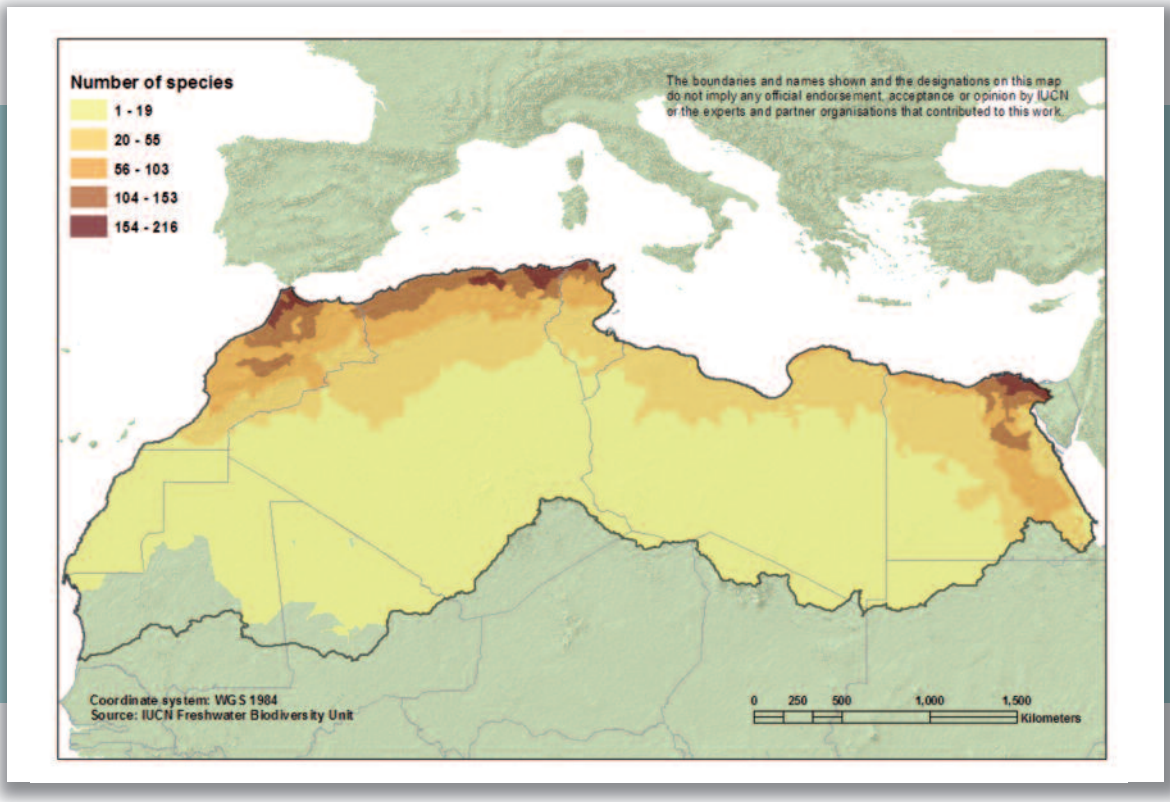

Figure 4.9. Distribution of species richness for aquatic plants in the northern African region.

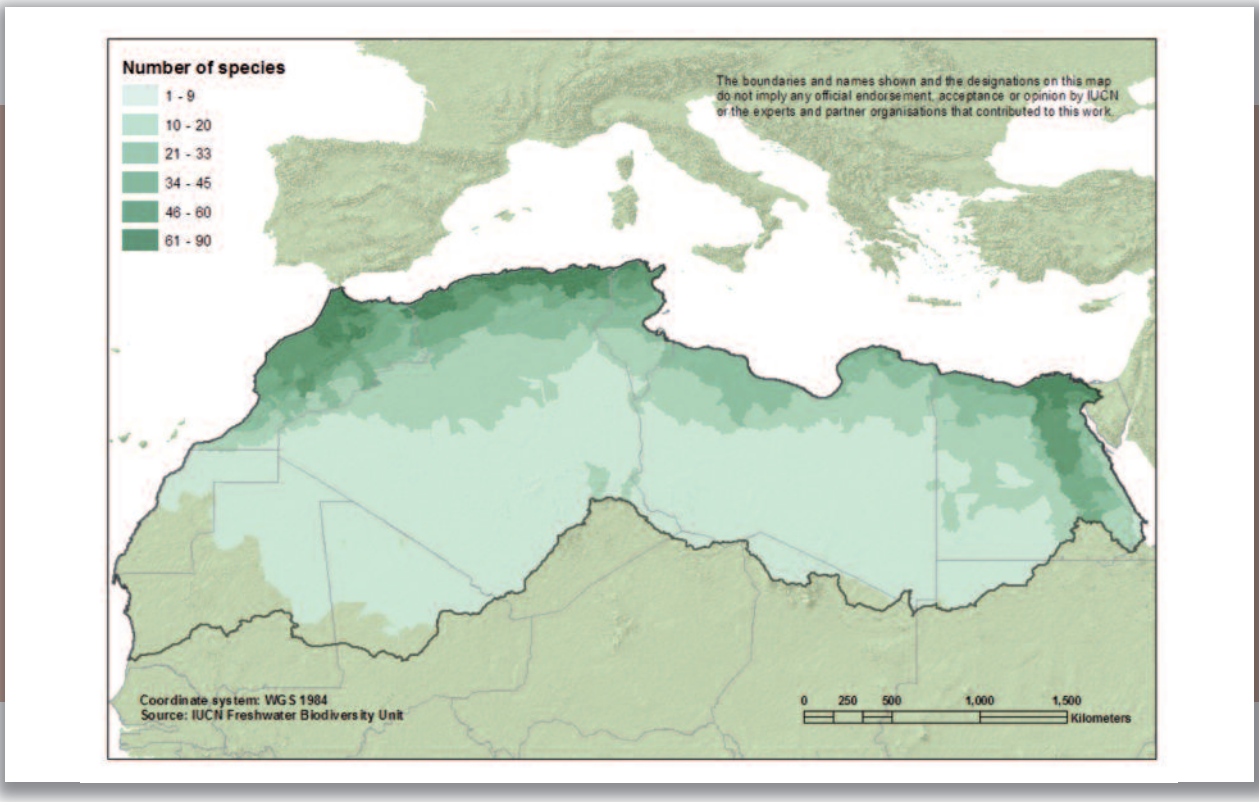

Figure 4.10. Distribution of species of socio-economic value in northern Africa. Note that CWR are not included in this map unless they are currently being used.

Important Plant Areas (IPAs) in the south and east Mediterranean were recently identified in a project involving PlantLife International, IUCN and WWF (Radford, et al., 2011). This project identified 207 IPAs in the south and east Mediterranean region. In northern Africa, 78 IPAs were identified overall in Morocco (19), Algeria (21), Tunisia (13), Libya (5) and Egypt (20). While IPAs do not focus on aquatic plants, they do include some important freshwater systems and provide an insight into where some of the most ecologically important sites are located from a plant conservation perspective and, as discussed above, they overlap with important areas for freshwater plant conservation. IPAs are also considered critically important for the Mediterranean region because they support the livelihoods of many people, provide ecosystem services such as water and flood control, prevent desertification and are a reservoir of genetic species and diversity (Radford, et al., 2011). Areas identified in this study as important and which also include IPAs are the Middle and High Atlas in Morocco, and the Nile Delta and lower Nile basin in Egypt.

Figure 4.11 reveals the distribution of species that are both threatened and of economic importance. These are places where conservation action is needed to: i) save species from exctinction, and ii) protect a resource that is valued and used by local people. Two important areas emerge from this study: the Rif mountain range and Mediterranean coast of Morocco, and the Kabylias–Numidia–Kroumiria–Mogods complex, from north-eastern Algeria to the Mogods region in Tunisia, including the Sejenane region, which has been mentioned before as an area that includes several RAMSAR sites and IPAs. There is also a significant number of threatened species of socio-economic value in the Nile Delta area.

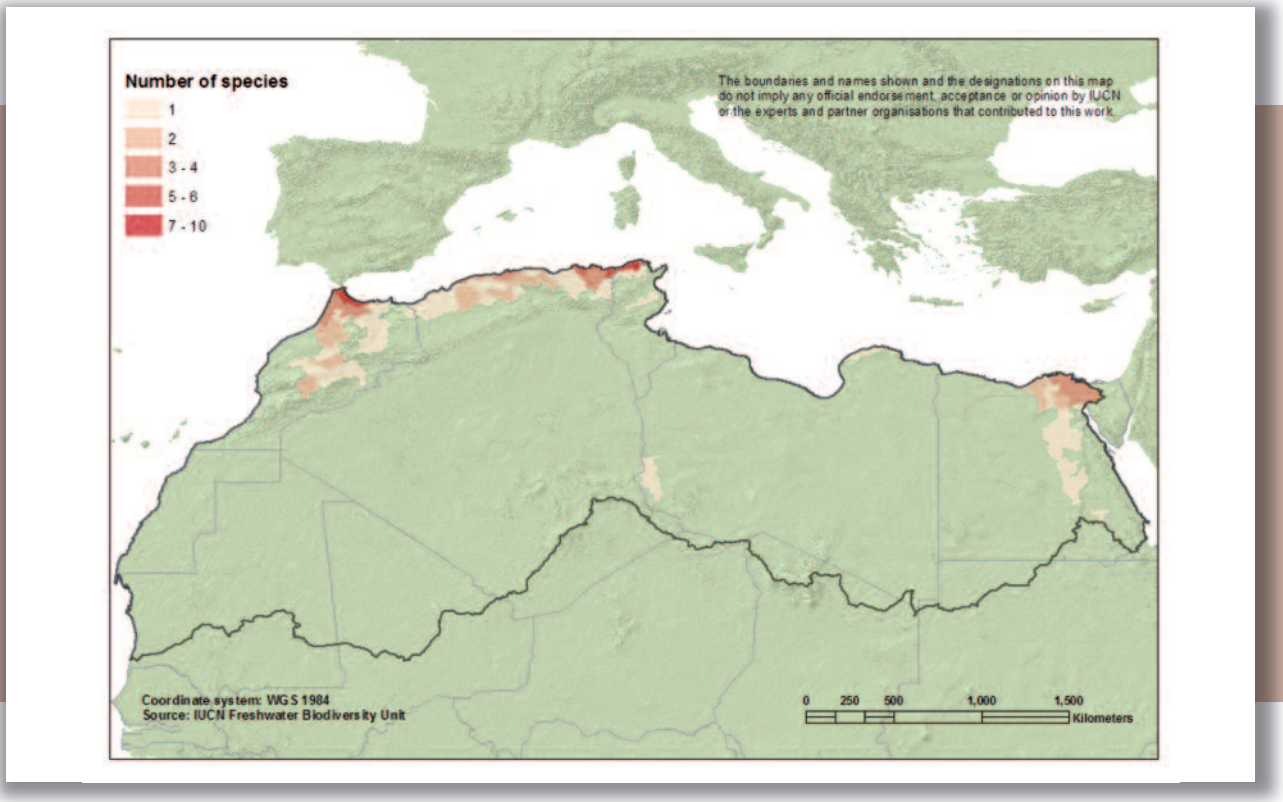

Figure 4.11. Distribution of threatened species that are of socio-economic value in northern Africa.

4.6. THREATS TO SPECIES OF SOCIO-ECONOMIC VALUE

At least one in five (20.28%) utilized freshwater plants in northern Africa is threatened with extinction in the region. The main threats to such species in northern Africa are the same as those that affect all other aquatic plants in the region. Habitat loss and degradation are affecting 95% of the aquatic plants in northern Africa (Rhazi & Grillas, 2010). The main causes of habitat loss are over-abstraction of ground water, agricultural development and intensification, infrastructure development and pumping of polluted surface water into wetlands. For example, the Blue Egyptian Water Lily (*Nymphaea nouchali caerulea*, formerly known as *Nymphaea caerulea*) is an emblematic species in Egypt that is now listed as Critically Endangered (CR^{RG}). The rhizome and fruit of this species are edible and have also been used since ancient times as a medicine and perfume. It was a very common and valued species in ancient Egypt and remains of this species were found in Tutankhamun's tomb (Carvalho & Fernandes, 2003). *Mentha cervina*, which is found in Algeria, Morocco and other Mediterranean countries, is listed as CR^{RG} in northern Africa. It is a species in the mint family that may be specifically or accidentally targeted for use but it has not been recorded as being as severely affected by harvesting as other *Mentha* species (*see* Table 4.4). Its main threats are the destruction of the habitat by anthropogenic activities such as hydrological changes due to drainage or permanent flooding, agriculture, land reclamation, and dams. The small number of populations and their remoteness put them at risk of extinction in the Maghreb countries. *Cyperus papyrus* (VU^{RG}) is another example of a threatened species that is utilized in Africa and was very common in Egypt. It is now very restricted in the region, where it is found in the wild at just a few sites, but it used to be a very valuable species

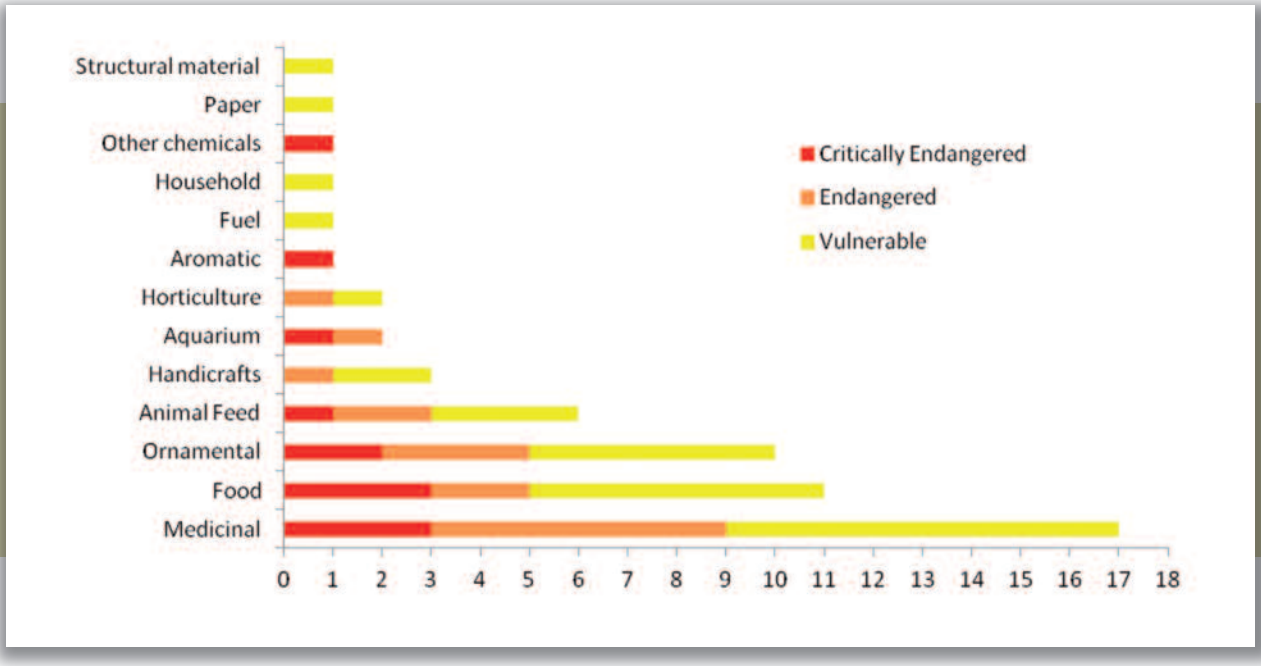

Figure 4.12. Recorded uses for threatened aquatic plant species of socio-economic value in northern Africa (source: IUCN Freshwater Biodiversity Unit). Note that a single species may be used for several purposes.

extensively utilized as a paper-like material in ancient Egypt for centuries until it was outcompeted by more effective materials. Other recorded uses of the species in Africa include medicinal, food (rhizomes), materials for construction and handicrafts, and ornamental. In Egypt papyrus reeds are cultivated on a small scale for making papyrus scrolls, which are painted with scenes and figures copied from original paintings on tomb walls and are very popular among tourists. This is a profitable business for some companies established on the banks of the Nile in Giza, near Cairo, where this activity is currently carried out (Zahran & Willis, 2003).

Seventeen threatened species are used as medicinal plants (Figure 4.12). Some of them, such as *Butomus umbellatus* (VU^{RG}) and *Menyanthes trifoliata* (VU^{RG}), have northern Africa as the southern limit of their range; they are rare in the region and are affected by agriculture, which has caused deterioration of the soils and ecosystems along freshwater systems. They are used in Egypt, Algeria and Morocco. *Menyanthes trifoliata* has been used to treat poor digestion, lack of appetite, anaemia and intestinal parasites in Egypt and Morocco. *Butomus umbellatus* seeds and underground stems have been reported to be used in Algeria as an emollient with healing properties. *Mentha cervina* is listed as CR^{RG} in northern Africa and NT^{RG} in the Mediterranean. Like most species in this genus it has medicinal properties and is reported to be occasionally used at a local scale with other *Mentha* species. It is threatened by habitat degradation due to anthropogenic activities such as hydrological changes caused by drainage or permanent flooding, agriculture, land reclamation and dams.

As mentioned throughout this chapter, utilization has not been identified as a major threat to aquatic plants in general. Harvesting of wild plants has been identified as a major threat to eight species (Table 4.4) or 5% of the utilized species in northern Africa. These include two regionally threatened species and three Near Threatened species. However, overall 32.3% (41 species) of all threatened plants are known to be used. This contrasts with the results of the IPA study mentioned above, which found that unsustainable plant exploitation affected 33% of the IPAs included in that study. These results should not

be extrapolated to freshwater ecosystems, however, as the IPA study did not focus on wetland plant use and its geographical scope was much larger, covering the south and east Mediterranean region. Of the 49 sites affected by over-collecting, 12 lie within the northern African project area. Nevertheless, the study emphasized that 'The threat of over collection may provide a conservation opportunity in terms of using plant conservation to secure livelihoods and assist development' (Radford, et al., 2011). Indeed, although a complex issue in some groups, the sustainable collection and/or cultivation of valuable plants for trade can both help to protect the species (since local communities will be interested in preserving their resources) and provide new sources of income in rural areas.

4.7. TEN CONCLUSIONS AND RECOMMENDATIONS

1. The northern African flora includes a great wealth of aquatic plants of socio-economic value. These play an important role in local economies where they are traded in markets as medicinal plants, harvested for making handicrafts and as construction materials, or cultivated for food.
2. At least a quarter of the freshwater plants native to northern Africa are utilized directly by people in the region; 70% of these species are collected from the wild.
3. Uses of aquatic plants are diverse but the most predominant are as medicines and food. Other significant uses include use as ornamentals, animal feed, production of handicrafts and construction materials.
4. One in five (20.28%) of the 143 utilized aquatic plant species in northern Africa are threatened with extinction. The Rif mountain range and Mediterranean coast of Morocco, the Kabylias–Numidia–Kroumiria–Mogods complex, from north-eastern Algeria to the Mogods region in Tunisia, and the Nile Delta area hold large numbers of threatened plants of socio-economic value.
5. Main threats to freshwater species are habitat loss and degradation, which affects up to 95% of the species. This is caused by underground water extraction, water pollution, and agricultural and industrial development. At least 5% of utilized aquatic plants are known to be threatened by harvesting.

Table 4.4. Aquatic plant species of socio-economic value threatened by harvesting in northern Africa

SPECIES	REGIONAL RED LIST CATEGORY	ADDITIONAL INFORMATION
Cyperus papyrus	VU	Listed globally as Least Concern
Genista ancistrocarpa	EN	Endemic to Morocco and the Iberian peninsula. Listed as EN in the Mediterranean basin.
Limonium cymuliferum	NT	Endemic to Morocco and Algeria
Mentha gattefossei	NT	Endemic to Morocco
Mentha suaveolens ssp. timija	NT	Endemic to Morocco
Menyanthes trifoliata	EN	Only found in Morocco in Africa. Listed as Least Concern in the Mediterranean basin
Salix pedicellata	LC	Endemic to the Mediterranean
Typha elephantina	LC	Listed globally as Least Concern

6. The plant families with the largest numbers of utilized species are the Sedges (Cyperaceae) and Grasses (Poaceae), and those providing the highest socio-economic value in terms of the numbers of people involved and income generated are the Grasses (Poaceae), Rushes (Juncaceae), Mints (Lamiaceae) and Bulrushes (Typhaceae).
7. Of the plants included in this study, 66% are Crop Wild Relatives, with a clear value to people through providing the genetic base upon which many commercial crops depend.
8. The socio-economic value of aquatic plants should serve as a basis to encourage policymakers to take action for the conservation of freshwater ecosystems.
9. Although there is qualitative evidence of the socio-economic value of aquatic plants in northern Africa, further studies are necessary to carry out an overall economic assessment.
10. It is recommended that the cultivation of medicinal and aromatic plants be developed in order to reduce pressure on wild plants—almost all the aromatic and medicinal plants (90%) harvested and marketed in Morocco are taken from the wild. The collecting of aquatic plants (helophytes) should be rationalized locally to ensure the sustainability of the operation and thereby boost an artisanal-scale economy.

Woman explaining the ancient art of making papyrus to tourists in Egypt. Photo © golisoda.

Case study 4.1 Uses and socio-economic value of *Mentha* species in northern Africa

by Rhazi[1], L., Grillas[2], P. and Juffe-Bignoli[3], D.

In north Africa, the genus *Mentha* comprises about 11 species (with several subspecies, forms, varieties and sub varieties): two are cultivated (*M. spicata* L. = *M. viridis* L., and *M. piperita* (L.) Huds.), and nine are wild (*Mentha aquatica* L.; *M. cervina* L.; *M. gattefossei* Maire; *M. longifolia* (L.) Huds. = *M. sylvestris* L.; *M. niliaca* Jacq.; *M. pulegium* L.; *M. rotundifolia* L.; *M. suaveolens* Ehrh. and *Mentha villosa* Hudson). The possibilities of hybridization between species are numerous, making them particularly difficult to identify and/or individualize. They are all herbaceous perennials of the family Lamiaceae and two are strict Moroccan endemics (*M. gattefossei* Maire and *M. suaveolens* Ehrh. ssp. *timija* (Briq.) Harley). The various species of mint are found in moist habitats in plains and mountains (e.g. marshes, temporary ponds, edges of streams, wet meadows, bogs and irrigated land).

In the northern Africa Freshwater Biodiversity Assessment (García, et al., 2010) seven species and one subspecies of *Mentha* were assessed. Only *M. cervina* was listed as threatened (CR^{RG}), although two Moroccan endemics (*M. gattefossei* and *M. suaveolens* ssp. *timija*) were assessed as Near Threatened. Main threats to these species are habitat destruction due to anthropogenic activities that cause hydrological changes and temporary flooding, such as dam construction, water abstraction or land reclamation for agriculture. Livestock overgrazing and wild harvesting have also been identified as threats to these endemics.

Mentha species have been used since ancient times. Dried leaves dating from the first millennium BC have been discovered by archaeologists in the Egyptian pyramids. Hippocrates and Aristotle used mint as a sedative and anaesthetic. The various species of mint are widely used as food, medicinal and aromatic plants (for refreshing, antiseptic, tonic, anaesthetic, analgesic, anti-spasmodic, febrifuge, diuretic, and antibacterial uses). Similarly, they are applied externally to relieve insect bites and also planted around crops as a natural repellent of crop pests such as aphids.

Figure 1. *Mentha pulegium*. Photo © Patrick Grillas, Tour du Valat.

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[3] Freshwater Biodiversity Unit, IUCN Global Species Programme, Cambridge, UK.

Mint is grown in Europe, Asia, North America and northern Africa. It is used in similar ways across the northern African region. For example, Spearmint (*Mentha spicata*) is mainly used to flavour tea in Morocco, Algeria, Tunisia and Libya. Pennyroyal (*Mentha pulegium*) is widely used in all northern African countries for its medicinal properties against influenza, colds, coughs and lung diseases (Boukef, 1986; Chaieb, et al., 1999; Ould El Hadj, et al., 2003; Ouelmouhoub, 2005; Hseini & Kahouadji, 2007; Salhi, et al., 2010). It is regarded as a general treatment for winter diseases. Fresh or dried leaves of Pennyroyal are also used as a decoction against abdominal diseases (ulcers, gastritis and pain). The plant is also kneaded and then applied externally to the head to treat acute headaches (Ouelmouhoub, 2005).

In Morocco, mint is collected mainly by women and children in the spring or early summer. A small part is kept for household use and the rest is sold in weekly markets (souks) or in the nearest urban centres. The selling price is MAD 1–2 per bale (USD 0.12–0.24) depending on the size of the bale. The sale of mint (wild or cultivated) generates income for local people living near wetlands or in rural suburban areas. For example, in the province of Benslimane, the sale of Pennyroyal (*Mentha pulegium*) taken from temporary pools generates about MAD 1,000/household/year (USD 120). A small part of the mint produced in Morocco is exported. Exports in 2009–2010 were around 5,200 tonnes (6.2% of the national mint harvest), worth USD 12.34 million (El Fadl & Chtaina, 2010). In addition to local sales and exports of fresh and dried mint, the production of essential oils from the mint is well established in various regions of Morocco. These oils are used in the pharmaceutical industry and in the manufacture of confectionery and liqueurs. They are used for flavouring creams, toothpastes, mouthwashes, chewing gum and soft drinks. In 1992, for example, about 16.5 tonnes of essential oil of Pennyroyal were exported from Morocco (MATEE, 2004). An environmentally friendly way of producing mint in Morocco was developed in 2006–2007 in the region of El Borouj (Province of Settat). The organic Spearmint thus produced is used to flavour tea. Its selling price was MAD 12/kg (USD 1.4) in 2008, generating a gross income of USD 113,369/ha/year. Additionally, 3.70 tonnes of organic mint were exported in 2009–2010, worth MAD 85,120 (USD 10,096) (El Fadl & Chtaina, 2010). This is only the beginning (14 ha of organic crops were certified in 2009); combining local trade with exports of organic mint is a very promising business which is likely to contribute significantly to the national economy in the medium term.

A typical mint tea as served in Casablanca, Morocco. Photo © David Darricau.

Case study 4.2 Socio-economic importance of *Phragmites australis* in northern Africa

by Rhazi[1], L., Grillas[2], P., Poulin[2], B. and Mathevet[3], R.

Phragmites australis (common names: Reed, Common Reed; Roseau commun in French; Carrizo in Spanish; Canetto in Italian; Kassab in Arabic) is a perennial (rhizomatous geophyte) clonal grass in the family Poaceae. Present on all continents except Antarctica, it is probably the most widely distributed flowering plant on earth. The Common Reed is found in a wide variety of permanent, semi-permanent and temporary wetlands: deltas, marshes, lake shores, river and channel edges, roadsides and ditches. It is typically found in stagnant to slow-moving, fresh or brackish (0–22 g/l salt content), shallow (0–1.5 m deep) waters. The main factors limiting the occurrence and spread of Common Reeds are water depth, currents or waves, and hypertrophic and hypersaline conditions. The species is globally listed as Least Concern and tends to form monospecific, productive stands under optimal conditions. Such sheltered, nutrient-rich reed stands are important refuges for invertebrates, fish and birds, with several vulnerable bird species depending on this habitat for breeding (Barbraud, et al., 2002; Poulin, et al., 2002; Poulin, et al., 2009) or migration (Poulin, et al., 2010).

Phragmites australis has significant socio-economic value for local people living near wetlands in northern Africa and in the Mediterranean basin. Many reedbeds have been preserved because of the products and services they provide, which include fibre, thatching material, food (waterfowl and fish)

Figure 2. *Phragmites australis* is a widely used and economically important species across the world. Photo © M.Menand.

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and grazing, as well as water purification, shoreline stabilization, water retention and flood control. For centuries, reeds have been cut, dried and used locally for roofing houses, for windbreaks, hedging, fencing, shading and also for the manufacture of household items (such as tables, chairs and cupboards) or musical instruments (flutes). The sale of reed stems, either raw (in bundles) or processed (as handicrafts), generates significant income and contributes to improving the living standards of local people. Reed cutting generates seasonal jobs for the local workforce.

There is, however, a difference in the way people exploit Reed in northern and southern Mediterranean countries. In northern Africa, in a wetland complex in Smir in northern Morocco for instance, the biomass produced by the reed is estimated at 22.95 tonnes/ha (Ennabili & Ater, 2005). It is harvested by men from rural settlements close to the reedbeds by traditional methods using sickles, generating an income of MAD 50/person/day (USD 5.9). This entire production is destined for the domestic market. However, in the Camargue (Mathevet & Sandoz, 1999) in southern France, 2,000 ha of reed are harvested mechanically, yielding 1 to 1.5 million bundles. The turnover of the sector was EUR 2 million in 1997 for four companies, mostly family business, generating about 26

Bundle of *Phragmites australis* being cut in the Camargue, France. Photo © Emilien Duborper, Tour du Valat.

full-time jobs and 40 seasonal jobs. Camargue reed is mainly sold in France, England and the Netherlands.

In addition to the long-standing traditional use of dry reed, green reed was an important forage crop for cattle before the agricultural revolution. Summer harvesting has become rare, but extensive grazing is still a common practice in Mediterranean wetlands, with *Phragmites australis* being one of the most appetizing plants due to its high protein content (Mesléard & Perennou, 1996). Waterfowl hunting, commercial or sport fishing, and ecotourism are other economic activities not specific to, but frequently associated with reedbeds, especially those enclosing large open-water areas.

The plastic morphology of reed stems and the ability of rhizomes to store reserves increase the plant's resistance to stress and pollution. Bacterial activity around the rhizomes, through aerobic and anaerobic processes, give the plant good water-purification properties (Chu, et al., 2006; Stamati, et al., 2010). This biological process occurs within natural ecosystems (deltas, lakes, and canals) and can be transferred to semi-natural or constructed beds (Figure 2) for the treatment of waste water from villages and hamlets. This phytopurification process is increasingly being used in southern France, but is only in its early stages in northern Africa (e.g. Smir in the M'diq region in northern Morocco and Ouargla wilayah in Algeria).

Figure 3. Water treatment plant using *Phragmites australis* in southern France. Photo © Brigitte Poulin, Tour du Valat.

5 CONCLUSIONS AND RECOMMENDATIONS

Diego Juffe-Bignoli[1] and William R. Darwall[1]

An herbalist and healer in Morocco. Usually acting as doctors and pharmacists in rural Morocco, they often use aquatic species for their treatments. Photo © M. Melhaoui.

[1] Freshwater Biodiversity Unit, IUCN Global Species Programme, Cambridge, UK.

ONE IN THREE FRESHWATER SPECIES IN NORTHERN AFRICA IS OF SOCIO-ECONOMIC VALUE

This is the first time that a study has been conducted at the species level to collate and integrate information on the socio-economic value of freshwater species and the threats to those species. The findings are most revealing. The high socio-economic value of freshwater species is clearly demonstrated, with 46.06% of fish and 27.61% of plants utilized in some way by people (Table 5.1). These figures include only the direct uses of species; the total numbers are undoubtedly much greater once the many indirect benefits—not accounted for in this study— are included, such as the provision of drinking water, nutrient cycling, flood prevention or genetic materials (see Section 1.1). For example, if Crop Wild Relatives (CWR) were regarded as an indicator of value (see section 4.4), 66% of aquatic plants would be considered to be of socio-economic value. Of these CWR species, 24.92% are already threatened, largely through human exploitation of wetland ecosystems most often with little, if any, regard for the conservation or sustainable use of these ecosystems and their associated species. We therefore conclude that a valuable resource—the freshwater species making up wetland ecosystems—is rapidly being lost through human actions, since 24.75% of all utilized species are threatened (Table 5.1.), and that many people who rely directly on these species are likely to suffer as a consequence.

This loss can be particularly critical when access to the resources that healthy ecosystems provide is the only option available for local communities. For example, small-scale inland fisheries have been recognized to play a role as a 'safety net', in that fishing can provide an alternative or additional source of income or food to livelihoods that have been hit by periods of civil unrest or economic crisis (Welcomme, et al., 2010).

INVOLVING LOCAL COMMUNITIES AND ENCOURAGING SUSTAINABLE EXPLOITATION

Local communities whose livelihoods depend on natural resources should be considered and consulted in conservation planning activities as they are the first to be affected by habitat modification. Local stakeholders need to be encouraged to develop and/or participate in sustainable harvesting and/or farming programmes and in ecotourism initiatives that can help to protect these resources. It is also recommended that revenue-generating projects be developed for local people to reduce pressure on natural environments and to boost local economies.

INTEGRATING SOCIO-ECONOMIC VALUE IN THE PLANNING PROCESS

The value of freshwater species still fails to be appreciated and is rarely adequately considered in decision-making processes relating to the exploitation and development of wetlands. The total value of wetland ecosystems, supported by the many freshwater species studied here, must be factored into decision making. Ultimately this

Table 5.1 Socio-economic value and level of threat for freshwater fishes and aquatic plants in the northern African region

Group	All species	Species utilized in northern Africa	Threatened (all species)	Threatened (utilized species)
Freshwater fishes	128	59 (46.06%)	35 (27.34%)	21 (35.59%)
Aquatic plants	518	143 (27.61%)	127 (24.51%)	29 (20.28%)
All species	646	202 (31.26%)	162 (25.07%)	50 (24.75%)

information could be linked to other geographical information associated with human development, such as rural poverty, agricultural intensification or water security.

We recommend that Environmental Impact Assessments be conducted before any actions that impact on wetlands are approved and that they include a fully balanced cost/benefit analysis based on the inclusion of a total economic valuation of the wetland in question. Subsequent actions should, in appreciation of these values, ensure the adequate conservation and/or sustainable use of these wetland resources. If we continue to destroy and degrade inland wetlands and their associated species at the rate at which we are doing so today we will, often unwittingly, cause the loss of many species to the great detriment of the large numbers of people who depend upon them for many aspects of their daily lives. The conservation value of species has long been recognized by organizations such as IUCN but this study now also confirms the great socio-economic value these species bring to our society. Given the high level of threat to these species, as recorded by the IUCN Red List, the time has come to rethink our approach to the development and exploitation of wetlands.

FURTHER RESEARCH

Information on the socio-economic value of species is not easily accessible, as it is often scattered, kept in people's heads, or published in the grey literature. The information presented here was collated through a combination of literature survey and email correspondence alone. It was outside the scope of the project to draw directly upon the wealth of knowledge of individuals, such as would be possible through workshops. It is therefore highly recommended that regional workshops be held to better access the wealth of additional information that could not be accessed through this study.

This study of the socio-economic value of freshwater ecosystems in northern Africa raises important questions, such as what results would be obtained if the same kind of analyses were performed on the vast and renowned freshwater ecosystems of sub-Saharan Africa (i.e. the Congo basin, Zambezi basin and eastern Great Lakes). We therefore encourage scientists and organizations to carry out similar studies investigating socio-economic value at a species level, in order to reveal the true importance of species to local communities.

Osmunda regalis in a small peat swamp in la Garâa Sejenane, Mogods, Tunisia. This fern is used across northern Africa as an ornamental plant. The roots are diuretic, astringent and tonic. Listed regionally as LC. Photo © Amina Daoud-Bouattour.

6 APPENDICES

Use of rushes (*Juncus* spp.) for traditional basketry in a market in Marrakech, Morocco. Photo © M. Sheppard.

Appendix 1 — List of freshwater fish species of socio-economic value

FAMILY	SPECIES NAME	COMMON NAME	REGIONAL RED LIST CATEGORY	END USES	AREAS WHERE HARVESTED
ALESTIIDAE	*Alestes baremoze*	Meloha	RE	Food	Western Africa, Eastern Africa, Nile Basin
ALESTIIDAE	*Alestes dentex*	Kawwara Baladi	VU	Food	Nile Basin
ALESTIIDAE	*Brycinus macrolepidotus*	True Big-scale Tetra	RE	Food	Sub-Saharan Africa
ALESTIIDAE	*Brycinus nurse*	Nurse Tetra	DD	Food, Aquarium	Africa
ALESTIIDAE	*Hydrocynus brevis*	Kalb El Bahr Brevis	RE	Food	Africa
ALESTIIDAE	*Hydrocynus forskahlii*	Elongate Tiger Fish	LC	Food, Gamefish	Africa
ALESTIIDAE	*Hydrocynus vittatus*	Tiger Fish	DD	Food, Gamefish	Nile Basin, Africa
ALESTIIDAE	*Micralestes acutidens*	Sharptooth Tetra	RE	Food, Aquarium, Bait	Sub-Saharan Africa
ANABANTIDAE	*Ctenopoma kingsleyae*	Tailspot Ctenopoma	DD	Food, Aquarium	Sub-Saharan Africa
ANGUILLIDAE	Anguilla anguilla	European Eel	EN	Food	Europe, Mediterranean, Northern Africa
ARAPAIMIDAE	*Heterotis niloticus*	Heterotis	RE	Food, Aquarium, Aquaculture	Sub-Saharan Africa
BAGRIDAE	*Bagrus bajad*	Bayad	LC	Food, Gamefish	Nile Basin, Northern Africa, Western Africa, Eastern Africa
BAGRIDAE	*Bagrus docmak*	Semutundu	LC	Food, Gamefish	Nile Basin, Northern Africa, Western Africa, Eastern Africa
BLENNIIDAE	*Salaria fluviatilis*	Freshwater Blenny	LC	Aquarium	Europe, Mediterranean
CICHLIDAE	*Astatotilapia bloyeti*	Bloyet's Haplo	VU	Food, Aquarium	Western Africa, Eastern Africa
CICHLIDAE	*Hemichromis bimaculatus*	Jewelfish	EN	Food, Aquarium	Africa
CICHLIDAE	*Hemichromis fasciatus*	Banded Jewelfish	DD	Food, Aquarium, Aquaculture	Nile Basin, Western Africa, Eastern Africa
CICHLIDAE	*Oreochromis aureus*	Blue Tilapia	LC	Food, Aquarium, Aquaculture	Africa, Egypt
CICHLIDAE	*Oreochromis niloticus*	Nile Tilapia	LC (Global)	Food, Aquaculture	Africa, Egypt
CICHLIDAE	*Pseudocrenilabrus multicolor multicolor*	Egyptian Mouthbrooder	DD	Aquarium	Unknown
CICHLIDAE	*Sarotherodon galilaeus galilaeus*	Mango Tilapia	LC	Food	Africa, Egypt
CICHLIDAE	*Sarotherodon melanotheron heudelotii*	Mango Fish	DD	Food	Western Africa
CICHLIDAE	*Sarotherodon melanotheron notheron*	Blackchin Tilapia	DD	Food, Aquarium, Aquaculture	Western Africamela
CICHLIDAE	*Thoracochromis wingatii*		DD	Food	Egypt, Sudan
CICHLIDAE	*Tilapia guineensis*	Guinean Tilapia	DD	Food, Aquarium, Aquaculture	Western Africa, Central Africa
CICHLIDAE	*Tilapia rendalli*	Redbreast Tilapia	DD	Food	Western Africa, Southern Africa
CICHLIDAE	*Tilapia zillii*	Redbelly Tilapia	LC	Food, Aquarium, Aquaculture	Northern Africa, Eastern Africa
CITHARINIDAE	*Citharinus citharus citharus*	Moon Fish	VU	Food, Aquarium	Egypt, Western Africa, Central Africa
CITHARINIDAE	*Citharinus latus*		VU	Food	Lake Nasser, Eastern Africa, Western Africa, Central Africa
CITHARINIDAE	*Distichodus engycephalus*		RE	Food	Central Africa, Western Africa
CITHARINIDAE	*Distichodus rostratus*		RE	Food	Eastern Africa, Western Africa
CITHARINIDAE	*Ichthyborus besse besse*		RE	Food	North-eastern Africa, Western Africa
CLARIIDAE	*Clarias anguillaris*	Mudfish	DD	Food	Egypt, Western Africa, North-eastern Africa

Appendix 1 — List of freshwater fish species of socio-economic value

FAMILY	SPECIES NAME	COMMON NAME	REGIONAL RED LIST CATEGORY	END USES	AREAS WHERE HARVESTED
CLARIIDAE	*Clarias gariepinus*	North African Catfish	LC	Food, Gamefish, Aquaculture	Nile Basin, Sub-Saharan Africa
CLARIIDAE	*Heterobranchus bidorsalis*	Garmout	VU	Food	Egypt, Chad, Sudan, Western Africa
CLARIIDAE	*Heterobranchus longifilis*	Sampa, Vundu	VU	Food, Aquaculture, Gamefish	Egypt, Chad, Sudan, Western Africa
CLAROTEIDAE	*Auchenoglanis biscutatus*	Dokman	VU	Food, Aquarium	Sub-Saharan Africa, Nile Basin
CLAROTEIDAE	*Auchenoglanis occidentalis*	Bubu	VU	Food	Nile Basin, Sub-Saharan Africa
CLAROTEIDAE	*Chrysichthys auratus*	Abu Rial	DD	Food	Northern Africa, Western Africa
CLAROTEIDAE	*Chrysichthys nigrodigitatus*	Bagrid Catfish	DD	Food, Gamefish, Aquaculture	Sub-Saharan Africa
CLAROTEIDAE	*Clarotes laticeps*	Widehead Catfish	RE	Food	Sub-Saharan Africa
CLUPEIDAE	*Alosa alosa*	Allis Shad	RE	Food	Europe, Morocco
CLUPEIDAE	*Alosa fallax*	Twait Shad	RE	Food	Europe, Morocco
CYPRINIDAE	*Barbus anema*	Benni Anema	RE	Food, Aquarium	Nile Basin, Western Africa, Central Africa
CYPRINIDAE	*Barbus bynni bynni*		LC	Food	Nile Basin
CYPRINIDAE	*Barbus callensis*	Algerian Barb	LC	Food, Aquarium	Northern Africa
CYPRINIDAE	*Barbus figuiguensis*		LC	Food	Morocco
CYPRINIDAE	*Barbus moulouyensis*		LC	Food	Morocco
CYPRINIDAE	*Barbus nasus*		NT	Food	Morocco
CYPRINIDAE	*Barbus neglectus*	Benni Neglectis	RE	Food	Ethiopia, Sudan, Lake Nasser
CYPRINIDAE	*Barbus perince*	Fahdah	VU	Food	Nile Basin, Western Africa
CYPRINIDAE	*Barbus pobeguini*		DD	Food	Western Africa
CYPRINIDAE	*Barbus stigmatopygus*		DD	Food	Eastern Africa, Western Africa
CYPRINIDAE	*Barbus yeiensis*		DD	Food	Nile Basin, Chad, Sudan
CYPRINIDAE	*Chelaethiops bibie*		EN	Food	Eastern Africa, Western Africa
CYPRINIDAE	*Labeo coubie*	African Carp	EN	Food, Public Aquaria	Sub-Saharan Africa
CYPRINIDAE	*Labeo niloticus*	Nile Labeo	LC	Food	Nile Basin
CYPRINIDAE	*Leptocypris niloticus*	Nile Minnow	EN	Food	Eastern Africa, Western Africa
CYPRINIDAE	*Raiamas senegalensis*	Silver Fish	EN	Food	Nile Basin, Sub-Saharan Africa
CYPRINODONTIDAE	*Aphanius apodus*		DD	Aquarium	Unknown
CYPRINODONTIDAE	*Aphanius dispar dispar*		LC	Aquarium	Persian Gulf, Red Sea, Indian Ocean
CYPRINODONTIDAE	*Aphanius fasciatus*		LC	Aquarium	Mediterranean
CYPRINODONTIDAE	*Aphanius saourensis*	Sahara Aphanius	CR	Aquarium	Unknown
GYMNARCHIDAE	*Gymnarchus niloticus*	Aba, Gefar	DD	Food	Egypt, Western Africa, Central Africa
LATIDAE	*Lates niloticus*	Nile Perch	DD	Food, Aquaculture	Nile Basin, Western Africa, Central Africa, Eastern Africa
MALAPTERURIDAE	*Malapterurus electricus*	Electric Catfish	VU	Food, Public Aquaria, Gamefish	Nile Basin, Western Africa, Eastern Africa, Zambia
MOCHOKIDAE	*Mochokus niloticus*	Mokawkas Nili	VU	Food	Eastern Africa, Western Africa
MOCHOKIDAE	*Synodontis batensoda*		RE	Food, Aquarium	Western Africa
MOCHOKIDAE	*Synodontis clarias*	Mandi, Shilane	VU	Food	Nile Basin, Northern Africa, Western Africa
MOCHOKIDAE	Synodontis filamentosus	Mbakorobo	DD	Food	Nile Basin, Central African Republic, Western Africa

Appendix 1 — List of freshwater fish species of socio-economic value

FAMILY	SPECIES NAME	COMMON NAME	REGIONAL RED LIST CATEGORY	END USES	AREAS WHERE HARVESTED
MOCHOKIDAE	*Synodontis frontosus*	Sudan Squeaker	DD	Food	Nile Basin, Eastern Africa, Western Africa
MOCHOKIDAE	*Synodontis membranaceus*	Galabaya	RE	Food	North-eastern Africa
MOCHOKIDAE	*Synodontis nigrita*	Kerkar Kabir	DD	Food	Western Africa
MOCHOKIDAE	*Synodontis schall*	Wahrindi	LC	Food, Gamefish	Nile Basin, Western Africa
MOCHOKIDAE	*Synodontis serratus*	Shaal	VU	Food	Egypt, Ethiopia, Sudan
MOCHOKIDAE	*Synodontis sorex*	Egungigi	DD	Food	Egypt, Western Africa
MONODACTYLIDAE	*Monodactylus argenteus*	Silver Moony	DD	Food, Aquarium	Red Sea, Egypt, Eastern Africa, Japan, Australia, Mekong Delta
MORMYRIDAE	*Hyperopisus bebe bebe*		RE	Food	Western Africa
MORMYRIDAE	*Marcusenius cyprinoides*	Anoma	VU	Food	Nile Basin, Nigeria, Chad
MORMYRIDAE	*Mormyrus caschive*	Elephant Snout	VU	Food	Egypt
MORMYRIDAE	*Mormyrus hasselquistii*	Anomah Hasselquist	RE	Food	Western Africa
MORMYRIDAE	*Mormyrus kannume*	Bottlenose	VU	Food, Aquarium	Nile Basin, Eastern Africa
MORMYRIDAE	*Mormyrus niloticus*	Anomah Nilieh	RE	Food	Eastern Africa
MORMYRIDAE	*Petrocephalus bane bane*	Ros El Hagar	VU	Food, Aquarium	Western Africa, Nile Basin
MORMYRIDAE	*Petrocephalus bovei bovei*		RE	Food	Sub-Saharan Africa
MORMYRIDAE	*Pollimyrus isidori isidori*	Elephant Fish	VU	Food, Aquarium	Nile Basin, Gambia Basin, Niger Basin, Volta Basin, Chad Basin
OPHICHTHIDAE	*Dalophis boulengeri*		DD	Food	Eastern Africa, Western Africa, Central Africa
POECILIIDAE	*Micropanchax pfaffi*	Pfaff's Lampeye	DD	Aquarium	Egypt, Western Africa
POLYPTERIDAE	*Polypterus bichir bichir*	Emsir	RE	Food, Public Aquaria	Africa
POLYPTERIDAE	*Polypterus senegalus senegalus*	Gray Bichir	DD	Food	Egypt, Western Africa, Eastern Africa, Central Africa
PROTOPTERIDAE	*Protopterus aethiopicus aethiopicus*	Dabib Elhoot, Marbled Lungfish	DD	Food	Eastern Africa, Zambia, Egypt
SALMONIDAE	*Salmo akairos*	Truite Naine Du Lac Ifni	VU	Food	Morocco
SALMONIDAE	*Salmo macrostigma*		DD	Gamefish	Algeria, Morocco
SCHILBEIDAE	*Parailia pellucida*		DD	Food, Aquarium	Central Africa, Western Africa
SCHILBEIDAE	*Schilbe mystus*		LC	Food, Aquarium, Gamefish	Nile Basin, Northern Africa, Western Africa, Central Africa
SCHILBEIDAE	*Schilbe uranoscopus*		VU	Food	Nile Basin, Western Africa
SCHILBEIDAE	*Siluranodon auritus*		RE	Food	Western Africa
TETRAODONTIDAE	*Tetraodon lineatus*	Fahaka Assielah	DD	Aquarium	Nile Basin, Western Africa, Eastern Africa

Catch of Nile Tilapia (*Oreochromis niloticus*), Egypt. Photo © Sherif Sadek.

Appendix 2 — List of aquatic plant species[1] of socio-economic value.

FAMILY	SPECIES NAME	COMMON NAME	REGIONAL RED LIST CATEGORY	END USES	AREAS WHERE HARVESTED
ADIANTACEAE	*Adiantum capillus-veneris*	Maidenhair Fern	LC	Medicinal, Ornamental	Morocco, Algeria, Egypt, Libya, China, Europe
ALISMATACEAE	*Alisma gramineum*		NT	Medicinal	Egypt
ALISMATACEAE	*Alisma plantago-aquatica*	Great Water Plantain	LC	Medicinal, Food, Ornamental	Egypt, Morocco, Algeria
ALISMATACEAE	*Baldellia ranunculoides*		NT	Aquarium	Unknown
ALISMATACEAE	*Damasonium bourgaei*	Starfruit	NT	Food	Mediterranean
AMARANTHACEAE	*Alternanthera sessilis*	Sessile Joyweed, Sanchi	LC	Food, Animal feed, Medicinal, Aquarium	India, Sub-Saharan Africa, Asia
APIACEAE	*Apium graveolens*		LC	Food, Medicinal	Morocco, Algeria, Tunisia, Libya, Egypt
APIACEAE	*Apium nodiflorum*		LC	Medicinal	Morocco
APIACEAE	*Berula erecta*	Cutleaf Waterparsnip	LC	Medicinal	Mediterranean
APIACEAE	*Hydrocotyle vulgaris*	Marsh Pennywort	LC	Ornamental	Europe, Mediterranean
APIACEAE	*Oenanthe crocata*	Hemlock Water Dropwort	LC	Medicinal	Europe
APIACEAE	*Oenanthe fistulosa*		LC	Medicinal	Morocco, Algeria
ARACEAE	*Lemna aequinoctialis*		LC	Food, Medicinal	Namibia
ARACEAE	*Lemna gibba*	Gibbous Duckweed	LC	Food	Mediterranean, Africa
ARACEAE	*Lemna minor*	Duckweed	LC	Medicinal, Food	Mediterranean, Africa, South-East Asia
BLECHNACEAE	*Woodwardia radicans*	Chain Fern	VU	Medicinal, Ornamental, Handicrafts	Algeria, China
BRASSICACEAE	*Cardamine pratensis atlantica*		VU	Food, Medicinal	Morocco
BRASSICACEAE	*Nasturtium officinale*		DD	Medicinal	Morocco, Egypt
BRASSICACEAE	*Rorippa indica*		LC	Food, Medicinal	Unknown
BUTOMACEAE	*Butomus umbellatus*	Flowering Rush	EN	Food, Medicinal, Handicrafts	Europe, Mediterranean, Egypt, Algeria
CAMPANULACEAE	*Sphenoclea zeylanica*		DD	Food	Java
CARYOPHYLLACEAE	*Spergularia media intermedia*		DD	Medicinal	Morocco
CARYOPHYLLACEAE	*Spergularia media occidentalis*		NT	Medicinal	Morocco
CERATOPHYLLACEAE	*Ceratophyllum demersum*		LC	Aquarium	Morocco, Algeria, Tunisia, Egypt
CERATOPHYLLACEAE	*Ceratophyllum muricatum*		LC	Aquarium	Morocco, Algeria, Tunisia, Egypt
CHARACEAE	*Chara vulgaris*	Common Stonewort	LC	Other chemicals	China, Morocco
COMPOSITAE	*Ambrosia maritima*	Sea Ambrosia	LC	Medicinal	Egypt
COMPOSITAE	*Ceruana pratensis*	Garawan	LC	Household	Egypt
COMPOSITAE	*Ethulia conyzoides*	Hashish El-Faras	DD	Medicinal, Food	Sudan, Southern Africa
COMPOSITAE	*Grangea maderaspatana*		DD	Medicinal, Food	Africa
COMPOSITAE	*Lactuca virosa cornigera*		LC	Medicinal	Morocco
COMPOSITAE	*Pluchea dioscoridis*		LC	Medicinal	Egypt
COMPOSITAE	*Pluchea ovalis*		NT	Medicinal, Animal feed	Africa
COMPOSITAE	*Pseudoconyza viscosa*	Southern Africa	DD	Medicinal	South Africa, Angola
COMPOSITAE	*Sonchus maritimus*		LC	Animal feed	Unknown
CONVOLVULACEAE	*Cressa cretica*		LC	Medicinal	Morocco
CONVOLVULACEAE	*Ipomoea carnea*		DD	Medicinal, Ornamental	South America, India
CONVOLVULACEAE	*Ipomoea sagittata*		EN	Medicinal	Algeria
CYPERACEAE	*Bolboschoenus maritimus*		LC	Medicinal	Morocco
CYPERACEAE	*Carex divisa*		LC	Handicrafts	Morocco
CYPERACEAE	*Cladium mariscus*		LC	Structural material, Household	Morocco, Libya, Egypt
CYPERACEAE	*Cyperus alopecuroides*	Foxtail Flatsedge	LC	Animal feed, Handicrafts	Africa
CYPERACEAE	*Cyperus articulatus*		LC	Handicrafts, Medicinal, Chemicals	Egypt, Central Africa, Mozambique, Eastern Africa

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Appendix 2 — List of aquatic plant species[1] of socio-economic value.

FAMILY	SPECIES NAME	COMMON NAME	REGIONAL RED LIST CATEGORY	END USES	AREAS WHERE HARVESTED
CYPERACEAE	*Cyperus bulbosus*	Bush Onion	LC	Animal feed, Food	Australia, Kenya, Sudan, Tanzania, Burkina Faso, Somalia, Sri Lanka
CYPERACEAE	*Cyperus compressus*		DD	Animal feed, Food	Kenya
CYPERACEAE	*Cyperus difformis*	Smallflower Umbrella Sedge	LC	Animal feed, Medicinal	Africa
CYPERACEAE	*Cyperus digitatus*		LC	Food, Medicinal, Fibre	Zimbabwe, Angola, Namibia
CYPERACEAE	*Cyperus esculentus*		LC	Food, Animal feed, Medicinal	Egypt, Libya, Morocco, Sub-Saharan Africa, Malaysia, Southern Europe, China
CYPERACEAE	*Cyperus imbricatus*		LC	Animal feed, Food	Africa
CYPERACEAE	*Cyperus laevigatus*	Smooth Flatsedge	LC	Food, Medicinal	Africa
CYPERACEAE	*Cyperus longus*	Galingale, Sweet Cyperus	LC	Food, Handicrafts, Ornamental, Medicinal	Morocco, India, Pan Africa
CYPERACEAE	*Cyperus maculatus*		LC	Food	Africa
CYPERACEAE	*Cyperus papyrus*		VU	Food, Medicinal, Structural Material, Animal feed, Handicrafts, Paper, Horticulture	Morocco, Egypt, Sub Saharan Africa
CYPERACEAE	*Cyperus rotundus*		LC	Medicinal, Animal feed, Poison, Other chemicals, Food	Algeria, Egypt, Morocco, India, Vietnam, Southern Africa
CYPERACEAE	*Isolepis cernua*		LC	Structural material, Ornamental	Unknown
CYPERACEAE	*Pycreus mundtii*		LC	Household	Africa
CYPERACEAE	*Schoenoplectus corymbosus*		LC	Household	Eastern Africa, South Africa
HALORAGACEAE	*Myriophyllum spicatum*		LC	Ornamental	Unknown
HALORAGACEAE	*Myriophyllum verticillatum*		LC	Ornamental, Food, Medicinal, Other	Africa
HYDROCHARITACEAE	*Hydrocharis morsus-ranae*		EN	Ornamental	Morocco, Algeria
HYDROCHARITACEAE	*Najas horrida*	Shelbika	VU	Animal feed	Mediterranean
HYDROCHARITACEAE	*Najas marina*	Holly-leaved Naiad	LC	Aquarium, Food	Vietnam, Egypt
HYDROCHARITACEAE	*Ottelia alismoides*	Duck-Lettuce	LC	Medicinal, Aquarium	India
HYDROCHARITACEAE	*Vallisneria spiralis*		CR	Aquarium	Egypt
ILLECEBRACEAE	*Illecebrum verticillatum*		LC	Medicinal	Morocco
IRIDACEAE	*Iris pseudacorus*	Yellow Iris	LC	Ornamental	Morocco, North Africa
ISOETACEAE	*Isoetes histrix*		LC	Animal feed	Tunisia
ISOETACEAE	*Isoetes velata*		LC	Animal feed	Tunisia, Europe, Asia
JUNCACEAE	*Juncus acutus*	Sharp Rush	LC	Handicrafts, Medicinal	Morocco, Algeria, Tunisia, Libya, Egypt
JUNCACEAE	*Juncus articulatus*	Jointed Rush	LC	Ornamental	Europe
JUNCACEAE	*Juncus effusus*	Soft Rush	LC	Food, Medicinal, Handicrafts, Household	Europe, Africa
JUNCACEAE	*Juncus inflexus*	Hard Rush	LC	Household, Handicrafts	Africa
JUNCACEAE	*Juncus maritimus*	Sea Rush	LC	Medicinal, Animal feed, Household	Morocco, Libya, Iraq, Africa
LAMIACEAE	*Genista ancistrocarpa*		EN	Ornamental	Mediterranean, Morocco
LAMIACEAE	*Mentha aquatica*	Water Mint	LC	Food, Medicinal	Morocco, Algeria, Tunisia, Mediterranean
LAMIACEAE	*Mentha cervina*	Hart's Pennyroyal, Menthe des Cerfs	CR	Food, Medicinal, Aromatic	Morocco, Mediterranean, Africa
LAMIACEAE	*Mentha gattefossei*	Menthe de Perse	NT	Food, Medicinal, Essential oils	Mediterranean
LAMIACEAE	*Mentha longifolia*	Horsemint	LC	Food, Medicinal, Essential oils	Morocco, Algeria, Tunisia, Egypt, Libya, Mediterranean
LAMIACEAE	*Mentha pulegium*	Pennyroyal	LC	Food, Medicinal, Essential oils	Morocco, Algeria, Tunisia, Egypt, Libya, Mediterranean, Europe

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FAMILY	SPECIES NAME	COMMON NAME	REGIONAL RED LIST CATEGORY	END USES	AREAS WHERE HARVESTED
LAMIACEAE	*Mentha spicata*	Spearmint	LC	Food, Medicinal, Essential oils	Morocco, Algeria, Tunisia, Egypt, Libya, Mediterranean, China
LAMIACEAE	*Mentha suaveolens*	Round-Leaved Mint	LC	Food, Medicinal, Essential oils	Morocco, Mediterranean
LAMIACEAE	*Mentha suaveolens timija*	Timija	NT	Food, Medicinal, Essential oils, Ornamental	Morocco
LAMIACEAE	*Teucrium scordium*		LC	Medicinal	Morocco
LENTIBULARIACEAE	*Pinguicula lusitanica*		EN	Medicinal	Algeria
LENTIBULARIACEAE	*Utricularia gibba*	Utriculaire Bossue	NT	Aquarium	Europe, United States
LENTIBULARIACEAE	*Utricularia inflexa*		VU	Medicinal	Unknown
LENTIBULARIACEAE	*Utricularia vulgaris*	Greater Bladderwort	LC	Medicinal	Europe, Mediterranean
LYTHRACEAE	*Ammannia baccifera*	Blistering Ammannia	LC	Medicinal	Africa
LYTHRACEAE	*Ammannia senegalensis*	Red Ammannia	LC	Aquarium	Unknown
LYTHRACEAE	*Lythrum borysthenicum*		LC	Medicinal	Morocco
LYTHRACEAE	*Lythrum hyssopifolia*		LC	Medicinal	Morocco
LYTHRACEAE	*Lythrum salicaria*	Purple Loosestrife	LC	Food, Medicinal, Ornamental	Morocco, China, Europe
LYTHRACEAE	*Trapa natans*	Water Chestnut	EN	Food, Animal feed, Medicinal	Malaysia, India, China, Africa
MENYANTHACEAE	*Menyanthes trifoliata*		EN	Medicinal	Morocco, Egypt
MOLLUGINACEAE	*Glinus lotoides*	Lotus Sweetjuice	LC	Medicinal	Africa, Asia
NYMPHAEACEAE	*Nymphaea alba*	European Waterlily	VU	Food, Ornamental, Medicinal	Morocco, Algeria, Libya, Mediterranean, Europe
NYMPHAEACEAE	*Nymphaea lotus*	Egyptian Lotus	CR	Food, Ornamental, Medicinal	Egypt, Africa, China, Indochina
NYMPHAEACEAE	*Nymphaea nouchali caerulea*	Bashneen Azraq	CR	Food, Ornamental	Egypt, Africa
ONAGRACEAE	*Epilobium angustifolium*	Willowherb	VU	Food	Mediterranean
ONAGRACEAE	*Epilobium hirsutum*		LC	Food, Medicinal	Egypt, Morocco, Libya, South Africa
ONAGRACEAE	*Epilobium parviflorum*	Hoary Willowherb	LC	Medicinal	Morocco, Algeria, Mediterranean
ONAGRACEAE	*Epilobium tetragonum*	Square-stalked Willowherb	LC	Medicinal, Ornamental	Mediterranean
ONAGRACEAE	*Ludwigia palustris*		NT	Aquarium	Europe, Asia
ORCHIDACEAE	*Anacamptis laxiflora*	Loose-flowered Orchid	DD	Medicinal, Food, Animal feed, Ornamental	Europe, Mediterranean
ORCHIDACEAE	*Anacamptis palustris*	Orchis Des Marais	DD	Ornamental	Mediterranean
ORCHIDACEAE	*Dactylorhiza elata*	Orchis Elevé	NT	Medicine, Food, Animal feed, Ornamental	Europe, Mediterranean
OSMUNDACEAE	*Osmunda regalis*	Royal Fern	LC	Medicinal, Ornamental	Morocco, Europe
PLUMBAGINACEAE	*Limonium cymuliferum*		NT	Ornamental	Morocco
POACEAE	*Agrostis stolonifera*	Creeping Bent Grass	LC	Animal feed, Horticulture	Global
POACEAE	*Alopecurus aequalis*	Shortawn Foxtail	VU	Food, Medicinal	China
POACEAE	*Arundo donax*	Giant Reed	LC	Medicinal, Food, Structural material, Fuel, Handicrafts	Morocco, Algeria, Libya
POACEAE	*Brachiaria eruciformis*	Giavone sottile	LC	Animal feed	India
POACEAE	*Brachiaria mutica*	Herbe de Para	LC	Animal feed	Mediterranean, Africa
POACEAE	*Catabrosa aquatica*	Water Whirl Grass	VU	Medicinal	United States
POACEAE	*Echinochloa colona*	Jungle Rice	LC	Food, Animal feed	India, China, Africa
POACEAE	*Echinochloa pyramidalis*	Antelope Grass	LC	Animal feed, Food	Africa, Mediterranean
POACEAE	*Glyceria declinata*		VU	Animal feed	Morocco, Algeria
POACEAE	*Glyceria fluitans*	Floating Manna Grass	EN	Animal feed	Morocco, Algeria
POACEAE	*Glyceria notata*		LC	Animal feed	Morocco, Algeria
POACEAE	*Glyceria spicata*		LC	Animal feed	Morocco, Algeria
POACEAE	*Leersia hexandra*	Swamp Cut Grass	LC	Animal feed	Africa, South America

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FAMILY	SPECIES NAME	COMMON NAME	REGIONAL RED LIST CATEGORY	END USES	AREAS WHERE HARVESTED
POACEAE	*Leptochloa panicea*	Mucronate Sprangletop	LC	Animal feed	India
POACEAE	*Molinia caerulea*		VU	Household	Morocco
POACEAE	*Panicum coloratum*		LC	Animal feed	Egypt
POACEAE	*Panicum repens*		LC	Animal feed, Medicinal	Morocco, Algeria, Libya, Tunisia
POACEAE	*Paspalidium geminatum*	Nseila	LC	Animal feed	Mediterranean
POACEAE	*Phalaris arundinacea*	Reed Canary-grass	LC	Animal feed, Structural material, Horticulture	Morocco, Algeria, Egypt, Sub Saharan Africa
POACEAE	*Phalaris paradoxa*	Awned Canary-grass	LC	Animal feed	Mediterranean
POACEAE	*Phragmites australis*	Common Reed	LC	Food, Animal feed, Structural material, Medicinal, Household	Global
POACEAE	*Phragmites mauritianus*	Reed Grass	LC	Handicrafts	Mediterranean, Southern Africa, Eastern Africa
POACEAE	*Polypogon monspeliensis*	Annual Beard-grass	LC	Animal feed	North America
POACEAE	*Saccharum spontaneum*	Canne Sauvage	LC	Handicrafts, Animal feed	India
POACEAE	*Sorghum halepense*	Aleppo Grass, Johnson Grass	LC	Animal feed	Egypt, Libya
POACEAE	*Sphenopus divaricatus*	Sphénope	LC	Animal feed	Mediterranean
POLYGONACEAE	*Persicaria bistorta bistorta*		VU	Medicinal	Mediterranean
POLYGONACEAE	*Persicaria hydropiper*		LC	Medicinal, Food	Morocco
POLYGONACEAE	*Persicaria lapathifolia*	Curlytop Knotweed	LC	Medicinal	Unknown
POLYGONACEAE	*Persicaria senegalensis*		LC	Medicinal, Food	Egypt, Eastern Africa
POLYGONACEAE	*Polygonum amphibium*		VU	Medicinal, Food	Morocco, Algeria
POLYGONACEAE	*Rumex crispus*		LC	Medicinal, Other chemicals	Morocco, Algeria, Tunisia, Libya
POLYGONACEAE	*Rumex dentatus*	Toothed Dock, Patience Dentée	NT	Medicinal	Mediterranean
POLYGONACEAE	*Rumex pulcher*		LC	Medicinal, Other chemicals	Morocco, Algeria, Egypt, Tunisia
POLYGONACEAE	*Rumex tunetanus*		CR	Animal feed	Tunisia
PORTULACACEAE	*Montia fontana*		LC	Food	Algeria, Morocco
PORTULACACEAE	*Portulaca oleracea*	Common Purslane, Green Purslane	LC	Food, Medicinal	Morocco, Algeria, Egypt, Libya, Australia, Europe
POTAMOGETONACEAE	*Groenlandia densa*		LC	Ornamental	Morocco
POTAMOGETONACEAE	*Potamogeton crispus*		LC	Ornamental	Morocco
POTAMOGETONACEAE	*Potamogeton lucens*		LC	Ornamental	Morocco
POTAMOGETONACEAE	*Potamogeton natans*	Broad-leaved Pondweed	LC	Food, Medicinal, Ornamental	China, Africa
POTAMOGETONACEAE	*Potamogeton nodosus*		LC	Ornamental	Morocco, Egypt
POTAMOGETONACEAE	*Potamogeton trichoides*		LC	Research	Morocco
POTAMOGETONACEAE	*Ruppia cirrhosa*		NT	Medicinal	Egypt
POTAMOGETONACEAE	*Ruppia maritima*	Beaked Tasselweed	LC	Medicinal, Fertilizer	India
PRIMULACEAE	*Lysimachia vulgaris*		CR	Medicinal, Other chemicals	Algeria
PRIMULACEAE	*Samolus valerandi*		LC	Medicinal, Food	Morocco
PTERIDACEAE	*Thelypteris interrupta*		EN	Ornamental, Horticulture	Morocco
PTERIDACEAE	*Thelypteris palustris*	Marsh Fern	VU	Ornamental, Horticulture, Food	Morocco, Algeria
RANUNCULACEAE	*Aquilegia vulgaris ballii*		LC	Medicinal	Algeria, Morocco
RANUNCULACEAE	*Ranunculus ficaria*		LC	Food	Morocco

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RANUNCULACEAE	*Ranunculus sceleratus*	Celery-Leaved Buttercup	LC	Medicinal	India, Europe
RHAMNACEAE	*Frangula alnus*	Frangola Commune	VU	Ornamental, Fuel, Medicinal	Algeria, Mediterranean, Europe
ROSACEAE	*Potentilla supina*	Potentille Couchée	LC	Medicinal, Other Chemicals	India, China
SALICACEAE	*Salix atrocinerea*		LC	Medicinal, Fuel	Morocco
SALICACEAE	*Salix mucronata*		DD	Fuel	Egypt, Libya
SALICACEAE	*Salix pedicellata*	Saule Pédicellé	LC	Fuel	Mediterranean
SALVINIACEAE	*Salvinia natans*		DD	Ornamental	Africa
SCROPHULARIACEAE	*Bacopa monnieri*	Water Hyssop	EN	Medicinal, Aquarium	India, Mediterranean
SCROPHULARIACEAE	*Gratiola officinalis*	Hedge Hyssop	VU	Medicinal, Ornamental	Mediterranean, Morocco
SCROPHULARIACEAE	*Peplidium maritimum*		DD	Food	India
SCROPHULARIACEAE	*Scrophularia auriculata*		LC	Medicinal	Algeria, Morocco
SCROPHULARIACEAE	*Veronica anagallis-aquatica*		LC	Medicinal	Morocco
SELAGINELLACEAE	*Selaginella denticulata*		LC	Medicinal	Morocco
TYPHACEAE	*Sparganium erectum*	Branched Bur-reed	NT	Food, Household	Europe, North America
TYPHACEAE	*Typha angustifolia*	Lesser Bulrush	LC	Food, Medicinal, Construction, Household, Handicrafts	Egypt, North America, China, Africa
TYPHACEAE	*Typha domingensis*	Massette Australe, Southern Cattail	DD	Food, Animal feed, Handicrafts, Fibre, Medicinal, Construction	Egypt, Algeria, Tunisia, Morocco, Africa, Asia
TYPHACEAE	*Typha elephantina*		LC	Structural Material, Medicinal	Africa, India
TYPHACEAE	*Typha latifolia*	Reedmace, Broadleaf Cattail	LC	Food, Medicinal, Handicrafts, Ornamental, Horticulture	Egypt, Mediterranean, China, Europe
VERBENACEAE	*Phyla nodiflora*	Frogfruit	LC	Medicinal	India
VERBENACEAE	*Verbena officinalis*		LC	Medicinal	Morocco, Algeria, Tunisia, Libya, Egypt
VERBENACEAE	*Verbena supina*		LC	Medicinal, Aromatic	Morocco

[1] For a definition of aquatic plants see Chapter 1 of this report.

In northern Africa, *Nymphaea alba*, listed as Vulnerable, is mainly threatened by habitat loss due to agriculture. Photo © DerHexer.

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