Chapter 7

The status and distribution of freshwater plants in the Lake Victoria Basin

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7.1 Introduction

The Lake Victoria Basin is home to a great diversity of freshwater plants, with the highest diversity found in the wetlands that occur along the shoreline of Lake Victoria and along the rivers (the Sio, Nzoia, Yala, Nyando, Sondu-Miriu, Awach, Kuja, Mara and Kagera) flowing into the lake. The basin is home to the most extensive wetlands in Eastern Africa and these wetlands support remarkably high biodiversity. Freshwater plants support both human and animal communities living in the water and in the riparian zone. This support occurs indirectly, through roles in wetland ecosystem services, and directly through provision of food and habitats for animal communities, and through provision of resources to support livelihoods for human populations (Millennium Ecosystem Assessment, 2005) (see Chapter 10).

Many plant species, such as water tolerant grasses, sedges, shrubs and trees, grow on the seasonal floodplains and riparian zones adjacent to the lake and inflowing rivers (Wakwabi *et al*., 2006). However, at present, macrophytes (plants large enough to be visible to the naked eye that grow submerged below, floating on or up through the water surface) dominate the freshwater plant taxa of the Lake Victoria Basin. It is thought that previously haplochromine cichlids inhibited establishment of macrophythes from the inshore areas of the lake by constantly causing disturbance of the substrate (Witte *et al*., 1991). However, a decline in the abundance of haplochromine cichlids (see Chapters 4 and 9), in combination with increased siltation of river mouths and the lake shores resulting from deforestation of the basin, have contributed to extensive establishment of macrophytes (Wakwabi *et al*., 2006). Macrophytes are regarded as the most productive plant communities in the world (Penfound, 1956; Reddy, 1984; Sculthorpe, 1976; Westlake, 1963) and are also known to be important for biological diversity, as many associated species of plants and animals depend on macrophytes for survival (Chapman *et al*., 2001).

7.2 Red List assessments

One hundred and thirty-five freshwater plant species native to the Lake Victoria Basin in 26 families were assessed. Please see Chapter 2 for an explanation of how the species list for assessment was generated. Twenty-one of these

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families were assessed comprehensively with respect to freshwater species in the basin and selected freshwater species from the remaining five families were assessed (Appendix 1). None of these species are endemic to the Lake Victoria Basin (Table 7.1).

The majority of the assessed species are classified as Least Concern (LC) (124 species, 91.9% of those assessed; Figure 7.1, Table 7.1) as they are relatively common and widespread with no major threats identified as likely to reduce their overall population viability. This percentage of LC species is high compared with the 2011 assessment of freshwater plant species (in selected plant families) endemic to continental Africa (Darwall *et al*., 2011) where 49.2% were assessed as LC.

Only eight species (6.0% of those assessed and excluding Data Deficient (DD) species; Figure 7.1, Table 7.1) are considered threatened with extinction (listed in the categories Critically Endangered (CR), Endangered (EN) or Vulnerable (VU)). This percentage is low compared with the wider continental 2011 assessment (Darwall *et al*., 2011) where one quarter were classified into one of the threatened Red List Categories.

Table 7.1 Number of assessed freshwater plant species native to the Lake Victoria Basin in each Red List Category. For a list of species and their Red List Categories and Criteria please see Appendix 1.

IUCN Red List Category	Number of species	Number of species endemic to the Lake Victoria Basin
Extinct (EX)	0	0
Extinct in the Wild (EW)	0	0
Critically Endangered (CR)	0	0
Critically Endangered (Possibly Extinct) (CR(PE))	0	0
Endangered (EN)	6	0
Vulnerable (VU)	2	0
Near Threatened (NT)	2	0
Least Concern (LC)	124	0
Data Deficient (DD)	1	0
Total	**135**	**0**

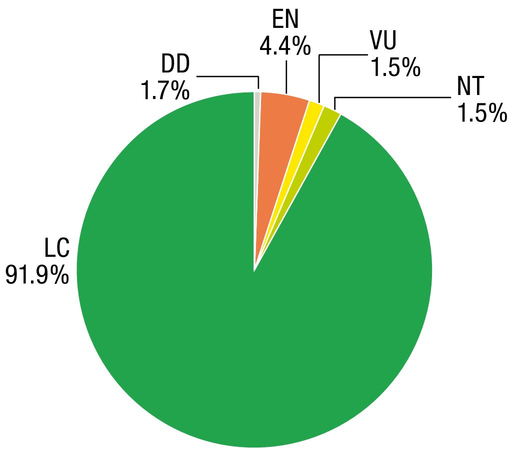

Figure 7.1 Proportion (%) of assessed freshwater plant species native to the Lake Victoria Basin in each Red List Category. For a list of species and their Red List Categories and Criteria please see Appendix 1.

Only one species assessed is listed as DD: *Bulbostylis trabeculata* (Table 7.1), as there was insufficient information on its distribution and the degree of severity of the threat of livestock grazing on the population to assess its extinction risk (Beentje, 2017a). The percentage of DD species (0.7% of assessed plant species; Figure 7.1) is low compared with the 2011 assessment (Darwall *et al*., 2011) where 16.5% of aquatic plants were classified as DD. This indicates that knowledge of freshwater plant species in this region is better than for other parts of Africa and that the true proportion of threatened freshwater plant species amongst those we assessed will be close to that indicated here (5.9–6.6% of assessed plant species).

No freshwater plant species native to the basin are assessed as Extinct (EX) or Extinct in the Wild (EW) (Table 7.1). This is unsurprising given that only one species was assessed as EW (*Nymphaea thermarum*; see Juffe, 2010) in the assessment of endemic species from selected freshwater plant families for the entirety of continental Africa (Darwall *et al*., 2011).

7.3 Patterns of species richness

The patterns of species richness discussed in this section refer to a subset of 118 of the 135 freshwater plant species assessed through this project for which distribution data were available. Distribution maps were not produced for 17 of the 135 species, all of which were widespread, as distribution data beyond occurrence in particular countries were not available. This level of information is already captured in the coded 'Countries of occurrence' section of the Red List assessment and, therefore, to maintain consistency in the resolution of spatial data, maps based only on country level data were not produced.

7.3.1 Overall species richness

The Lake Victoria Basin is rich in freshwater plant species with sub-basins containing on average 82 freshwater plant species (out of the 118 mapped species). Generally, from the subset of freshwater plant species investigated, the eastern basin has the greatest species richness (Figure 7.2), in particular to the east of Mount Elgon in Kenya (91 species per sub-basin), on the shores of Winam Gulf in Kenya (90–97 species per sub-basin), on the border of Kenya and Tanzania (93–96 species per sub-basin) and in the northern Serengeti in Tanzania (92–95 species per sub-basin). Eighty-six freshwater plant species are mapped to occur within Lake Victoria itself, including both shoreline species (e.g. rushes, *Juncus* species) and those occurring across large areas of the surface of the lake (e.g. Water Lettuce, *Pistia stratiotes*). In the western Lake Victoria Basin, regional highs of species richness of the subset of species investigated are found in the Kibale and Kagera River basins on the border of Tanzania and Uganda (88–89 species per sub-basin), in the Kagera River Basin on the border of Rwanda and Tanzania (84 species per sub-basin) and in the vicinity of Lakes Bulera and Ruhondo in Rwanda (87 species per sub-basin).

It is likely that some of these spatial trends are the result of greater sampling effort within protected areas, such as the Serengeti and Akagera National Parks, rather than reflecting the true distribution of species richness. Additionally, it should be noted that a comprehensive list of freshwater plant species could not be considered here.

7.3.2 Threatened species richness

Interestingly, in general, the patterns in threatened species richness for this subset of freshwater plant species do not correspond to the patterns of overall species richness, with the exception of the area to the east of Mount Elgon in Kenya, which has both high overall species richness and the highest threatened species richness (four species per sub-basin: *Ethulia scheffleri, Hygrophila asteracanthoides, Luzula mannii* and *Lagarosiphon hydrilloides*), and around Lakes Bulera and Ruhondo in Rwanda, where sub-basins have relatively high overall and threatened species richness (three species per sub-basin: *Carpha angustissima, Nymphoides tenuissima* and *Psilotrichum axilliflorum*) (Figure 7.3). No threatened freshwater plant species (out of the subset investigated) are found in Lake Victoria itself or across much of the Lake Victoria Basin. In the lower Nzoia River and the Yala River Basins (north-eastern Lake Victoria Basin), three threatened species (*Ethulia scheffleri, Lagarosiphon hydrilloides* and *Luzula mannii*) are found, and pairs of these three species are found in each sub-basin along the coast of Lake Victoria from Jinja in Uganda to Winam Gulf (and eastwards) in Kenya. In the western Lake Victoria Basin, one threatened species (*Carpha angustissima*) is found per sub-basin in the catchment of the Nyabarongo River in Rwanda. For all eight threatened freshwater plant species, the Lake Victoria Basin lies on the outskirts of wider distributions.

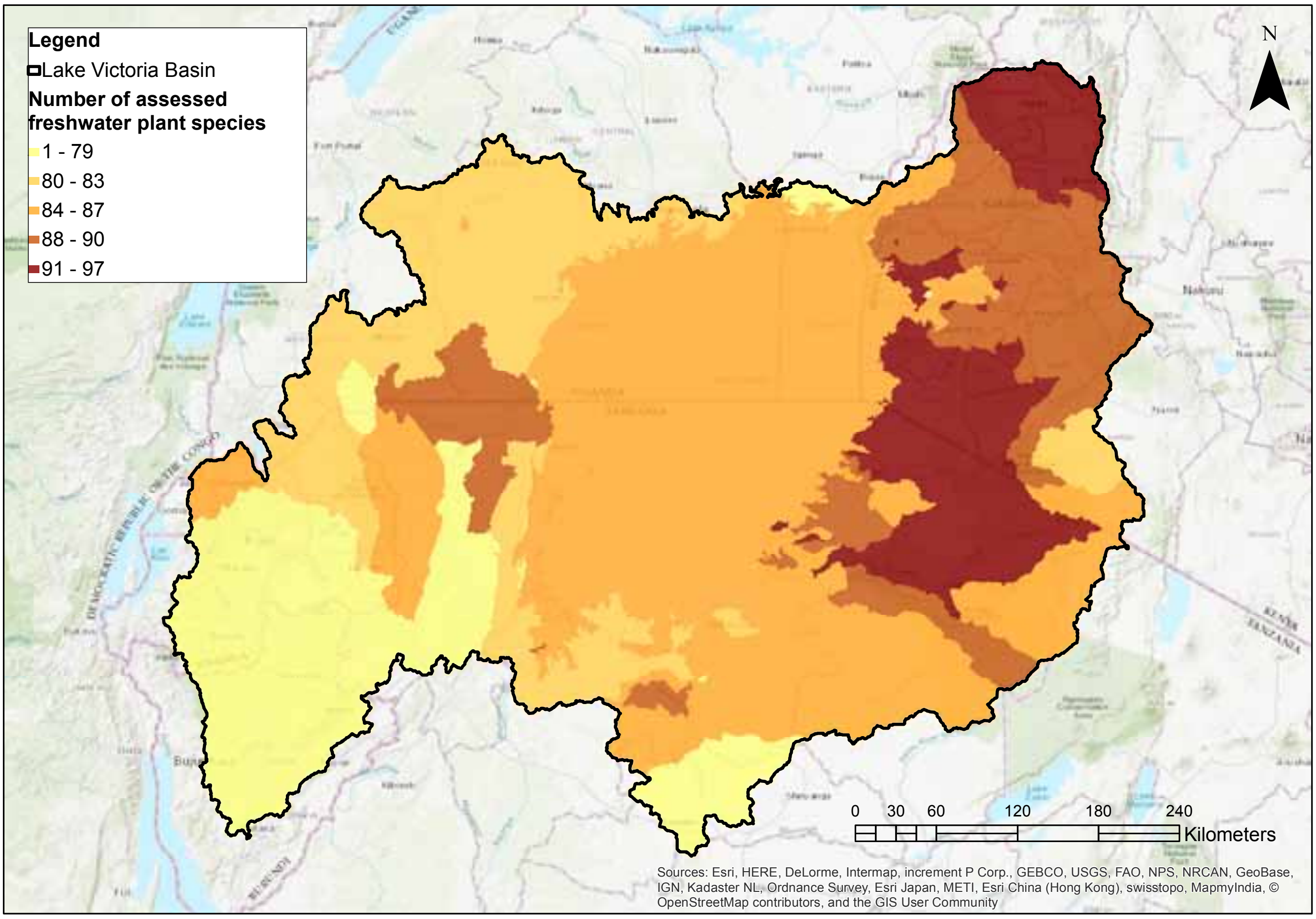

Figure 7.2 Richness of the assessed freshwater plant species in the Lake Victoria Basin, based on spatial data coded as Presence 1 (Extant) and Presence 2 (Probably Extant). Richness data are classified using quantiles.

7.4 Major threats

Although 91.9% of the aquatic plants assessed for this project are listed as LC (Figure 7.1), this does not mean that these species face no threats. Species listed as LC may be impacted by threats which, if not stopped or minimised, could result in the species becoming threatened with extinction in the future. The most significant threat to the aquatic plants of the Lake Victoria Basin is habitat loss and degradation, followed by pollution.

7.4.1 Habitat loss and degradation

Land use change for agriculture results not only in the loss of physical space for freshwater plant species to grow but also in the degradation of habitats. The Millennium Ecosystem Assessment (2005) lists conversion or drainage of wetlands for agriculture as the primary cause of inland wetland loss globally. In the Lake Victoria Basin, 42.2% of the assessed plant species are coded as threatened by loss of habitat resulting from agriculture, with 40% threatened specifically by annual and perennial non-timber crops. This includes *Helichrysum formosissimum* (Figure 7.4), a freshwater plant species found in moorland swamps and bogs and wet grassland sites, as well as in the upper bamboo zone. Wetland habitats in the lower altitudes of the species range are being converted to agricultural land by small-holders, which is leading to rapid declines in this part of its range (Beentje, 2017b).

Figure 7.4 *Helichrysum formosissimum*, although currently listed as Least Concern (LC), is under threat from conversion of its lower altitude wetland habitats to agricultural land.

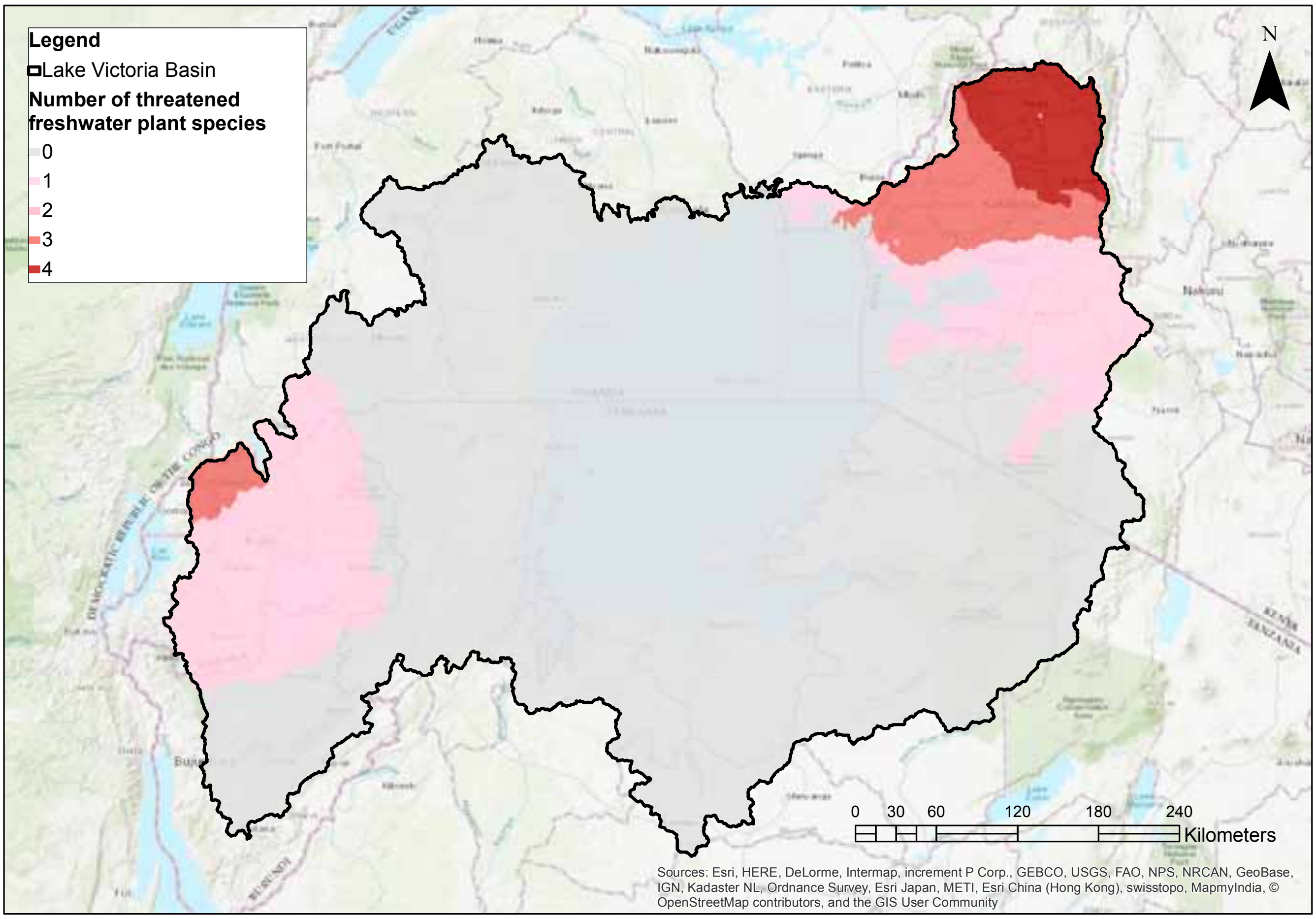

Figure 7.3 Richness of threatened freshwater plant species in the Lake Victoria Basin, based on spatial data coded as Presence 1 (Extant) and Presence 2 (Probably Extant). Richness data are classified using quantiles.

Figure 7.5 Deforestation of Bugala Island of the Ssese Islands in the Ugandan part of Lake Victoria for conversion of the land to an oil palm plantation. © Simon Whitaker (CC BY-NC 2.0)

Conversion of wetland habitats for agro-industry farming is also a threat to aquatic plant species. For example, around the start of the 21st century land in the Lake Victoria Basin, primarily in Uganda, started to be converted for oil palm plantations as part of a plan to reduce poverty (Figure 7.5). Oil palm plantations have been established within the range of the Endangered *Psilotrichum axilliflorum* and are leading to declines in the habitat (Beentje, 2017c).

Agricultural practices and deforestation or removal of the native vegetation also lead to soil erosion on land. This is carried in run-off into water bodies, leading to sedimentation, which is coded as a threat to *Nymphoides forbesiana* (Figure 7.6) (Beentje and Ghogue, 2017).

Livestock farming, including both conversion of land for small-holdings and nomadic grazing, is coded as a threat to 7.4% of plant species assessed. This includes *Brillantaisia owariensis* (Figure 7.7), a presently widespread species with important medicinal uses (Beentje, 2017d), and *Sphaeranthus samburuensis* (EN), which is restricted to the edge of waterholes in dry bushland, a habitat where large herds of cattle congregate (Beentje, 2017e).

Land use change for residential and commercial development is also a threat to aquatic plants in the Lake Victoria Basin but to a lesser extent than agriculture, with 3.7% of the plant species assessed coded as threatened by this activity.

7.4.2 Pollution

Pollution from agricultural, urban and industrial sources is coded as a threat to 11.9% of the plant species assessed with agricultural and forestry effluents representing the primary source, threatening 9.6% of these species. Eutrophication of water bodies is one of the main consequences of pollution, and this presents a serious problem across Africa (Nyenje *et al*., 2010). For freshwater plant communities, eutrophication often leads to the simplification of plant assemblages, resulting in a small number of dominant species and the loss of habitat specialists (Wetzel, 2001). Nutrient loading, leading to eutrophication, is a potential threat to the aquatic herb *Nymphoides forbesiana* (Figure 7.6) (Beentje and Ghogue, 2017) amongst others in the basin.

Figure 7.6 *Nymphoides forbesiana*, currently assessed as Least Concern (LC), is an aquatic herb thought to be threatened by nutrient loading leading to eutrophication, and by sedimentation of water bodies resulting from soil erosion. © Quentin Luke

Herbicides and pesticides enter water bodies through run-off from agricultural fields, and are coded as a threat to 5.2% of the plant species assessed through this project. These chemicals result in direct mortality of some aquatic plant species, including of the herb *Brillantaisia lamium* (Figure 7.8) (Beentje, 2017f), and also cause habitat degradation.

Figure 7.7 *Brillantaisia owariensis* although currently listed as Least Concern (LC), is under threat from conversion of its habitat to land for livestock grazing. © Scamperdale (CC BY-NC 2.0)

Figure 7.8 *Brillantaisia lamium*, currently Least Concern (LC), is a herb that is threatened by herbicides and pesticides. © Quentin Luke

7.4.3 Other threats

Although habitat degradation and pollution of water bodies are the primary threats to aquatic plant species in the Lake Victoria Basin, there are other threats causing severe declines in a small number of species. Actions to combat these threats will be required for the conservation of these species.

For example, *Carpha angustissima* is a range-restricted species that occurs from south-west Uganda to eastern Democratic Republic of Congo, and is assessed as EN. This species is found in montane or afro-alpine bogs, and this habitat is under threat from extended droughts in combination with increasing frequency or intensity of uncontrolled fires (Beentje, 2017g). These threats are coded to affect 3.7% and 3.0% of the plant species assessed, respectively.

Finally, biological resource use, including logging of wood and gathering of plants, is coded as a threat to 4.4% of the plant species assessed. However, it should be noted that many aquatic plants gathered for their uses as foods, medicines and structural materials contribute to human livelihoods, and in many cases this use is sustainable and can result in the conservation of local subpopulations of the species (see Chapter 10).

7.5 Climate change vulnerability

The climate change vulnerability assessment of the Lake Victoria Basin's freshwater plants considered 137 taxa. Eighteen biological traits, of which 14 related to 'Sensitivity' (Table 7.2), and four to 'Low Adaptive Capacity' (Table 7.3) were considered.

Ninety-six species (70%) are assessed as possessing one or more traits that make them highly sensitive to climate change. No species are assessed as 'low' in terms of their sensitivity, and 41 species (30%) are assessed as 'unknown'.

Within the sensitivity analysis, the most commonly possessed traits are habitat specialisation (Trait S2), present in 58 species (42%), and inferred low tolerances of temperature or precipitation changes (Traits S5 and S6), both of which are present in 32 species (23%). Data gaps on the sensitivity of freshwater plant species are most common across several traits, including seedbank dependence (Trait S4), unknown for 110 (80%) species, and traits relating to environmental triggers for flowering or germination (Traits S9-S11), unknown for around 130 (95%) species in each case.

In the assessment of adaptive capacity, 50 species (36%) are assessed as possessing traits that make them poorly able to adapt to climate change. One species is assessed as

Table 7.2 Climate change sensitivity traits used to assess 137 freshwater plant taxa, including thresholds used to classify species, and the total numbers of species falling into each category for each trait. A species can only be classified as having 'Low' sensitivity overall if it is not classified as 'High' for any trait, and if there are no missing data values for any trait.

Trait Groups	Traits		Thresholds	FRESHWATER PLANTS		
				Total species = 137		
SENSITIVITY				Low	High	Unknown
A. Specialised habitat and/or microhabitat requirements	Temporary freshwater dependence	**S1:** Species is known to depend exclusively upon natural freshwater habitats that are temporary in nature	Low = false; High = true	122	12	3
	Habitat specialisation	**S2:** Species described (with justification) as having specialised habitat requirements	Low = false; High = true	75	58	4
	Microhabitat specialisation	**S3:** Species is dependent on one or more microhabitats	Low = false; High = true	130	5	2
	Seedbank dependence	**S4:** Species requires a long-term seedbank as part of its life-cycle	Low = false; High = true	26	1	110
B. Narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle	Tolerance of changes to precipitation regimes	**S5:** Average absolute deviation in precipitation across the species' current range	Average absolute deviation in precipitation across the species' historical range: Low = highest 75%; High = lowest 25%	97	32	8
	Tolerance of temperature changes	**S6:** Average absolute deviation in temperature across the species' current range	Average absolute deviation in temperature across the species' historical range: Low = highest 75%; High = lowest 25%	97	32	8
	Inundation intolerance	**S7:** Species is highly intolerant of inundation (can only tolerate <1 month) and is NOT a 'true aquatic'	Low = false; High = true	118	1	18
	Water absence tolerance	**S8:** Species is highly intolerant of water absence (can only tolerate <1 month)	Low = false; High = true	76	13	48
C. Dependence on a specific environmental trigger that is likely to be disrupted by climate change	Drought + rain to flower or germinate	**S9:** Species requires a period of drought followed by rain in order to flower or germinate	Low = false; High = true	6	0	131
	Drop in water level to flower or germinate	**S10:** Species requires a drop in water level in order to flower or germinate	Low = false; High = true	5	2	130
	Peculiar germination requirement	**S11:** Species described (with justification) as having a peculiar germination requirement	Low = false; High = true	11	0	126
D. Interspecific interactions which could be disrupted by/ emerge as a result of climate change	Decreasing positive interactions with other species	**S12:** Species requires its habitat to be trampled by large animals in order to make it suitable for growth	Low = false; High = true	35	0	102
		S13: Species is carnivorous and relies upon five or less prey species, or it is a specialist nematode feeder	Low = false; High = true	137	0	0
	Increasing negative interactions with other species	**S14:** Species could experience increases in one or more of the following as a result of climate change: predation, competition, parasitism, disease	Low = false; High = true	97	0	40
Number of species in each sensitivity classification				**0**	**96**	**41**
Percentage				**0%**	**70%**	**30%**

Table 7.3 Climate change adaptive capacity traits used to assess 137 freshwater plant taxa, including thresholds used to classify species, and the total numbers of species falling into each category for each trait. A species can only be classified as having 'Low' adaptive capacity overall if it is not classified as 'High' for any trait, and if there are no missing data values for any trait.

Trait Groups		**Traits**	**Thresholds**	**FRESHWATER PLANTS**		
				Total species = 137		
LOW ADAPTABILITY				Low	High	Unknown
A. Poor dispersability	Extrinsic barriers to dispersal	**A1:** Extrinsic barriers to dispersal	High = occurs exclusively on mountaintops, small islands and/or areas where dispersal is blocked by unsuitable habitat (natural or anthropogenic); Low = no known barriers	127	6	4
	Low intrinsic dispersal capacity	**A2:** Median estimated dispersal distance per year	Low = >1 km/year; High = ≤ 1 km/year	34	49	54
B. Poor evolvability	Low rate of developing novel traits	**A3:** Species is only able to reproduce asexually	Low = false; High = true	137	0	0
	Low genetic diversity	**A4:** Species is described (with justification) as having a known lack of genetic diversity (e.g. a known historic bottleneck)	Low = false; High = true	4	0	133
Number of species in each adaptive capacity classification				**1**	**50**	**86**
Percentage				**1%**	**36%**	**63%**

'low' risk in terms of its adaptive capacity, and sufficient data are unavailable for 86 species (63%), meaning that they are assessed as 'unknown' in terms of their capacity to adapt to change.

Within the analysis of adaptive capacity, a low intrinsic dispersal capacity (Trait A2) is the most common trait – present in 49 (66%) species. Data on the genetic diversity are the most lacking, being unavailable for 133 (97%) species.

Table 7.4 summarises findings of the exposure assessments for 129 freshwater plant species (eight species could not be used as they lacked distribution maps). The exposure analysis found that between 73 (56.5%) (using RCP4.5 for the 2055 period) and 129 (100.0%) (using RCP8.5 for both time periods) freshwater plants (with available range maps) are expected to be highly exposed to climate change. Considering the proportions of species' ranges that are projected to experience novel conditions (relative to conditions in each species' current range), we calculate that between 1.6% (RCP4.5 for both time periods, and RCP8.5 for 2055 only) and 5.4% (RCP8.5 for 2085) of species are expected to 'lose' more than half of their current range.

Species were then assessed as vulnerable to climate change if they scored as 'high' under all three criteria of exposure, sensitivity and adaptive capacity. Overall, total numbers of climate change vulnerable freshwater plant species range from 20 (15%) (using RCP8.5 for the 2055 period) to 34 (25%) (for both RCPs for the 2085 time period, out of a total of 129 taxa), under an optimistic assumption of missing data values. These numbers increase to 80 (58%), 82 (60%) and 136 (99%) for RCP4.5 and the 2055 period, RCP8.5 and the 2055 period, and both RCPs and the 2085 period, respectively, when missing data values are treated pessimistically.

Table 7.4 Total numbers (and percentage of all species assessed) of freshwater plants considered highly exposed to climate change under both timeframes and Representative Concentration Pathways (RCPs) considered. Upper row shows numbers derived following the methods of Foden *et al*. (2013) (see Chapter 2), and lower row shows numbers for which ≥50% of their current range is projected to experience climatic conditions not currently present anywhere in their range. Note that eight species do not have range maps available, and so are not included in this table. The exposure analysis considered 129 taxa, a subset of the 137 investigated with distribution maps.

	RCP4.5		**RCP8.5**	
	2055	**2085**	**2055**	**2085**
Numbers (and percentages) of climate change exposed species, following the methods of Foden *et al.* (2013)	73 (56.5%)	129 (100%)	75 (58.1%)	129 (100%)
Numbers (and percentages) of species for which ≥50% of their ranges are projected to experience entirely novel conditions	2 (1.6%)	2 (1.6%)	2 (1.6%)	7 (5.4%)

In terms of the distribution of climate change vulnerable freshwater plants across the Lake Victoria Basin (using RCP8.5 for the 2055 period), we see an apparent gradient from west to east (Figure 7.9) – numbers being lowest in the west (typically six to seven species per grid cell), and highest in the north-east and eastern periphery of the Lake Victoria Basin (between 13 and 14 species per grid cell). In the main body of the lake itself, 10 species of climate change vulnerable freshwater plant species (of those assessed) are found. In terms of percentages, this equates to 13–15% of the plant species assessed in the north-east, south-east and

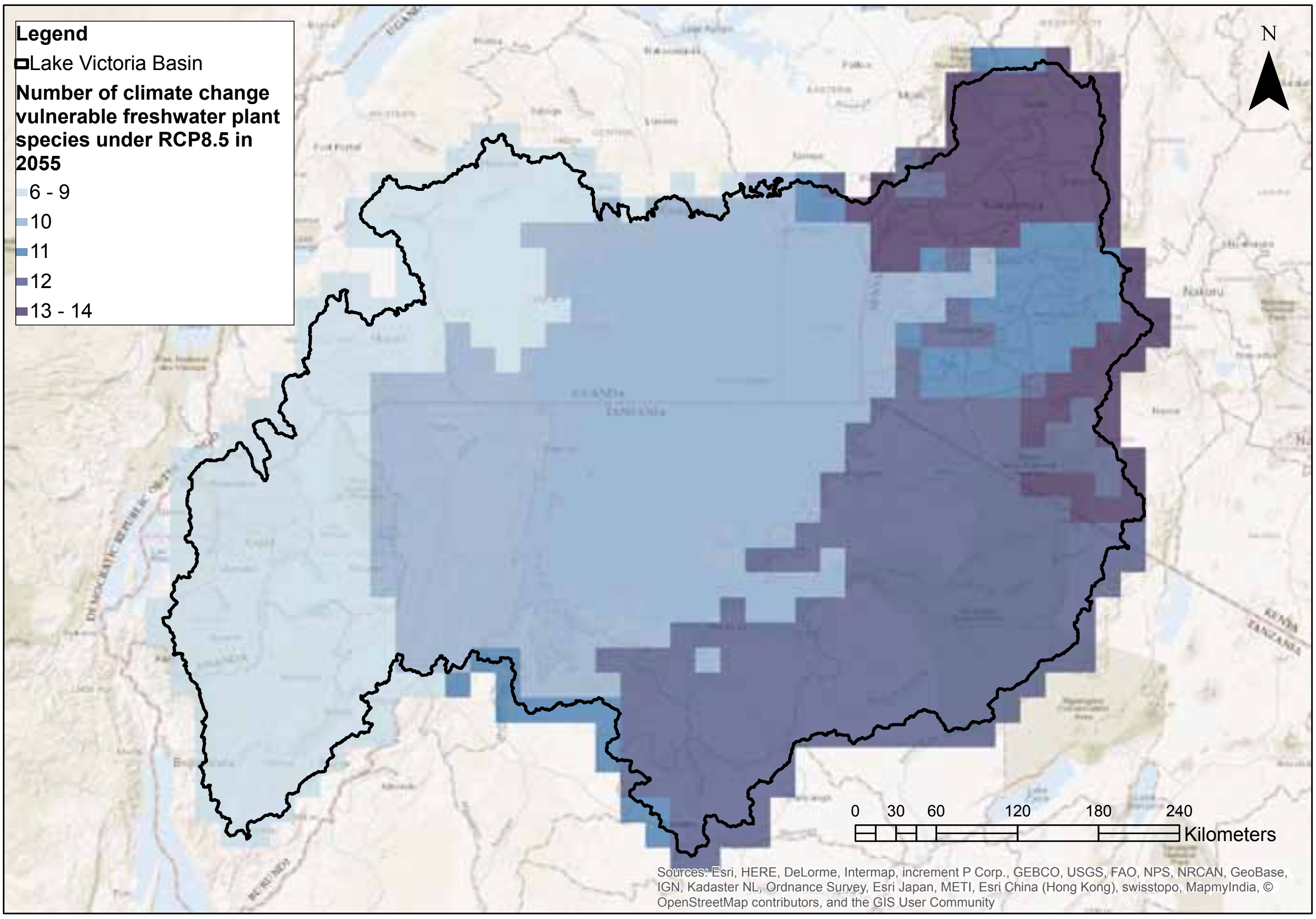

Figure 7.9 Richness of climate change vulnerable freshwater plants (using RCP8.5 for the 2055 period). Richness data are classified using quantiles.

eastern periphery of the Lake Victoria Basin, 11–12% of the plant species assessed in Lake Victoria itself and surrounding its shores, and 7–10% in the western basin (Figure 7.10). The border between Burundi and Rwanda in the western basin is an exception to this, with 11–12% of the plant species assessed considered climate change vulnerable.

7.6 Recommended research and conservation actions

7.6.1 Research actions recommended

Although only 0.7% of the freshwater plant species assessed are listed as DD (Figure 7.1), meaning that there is insufficient information available to evaluate their extinction risk, 58.5% of the species assessed are coded as requiring further research. In particular, research on species population size and trend, distribution and threats is frequently recommended.

Additionally, 8.1% of the species assessed are coded to require monitoring of their population trend. Species coded include both threatened species and those currently listed as LC, reinforcing the message that even species at low relative risk of extinction at present should be monitored as they could move to a higher category of threat if conservation actions are not implemented.

7.6.2 Conservation actions recommended

In terms of conservation actions, education and awareness raising is the most frequently coded action, recommended for 18.5% of the species assessed. This awareness raising should be focussed both around the presence of individual freshwater plant species, which may be of particular note due to their value for livelihoods or high relative extinction risk for example, and around the value of wetlands. Wetlands are often seen as wasted land and therefore a site for dumping waste products, or as the source of problematic animals such as mosquitoes (Smith *et al.*, 2014). It is important that the benefits of clean and healthy wetland systems are communicated.

In the case of freshwater plants that are important to livelihoods, the knowledge surrounding their traditional uses may be important for conserving and managing the sustainable use of these species (see Chapter 10). Conservation actions should seek to ensure that such traditional knowledge is not lost.

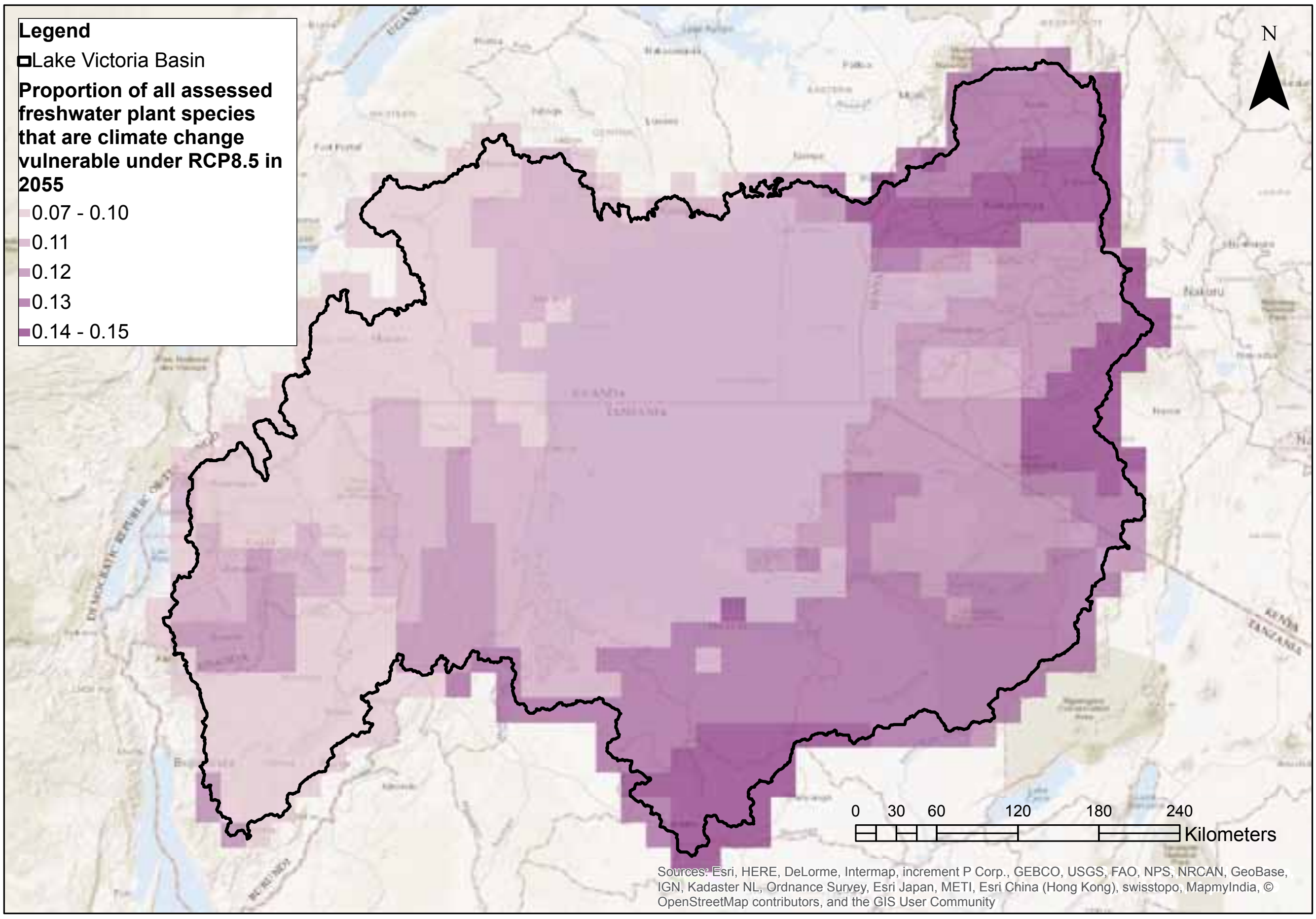

Figure 7.10 Proportion of all assessed freshwater plant species that are climate change vulnerable (using RCP8.5 for the 2055 period). Proportion data are classified using quantiles.

At the site level, 10.4% of the species assessed require site/area management where they occur, and 3.0% require site/area protection. Key Biodiversity Areas (KBAs), which are sites contributing to the global persistence of biodiversity, were identified through this project for freshwater species, including a number of freshwater plants. However, this project was only a starting point for the KBA delineation process within the Lake Victoria Basin (see Chapter 11) and there are likely more areas to be identified that are important for plant conservation. Once these sites have been identified, management actions should be targeted at the catchment scale, following methods such as Integrated River Basin Management (IRBM) or Environmental Flows (E-Flows), as many threats to aquatic species can spread rapidly through a catchment due to the high levels of hydrological connectivity.

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