

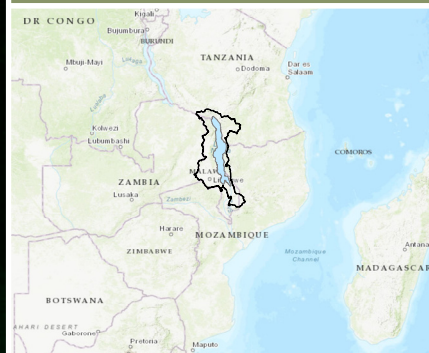


CONSERVATION PRIORITIES FOR FRESHWATER BIODIVERSITY IN THE LAKE MALAWI/NYASA/NIASSA CATCHMENT

Edited by Catherine A. Sayer, Amy F. Palmer-Newton and William R.T. Darwall



LAKE MALAWI/
NYASA/NIASSA
CATCHMENT



The IUCN Red List of Threatened Species™



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This publication has been made possible in part by funding from the JRS Biodiversity Foundation.

Published by: IUCN Cambridge, UK in collaboration with IUCN Gland, Switzerland

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Citation: Sayer, C.A., Palmer-Newton, A.F. and Darwall, W.R.T. (2019). *Conservation priorities for freshwater biodiversity in the Lake Malawi/Nyasa/Niassa Catchment*. Cambridge, UK and Gland, Switzerland: IUCN. xii +214pp.

ISBN: 978-2-8317-2021-0 (print version)

978-2-8317-2020-3 (PDF)

DOI: <https://doi.org/10.2305/IUCN.CH.2019.RA.1.en>

Cover photo: *Dimidiochromis compressiceps*, known locally as chimpeni (“big knife”) and with the English common name Malawi eyebiter, is a popular ornamental fish native to the Lake Malawi/Nyasa/Niassa Catchment. It is assessed for the IUCN Red List of Threatened Species™ as Least Concern (LC). © Ad Konings

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Layout by: NatureBureau www.naturebureau.co.uk

Printed by: Graphics Solutions

Available from: IUCN (International Union for Conservation of Nature)
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www.iucn.org/theme/species/our-work/freshwater-biodiversity

The text of this book is printed on 115 gsm gloss.

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Acknowledgements

Donor

First of all, we would like to thank the JRS Biodiversity Foundation (www.jrsbiodiversity.org) for funding this project “Biodiversity Information For the Lake Malawi Catchment Eastern Africa: Data For Decision-makers” and making this work possible. In particular, we would like to thank Don Doering for his unwavering support throughout the project, and to Samantha Garvin and Emily Grason for helping to communicate the project outcomes.

Project partners

The Freshwater Biodiversity Unit, part of the IUCN Global Species Programme, led this project in collaboration with the Malawi Department of Fisheries, without which this project would not have been possible. We would particularly like to thank Friday Njaya, Jacqueline Kazembe, Geoffrey Kanyerere and Titus Phiri.

IUCN Global Species Programme

Many thanks to all staff of the Red List Unit and in particular to Craig Hilton-Taylor, Caroline Pollock, Janet Scott and Max Fancourt for their help in publication of the Red List assessments, and to Ackbar Joolia and Kate Harding for their help in producing and publishing the species distribution maps. We are also grateful to Laura Máiz-Tomé and Adam Daniels of the Freshwater Biodiversity Unit for their help in finalising the report, to Elaine Paterson, Harriet Brooker and Goska Bonnaviera for their support in communicating the project outputs, and to Mickael Chevalier, Hanli Schmidt and Hussein Ahmed for their support with administrative and financial issues.

IUCN Forest Programme

We would like to thank Craig Beatty of the IUCN Forest Programme for his work on forest landscape restoration opportunities in the Malawian Key Biodiversity Areas (KBAs) identified through this project.

IUCN Water Programme

Thanks to colleagues from the IUCN Water Programme involved in the BRIDGE (Building River Dialogues and Governance) project for sharing their expertise on the Lake Malawi/Nyasa/Niassa Catchment and for their review of Chapter 1. Particular thanks to Mampiti Matete, Tariro Davison Saruchera and Melisa Mabel Mavhenge.

IUCN World Heritage Programme

We would also like to thank colleagues in the IUCN World Heritage Programme. Particular thanks to Mizuki Murai for her

engagement and advice surrounding the potential contribution of the Key Biodiversity Areas (KBAs) identified through this project to the World Heritage Committee recommendation on the Lake Malawi National Park World Heritage property. Thanks also to Matea Osti for her advice on the IUCN World Heritage Outlook.

Red List assessors and reviewers

We would like to thank the species experts, including members of the IUCN Species Survival Commission (SSC), who shared their knowledge by acting as assessors and/or reviewers in the Red List assessment process. The individuals involved directly in this project were: Neil Cumberlidge (decapods); Eugidio Gobo, Geoffrey Kanyerere, Ad Konings, Béla Nagy, Titus Phiri, Asilatu Shechonge, Jos Snoeks, Denis Tweddle, Brian Watters (fishes); Christian Albrecht, Martin Genner, Dirk Van Damme (molluscs); Charles Clarke, Richard Lansdown, Isabel Larridon, Zacharia Magombo, Gladys Mkwapatira, Elizabeth Mwafongo, Montford Mwanyambo, Malin Rivers and Peter Wilkie (plants). Particular thanks to the experts listed above who also co-authored the taxonomic summary chapters for this report.

Key Biodiversity Area (KBA) stakeholders

Thanks to the species experts who proposed sites for investigation as potential Key Biodiversity Areas (KBAs) prior to the KBA delineation and validation workshop: Christian Albrecht, Ad Konings, Benjamin Ngatunga, Denis Tweddle and Dirk Van Damme. We would also like to thank the participants who attended the KBA delineation and validation workshop: Ausward Bonongwe, Lucia Chigamane, Potiphar Kaliba, Geoffrey Kanyerere, Sam Manda, McPhillip Mwithokona, Zondiwe Ndhlovu, Maxon Ngochera, David Nkhwazi, Antonio Pegado, Titus Phiri, Stephen Sakhama, Asilatu Shechonge, George Turner, Denis Tweddle and Angus van Wyk. Thanks also to the individuals who reviewed the proposed KBAs online after the workshop: Christian Albrecht, Geoffrey Kanyerere, Ad Konings, McPhillip Mwithokona, Antonio Pegado, Titus Phiri, Asilatu Shechonge, George Turner, Denis Tweddle, Dirk Van Damme and Olaf Weyl. Finally, thanks to Andy Plumtre of the KBA Secretariat, Hugo Costa and all members of the Mozambique KBA National Coordination Group and to Gill Bunting and Tom Lambert of BirdLife International for their assistance in the review and publication of the KBAs on The World Database of Key Biodiversity Areas.

Photos

Many photographers have contributed photos to this report, including those who have provided access to their images

through Creative Commons, and we would like to thank them all for allowing us to use their images to bring this report to life. All photographers are credited alongside their images.

IUCN Publications and Editorial Board

We thank Sarina van der Ploeg, Publications Officer in the IUCN Science and Knowledge Unit, and the members of the IUCN Publications Committee and Editorial Board for their review and contribution to the publication of this report.

Reviewers

Finally, many thanks to both Olaf Weyl (South African Institute for Aquatic Biodiversity) and Kenneth Irvine (IHE Delft Institute for Water Education) for reviewing the report and providing constructive comments and helpful feedback.

Executive summary

The Lake Malawi/Nyasa/Niassa Catchment (hereafter LMNNC) supports exceptionally high diversity and endemism of freshwater species. This globally recognised centre of freshwater biodiversity is of extreme importance, not only for its biodiversity value but also for our understanding of evolutionary processes and species sorting. Additionally, it provides a resource that underpins the livelihoods of many people in each of the riparian countries of Malawi, Mozambique and Tanzania, and is important to national economies and human wellbeing. As such, sustainable development for these three countries requires focussed management of the freshwater ecosystems within the LMNNC, which are currently at risk due to a number of pressures, such as over abstraction of natural resources by a growing human population. In this study, we present the findings of an assessment of the distribution and status of all described species of freshwater decapods (crabs and shrimps), fishes, molluscs and odonates (dragonflies and damselflies), and

selected aquatic plants native to the catchment and evaluate change since the first baseline assessment by Darwall et al. (2011). The outputs presented here provide valuable input to guide future sustainable development of the LMNNC whilst helping to safeguard this unique biodiversity upon which so many depend.

Sustainable development is framed by the Sustainable Development Goals (SDGs), adopted by the three riparian countries in the LMNNC in 2015. As such national development policies will be aiming to meet the targets enshrined in these SDGs. Success depends in large part upon conserving the biodiversity that underpins many of the SDG targets and this is particularly important for the LMNNC which depends so heavily upon these natural resources. The importance of freshwater biodiversity in underpinning many of the SDG targets is visualised through the figure on page xi.

Key messages on the status of freshwater biodiversity

- **The LMNNC supports exceptionally high diversity and endemism of freshwater species.** Lake Malawi/Nyasa/Niassa (hereafter LMNN) itself is considered to be the most species rich lake on Earth, and is home to over 800 species of cichlid fishes of which over 99% are endemic and many of which have not been formally described (Konings, 2016; Snoeks, 2000). In this study, we consider a total of 909 species of freshwater decapods (crabs and shrimps), fishes, molluscs, odonates (dragonflies and damselflies) and plants native to the LMNNC, of which 423 species (47%) are endemic to the catchment.
- **Freshwater species in the LMNNC are primarily under threat at present from biological resource use (primarily over-fishing), pollution (mainly from agricultural and urban sources), land use change for agriculture, and poor water management.** These threats have resulted in 6% of native species and 11% of endemic species being classified as threatened with extinction (assessed as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) on The IUCN Red List of Threatened Species™). Levels of threat vary amongst the taxonomic groups considered, with molluscs being the most threatened (19% of species assessed), followed by fishes (9%), odonates (3%), plants (1%) and decapods (0%).
- **Actions are needed to conserve the freshwater ecosystems and species of the LMNNC.** LMNN is vulnerable to threats, such as unsustainable use of natural resources and invasive alien species, which could have significant and rapid negative effects on its biodiversity and the consequences of which could be irreversible.
- **We lack sufficient information on freshwater species to effectively inform their management, as well as environmental and development decision making within the LMNNC.** The current lack of basic information on the status and distribution of freshwater species, and the absence of long-term monitoring of freshwater biodiversity were noted as major failings. It was not possible to assess the extinction risk of 6% of freshwater species native to the basin based on the data available, with these species assessed as Data Deficient (DD). Additionally, many of the Red List assessments were based on inferred declines in species populations or distributions, rather than those estimated on the basis of scientific data.

- **Overall, freshwater biodiversity in the LMNNC is suffering ongoing decline and the risk of species extinctions is increasing.** The greatest declines are seen in the freshwater fishes of LMNNC, for which the Red List Index (RLI) value declined from 0.95 to 0.93 in the last decade. This decline is primarily due to harvesting, which is recorded as a threat to 75% of freshwater fishes native to the LMNNC, and includes commercially important species upon which livelihoods and economies depend.
- **The greatest richness of freshwater species overall and of endemic, threatened and DD species is found within LMNN itself.** Highest species richness is found within the narrow band of shallow, oxygenated waters around the shores of LMNN, in the southern arms, and around islands. However, these shallow waters are also those facing high levels of threat, for example from catchment generated and local pollution, and local harvest of fishes.
- **The ongoing decline in freshwater biodiversity is impacting livelihoods of the rural poor in the LMNNC.** Freshwater fishes are particularly important for provision of food with the fisheries supporting local livelihoods and national economies of the countries of the LMNNC. Freshwater plants have diverse uses, including for medicine and food, and constitute an important resource, since many communities either lack access to or cannot afford market goods.
- **Management of natural resources in the LMNNC needs to take freshwater biodiversity into full consideration.** Effective use of Integrated River Basin Management and Environment Flows methodologies can ensure that freshwater ecosystems can sustainably provide water and other ecosystem goods and services in the long term, while at the same time supporting biodiversity. This in turn will maintain social and economic benefits.
- **Site-scale conservation, focussed on Key Biodiversity Areas (KBAs), can help to guide conservation of freshwater species in the region.** Twenty-two important river, lake and wetland sites have been delineated as KBAs for freshwater biodiversity, including six Alliance for Zero Extinction (AZE) sites. It is now important to raise awareness of their importance and to develop plans for conservation action at these sites. Forty-nine potential KBA site champions have been identified as individuals or organisations well placed to raise awareness of the existence of the KBAs and the issues faced with respect to threats to biodiversity, and to help implement the required actions to safeguard these globally important sites.
- **The data collated through this study and presented in this report should be used by decision makers, from scientists and conservation practitioners to businesses and governments, for informing decisions around actions in the LMNNC to ensure sustainable development whilst safeguarding the freshwater biodiversity upon which it depends.** For non-commercial use, the Red List assessments, including spatial data, are available through the IUCN Red List website (www.iucnredlist.org) and point data records are also available through the Global Biodiversity Information Facility (GBIF) (www.gbif.org). Information on KBAs can be accessed through the World Database of Key Biodiversity Areas (www.keybiodiversityareas.org). For commercial use, the Red List and KBA datasets, together with information on protected areas, can be accessed through the Integrated Biodiversity Assessment Tool (IBAT) (www.ibat-alliance.org).

Freshwater biodiversity and the Sustainable Development Goals in the Lake Malawi/Nyasa/Niassa Catchment

Freshwaters cover less than 1% of the Earth's surface yet support over 10% of all described species (Strayer & Dudgeon, 2010). LMNN is considered to be the most species-rich lake on Earth and is home to over 800 cichlid fishes of which 99% are endemic (Snoeks, 2000; Konings, 2016).



Through this study we:

- assessed the extinction risk (Red List status) of freshwater biodiversity in the LMNNC to guide conservation policy and action. **6% of native species and 11% of endemic species are threatened with extinction.**
- calculated the Red List Index (RLI) for freshwater taxonomic groups in the LMNNC to track changes in their status. **Freshwater biodiversity in the LMNNC is in decline, with freshwater fishes declining at the highest rate.**
- identified sites of global importance to biodiversity (Key Biodiversity Areas, KBAs) for freshwater species to guide the establishment of protected areas and other safeguards. **22 river, lake and wetland sites within the LMNNC were identified as KBAs for freshwater trigger species.**

The role of freshwaters in the SDGs



Local livelihoods and national economies are supported by freshwater ecosystems. This is particularly true in the LMNNC where the mainstay of the economy is agricultural and fisheries production (World Bank, 2019). Fisheries provide a key source of protein for communities within the LMNNC, and it has been suggested that freshwater fishes make up around 70% of animal protein consumed by Malawians (Bland & Donda, 1995). The fisheries also make significant contributions to the economies of the three riparian countries, with data for Malawi alone in 2015 indicating the sector directly employed 60,600 people, with over a further 300,000 people directly engaged in secondary activities (Chavula, 2016), and contributed between 2-4% of the country's GDP (Kafakoma, 2019). Freshwater plants provide a vital alternative resource for the rural poor who lack access to, or funds to purchase, market goods and modern pharmaceuticals, as well as providing vital food supplies for both livestock and people.

Freshwaters supply clean water for human use in daily subsistence, agriculture and energy generation. However, secure water supplies are also needed to maintain healthy freshwater ecosystems. Around 80% of people in the LMNNC rely on agriculture for subsistence (Bootsma & Jorgensen, 2005) and agriculture is the most significant consumer of water in the catchment (Chavula, 2016; Faraji, 2016). Hydroelectric power is a key source of energy generation (Chavula, 2016).

SDG 14 only considers marine ecosystems but should be broadened to include freshwaters given the vital importance of freshwater fisheries worldwide in terms of both biodiversity and human livelihoods.



Threats

Through this study we documented threats to species to identify the major drivers of freshwater biodiversity decline in the LMNNC as a starting point for guiding conservation actions.

Over-harvesting, primarily of freshwater fishes, is the main threat to freshwater biodiversity in the LMNNC. This is leading to direct mortality of individuals, as well as degradation of habitats due to destructive fishing methods.

Three of the major threats to species in the LMNNC were driven by **agricultural expansion** to support the growing human population:

- land use change** leading to drainage of wetlands, or deforestation and resulting increased **sedimentation**;
- pollution** from agricultural sources; and
- poor water management** leading to over-abstraction of water.

In addition to that from agricultural sources, **pollution** from urban sources is a serious threat, with the most affected areas coinciding with areas of greatest species richness (the shallow waters of southern LMNN). Construction of **dams** also represents a threat by destroying freshwater habitats or disrupting species behaviours (e.g. migration).

LMNN is vulnerable to threats, such as **invasive alien species**, which could have significant and rapid negative effects on its biodiversity and the consequences of which could be irreversible.

Recommended actions

Through this study we documented recommended research and conservation actions for species as a starting point for guiding conservation actions. Recommendations include:

- Standardised, repeated surveys of freshwater biodiversity within the LMNNC to provide better information on the distribution and status of freshwater species
- Management at the catchment scale to address threats to biodiversity with consideration of hydrological connectivity
- Protection or management, as appropriate, of key sites in the LMNNC based on the newly delineated KBA network, ensuring that freshwater biodiversity is considered in conservation planning
- Improved management of harvested and traded species, to avoid fisheries depletion or collapse of stocks
- Education and awareness raising of the importance of clean and healthy wetland systems to humans, and of the value of the unique freshwater biodiversity of the LMNNC

Bibliography

- Bland, S. and Donda, S. (1995). 'Common Property and Poverty: Fisheries Co-management in Malawi', *Fish Bull*, 30.
- Bootsma, H.A. and Jorgensen, S.E. (2005). *Lake Malawi/Nyasa: Experiences and Lessons Learned*. Kusatsu, Japan: International Lake Environment Committee Foundation, Lake Basin Management Initiative: Experience and Lessons Learned Briefs.
- Chavula, G.M.S. (2016). *Malawi: Country report on the state of the environment and outlook report for Lake Malawi/Nyasa/Niassa*. IUCN, Building River Dialogue and Governance Phase 3 (BRIDGE-3): 2016–2018.
- Darwall, W.R.T., Smith, K.G., Allen, D.J., Holland, R.A., Harrison, I.J. and Brooks, E.G.E. (2011). *The diversity of life in African freshwaters: underwater, under threat*. Gland, Switzerland; Cambridge: IUCN. <https://portals.iucn.org/library/node/9409>
- Faraji, S.A. (2016). *Tanzania: Country report on the state of the environment and outlook report for Lake Malawi/Nyasa/Niassa*. IUCN, Building River Dialogue and Governance Phase 3 (BRIDGE-3): 2016–2018.
- Kafakoma, R. (2019). *State of the Lake Malawi/Nyasa/Niassa Ecosystem*, Building River Dialogue and Governance Phase 3 (BRIDGE-3): 2016–2018.
- Konings, A. (2016). *Malawi cichlids in their natural habitat*. El Paso, Texas: Cichlid Press.
- Snoeks, J. (2000). 'How well known is the ichthyodiversity of the large East African lakes?', *Advances in Ecological Research*, 31, pp. 17–38. [https://doi.org/10.1016/S0065-2504\(00\)31005-4](https://doi.org/10.1016/S0065-2504(00)31005-4)
- Strayer, D.L. and Dudgeon, D. (2010). 'Freshwater biodiversity conservation: recent progress and future challenges', *Journal of the North American Benthological Society*, 29(1), pp. 344–358. <https://doi.org/10.1899/08-171.1>
- World Bank (2019). *Agriculture, forestry, and fishing, value added (% of GDP)*. Available at: <https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS> [Accessed April 2019].