FISHERIES INTEGRATION OF SOCIETY AND HABITATS (FISH) PROJECT

An Atlas of the Fisheries Resources of Lake Chilwa

THE UNIVERSITY OF RHODE ISLAND GRADUATE SCHOOL OF OCEANOGRAPHY

CRC COASTAL RESOURCES CENTER

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Cover photo: Left and right: participatory mapping exercise conducted during field work. Center: Lake Chilwa. Credit: Cathy McNally.

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Preface

This map book chapter presents a series of maps with accompanying text for Lake Chilwa using data obtained in the Environmental Threats and Opportunity Assessment (ETOA), the Photographic Survey, and the Participatory Vulnerability and Capacity Assessment (PVCA). There are separate sections that include maps depicting aquatic habitat, fish species richness, and the locations of breeding, nursery, juvenile, and adult habitats for the most common fish species. The map book also shows the fishing ground locations for the most common species one, five, and ten years ago, as well as trend lines of catch over time when data were available from the Frame Surveys. Additional maps depicting the location and density of various fishing gear types were created using the georeferenced data gathered during the photographic survey. Each chapter concludes with maps depicting the lake shore area(s) most vulnerable to climate change and maps of each exposure, sensitivity, and adaptive capacity indicator used in the climate change vulnerability assessment. It is hoped that the atlas will serve as a valuable tool for guiding the development of District Development Plans and provide fisheries extension officers and lakeside communities with access to materials that can help inform decision making.

Contents

Introduction to Lake Chilwa

Lake Chilwa is located in the Southern Malawi Districts of Machinga, Phalombe, and Zomba, between 15° 15'S and 35° 45'E and shares its eastern shore with Mozambique. It is located 624 meters above sea level and has a total surface area of ~2248 km^2 covering an area of ~40 km long and 30 km wide. It has an average maximum depth of less than 6 meters (Njaya 2001). There are numerous islands within the lake, two of which are permanently inhabited.

The lake is an enclosed system, an endorheic and therefore slightly saline lake, with several inflowing rivers surrounded by swamps and marshes. The inflowing rivers are the Domasi, Likangala, Naisi, Namadzi, Phalombe, Sombani, and Thondwe. These rivers perennially and seasonally influence the open water area, contributing to lake level fluctuations, nutrients, and suspended silt and sediment load during the seasonal rains. During high water level periods, the open water covers approximately 1,500 km^2 while during low water level periods, the respective area ranges from 300 km^2 to 699 km^2 (UNESCO 2015). Lake Chilwa has completely dried up on eight occasions over the past century with the most recent drying event in 2012 (Kabwazi & Wilson 1998).

Satellite Image of Lake Chilwa

Habitats of Lake Chilwa

METHODS

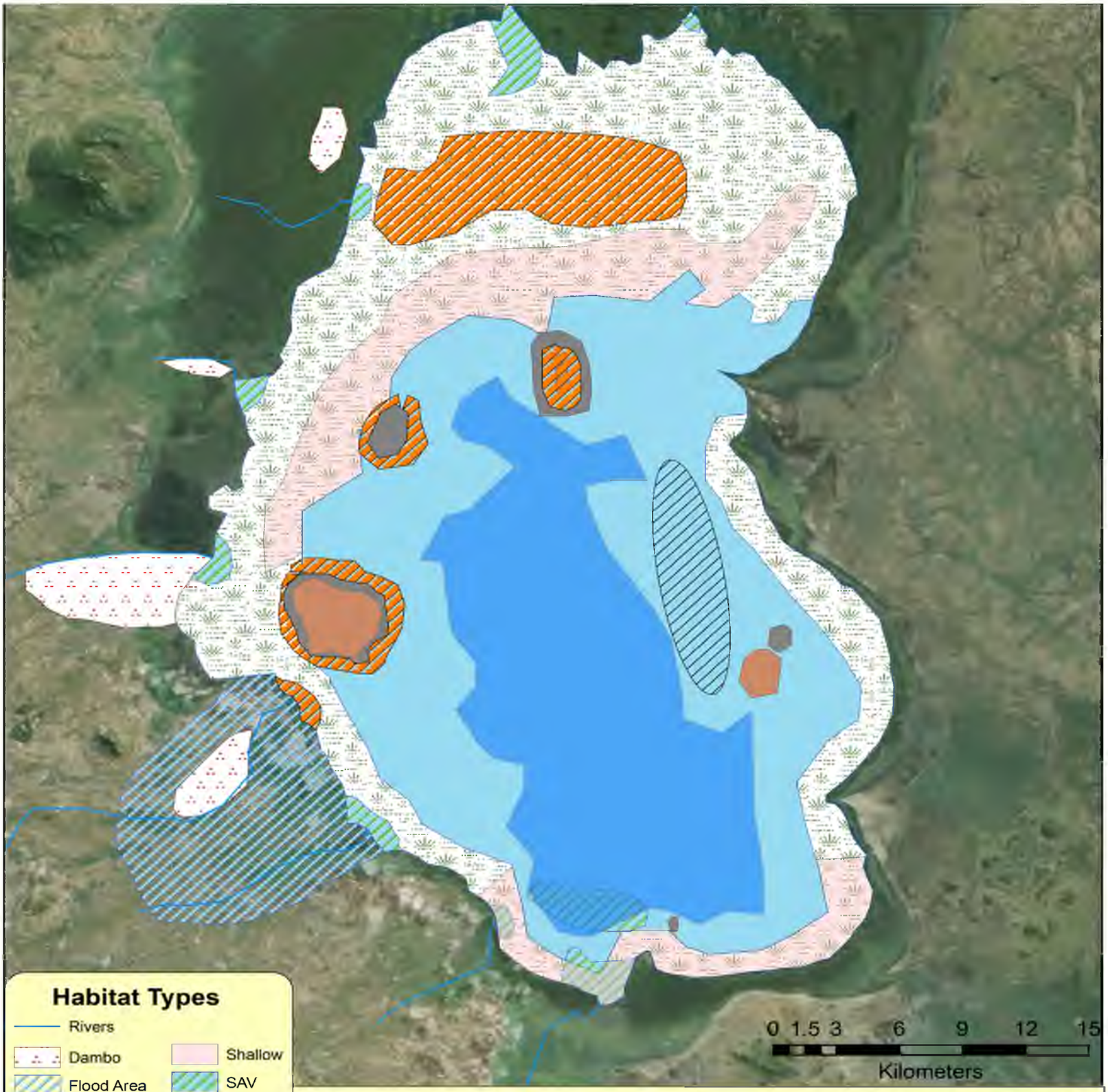
This map was created through a series of focus group discussions and mapping activities with local communities to capture their local ecological knowledge regarding the location and spatial extent of different types of habitats. Based upon the expertise provided by fishermen and other community members, a series of hand-drawn maps identifying the location of different habitat zones were created. Once the maps were completed, the information was compiled into a summary map and then digitized using ArcGIS. The maps were presented at a stakeholder forum and vetted by local experts for accuracy. All recommended changes were presented to the communities for their approval during a follow-up visit before updating the final product.

FINDINGS

Lake Chilwa is unique in its vegetative cover. It has an abundance of emergent aquatic vegetation (EAV) covering approximately two-thirds of the lake, some of which has been found to float as makeshift islands. The map to the right depicts habitat areas within Lake Chilwa as perceived by local communities and experts. The shoreline areas of Lake Chilwa are covered in thick EAV that provides refuge for many different species endemic to the lake. The northern section of the lake exhibits the densest vegetation, which sometimes encroaches significantly into the lake's waters. Submerged aquatic vegetation (SAV) grows primarily adjacent to river mouths where there is an inflow of fresh water into the lake. The lake's more brackish waters, ranging from 1.2 to 12 parts per thousand, are less habitable for certain SAV species (Njaya 2001). Aside from the islands, the only other significantly rocky areas lie near the southeastern shoreline. The center of the lake is the deepest, but the depths are less than 6 meters. Generally, all of the vegetated areas occur within relatively shallow waters less than 1 meter deep.

A series of wetland areas, locally referred to as dambos, extend landward from the western shoreline of Lake Chilwa and contribute to water circulation and fish habitat. Many of the inflowing rivers have deep pools, which provide refugia for fish species during droughts. The southwest corner of the lake experiences the most flooding, and the floodplain extends between two rivers expanding outwards from the lake. Overall, Lake Chilwa is an interesting system because the species are able to survive its more turbid, saline waters, and extreme changes in size.

Habitat Types within Lake Chilwa



This map shows habitat areas within Lake **Chilwa** . Data sources include both community and expert inputs.
"Veg Cutting" areas represent zones where EAV or SAV has been cut to facilitate illegal gears.

Created by B. Favitta
8/15

Species Richness in Lake Chilwa

METHODS

This map was created by conducting a series of focus group discussions and mapping activities with local fishermen living in communities distributed around the lake. The fishermen were first asked to list the species that they harvest for subsistence and generating income. For each individual species, they were asked to denote on a map the areas within the lake used as breeding areas and nursery grounds as well as the area inhabited by the juveniles and adults. Once the information was collected for each species across all the communities, it was synthesized together and the critical life stage polygon locations were heads-up digitized in ArcGIS. To identify the species rich zones within the lake, all of the fish sector data were converted into a raster dataset. Each species' respective habitat zones were given a score of 1 and were not weighted. The raster files were added together using a raster calculator tool in ArcMap. It is important to note that the multiple life stages of a single species coexisting within a habitat area were not double counted. The resulting output yielded a species richness map demarcating the areas of the lake with the greatest fish biodiversity perceived by the local fishermen.

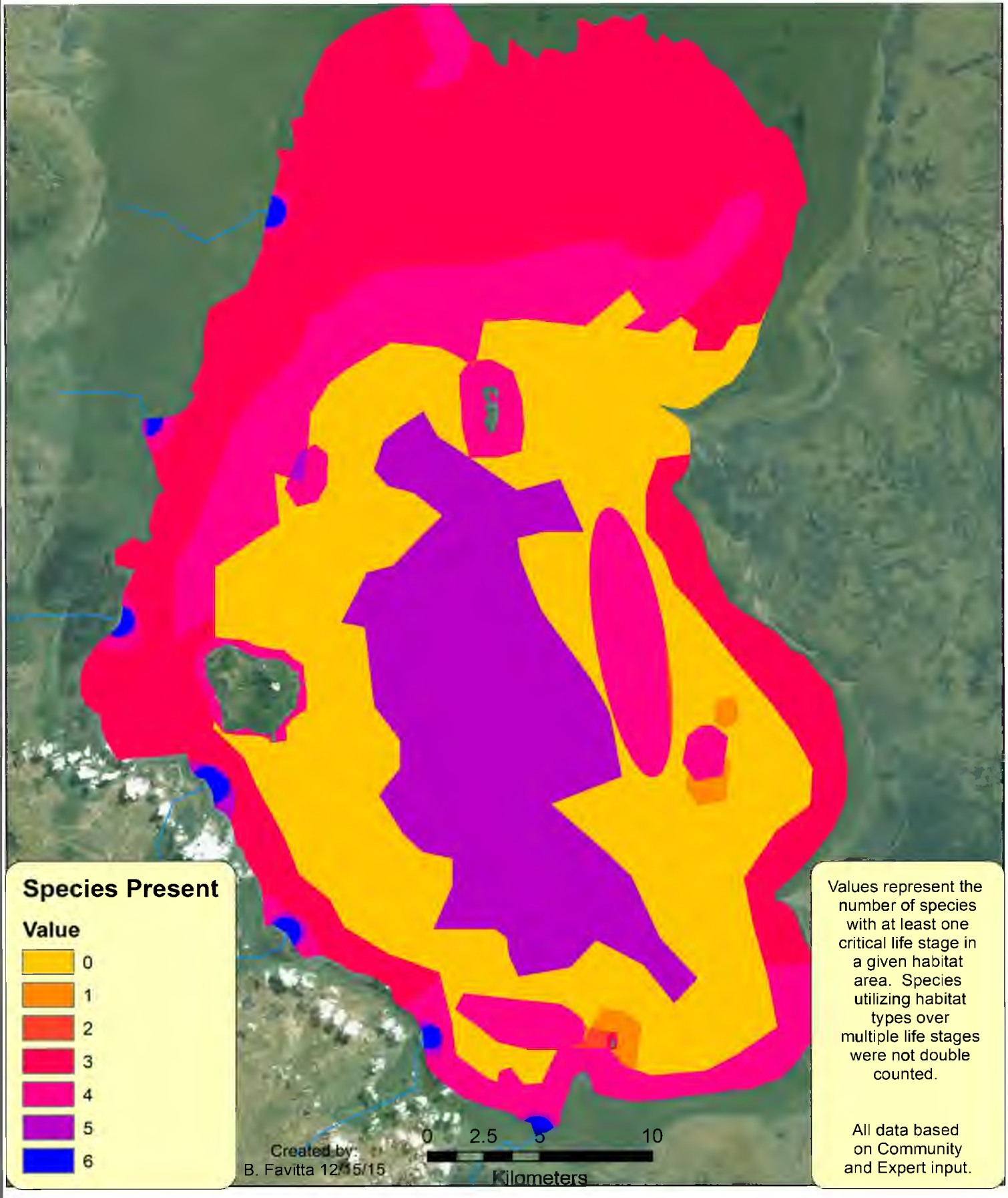
FINDINGS

Lake Chilwa's fishery production is ~344 kg/ha/yr, which accounts for approximately 25-30% of Malawi's total fish production (Macuiane *et al*. 2009, Kalindekafe 2014). The most commonly caught species are Mlamba (*Clarias gariepinus*) and Matemba (*Barbus paludinosus*). The high fisheries productivity is attributed to the high nutrient level in the soils and inflowing waters (MacLachlan *et al*. 1972, Msiska 2001). The fish species distribution within Lake Chilwa is influenced by depth, salinity levels, and water turbidity. The more dominant species are found in the open waters, where it is turbid and saline. The three main fish species found here are *Barbus paludinosus*, *Clarias gariepinus*, and *Oreochromis shiranus chilwae*, all of which can tolerate poorer water quality (Ambali & Kabwazi 1999, EAD 2000, Msiska 2001, Chandilanga *et al*. 2013). Species that can tolerate normal changes in salinity and lower oxygen levels are found in the swamps. These include *Barbus trimaculatus*, *Brynus imberi*, *Haplochromis callipterus*, *Hemigrammopetersius barnardi*, *Labeo cylindricus*, *Marcusiensis (Gnathanemus) macrolepidus*, *Paretropius longifilis*, *Petrocephalus catastoma*, *Pseudocrenila-brus philander* and *Tilapia rendalli* (Furse *et al*. 1979).

Fluctuating states of rain and drought change the water chemistry (i.e., dissolved oxygen, salinity and turbidity) influencing fish abundance and productivity (Cantrell 1988, Msiska 2001). However, the fish species in Lake Chilwa have adapted to these high fluctuations with greater fecundity, reproduction at an earlier age, and high variability in their spawning habits (Moss 1979). The fish abundance in Lake Chilwa recovers rapidly after a time of recession, generally bouncing back in two years, due to the residual and recolonizing fish breeding population that takes shelter in rivers, deep pool refugia, and the watershed (Jamu & Brummett 1999).

The map on the right highlights the harvested fish species rich zones within Lake Chilwa. The different colors on the map represent the cumulative score of fish species with the darker colors denoting higher richness. The highest species richness areas for the species targeted by the local communities are found in the vicinity of the river inlets within the submerged and emergent aquatic vegetation followed by the deeper water in the middle of the lake. Many species migrate to the river mouths for breeding and utilize these shallow, productive areas to nurse their young before moving back into the lake. Many species travel to river mouths for breeding and utilize those shallow, productive areas to nurse their young before moving back into the lake.

High Biodiversity Areas within Lake Chilwa



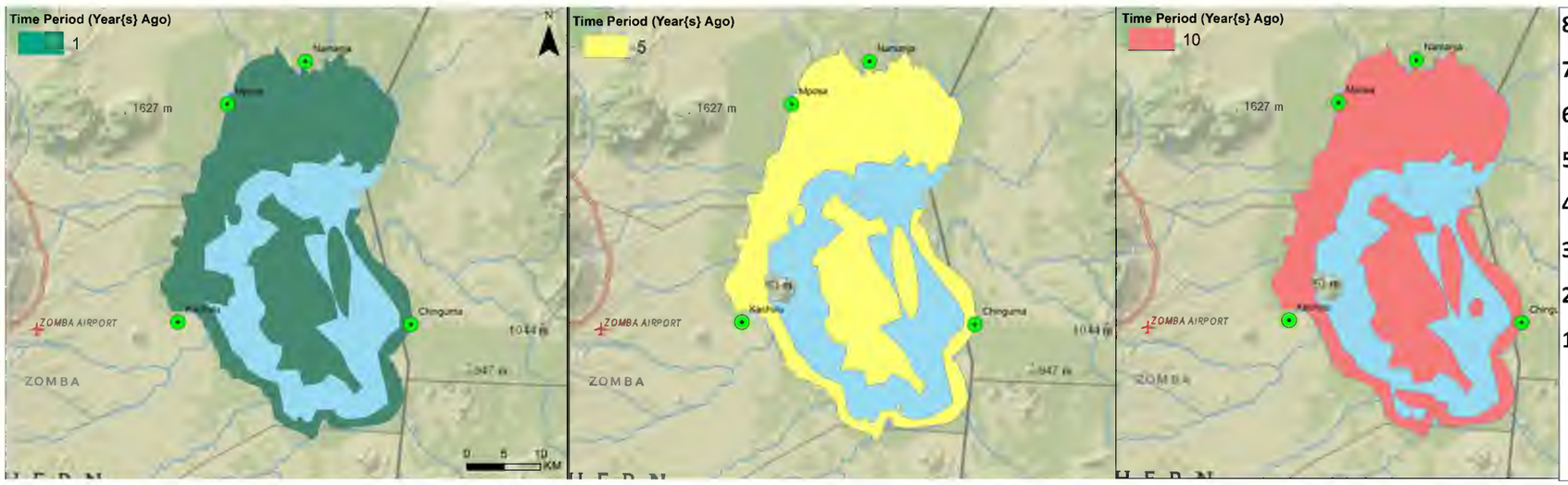
Species of Lake Chilwa

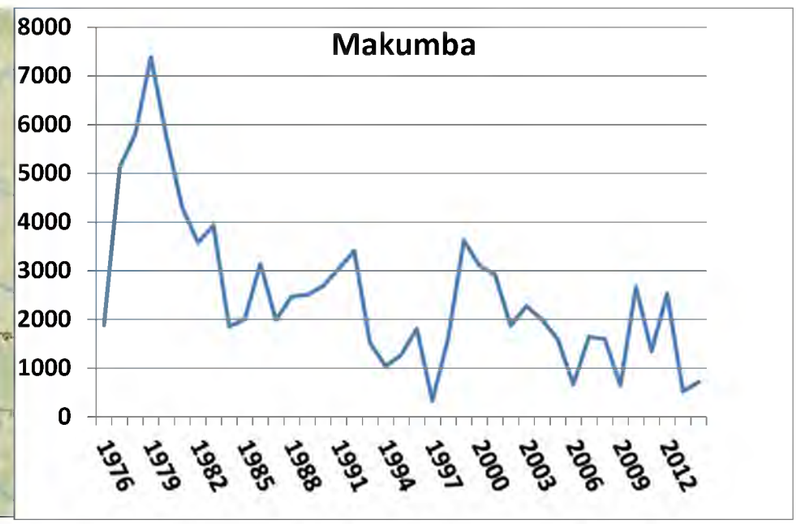
Makumba

Makumba (*Oreochromis shiranus chilwae*) are present throughout Lake Chilwa. They are most commonly found in the emergent and submerged aquatic vegetation located along the periphery of the lake. These shallow vegetated areas provide ample refugia for the Makumba to breed during the months of September to May and nurse their young. Once they reach the juvenile and adult stages, they venture out towards the middle of the lake and small islands, which have rocky outcrops to protect them from predators. When fishing for Makumba, fishers utilize all of the aforementioned areas. The fishing grounds have remained constant over the past ten years, but the total quantities of Makumba harvested have fluctuated.

Makumba Life Stages in Lake Chilwa

Makumba Fishing Areas in Lake Chilwa





One Year Ago | **Five Years Ago** | **Ten Years Ago**

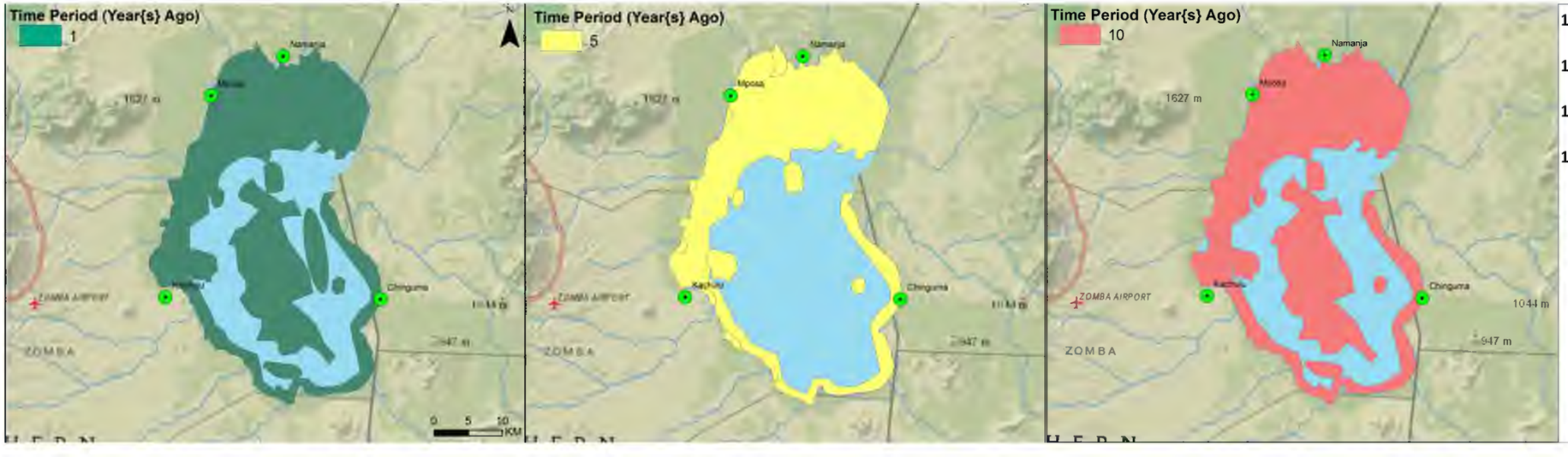
Source of data: Malawi Fisheries Research Unit.
Catch is in metric tonnes

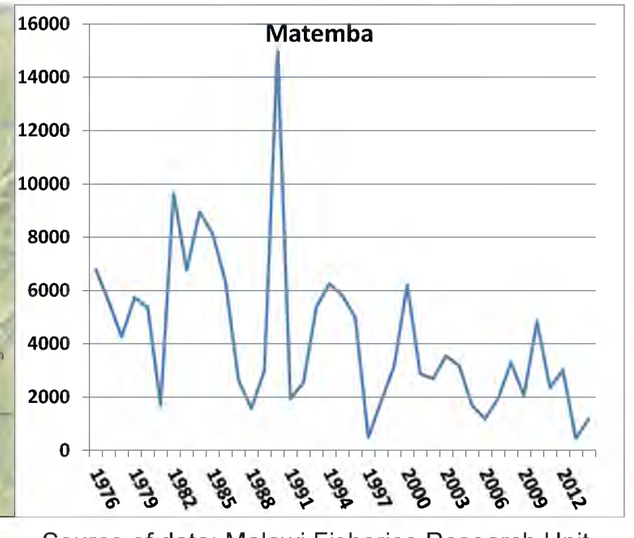
Matemba

Matemba *(Barbus paludinosus)*. These small ray-finned fish are one of the most prevalent species in Lake Chilwa. The Matemba breed in submerged aquatic vegetation near river inlets, emergent aquatic vegetation, and rocky areas throughout the year with the peak breeding activity occurring from November through January. The aquatic vegetation provides important nursery habitat and refugia for the juvenile Matemba. As they mature, the adults migrate into the deeper portion of Lake Chilwa. There is high inter-annual variability in the catch levels, but the local experts indicated that when the lake levels are normal, the Matemba can comprise up to 60% of Lake Chilwa's total fish catch. Both Matemba seines and fish traps are used to harvest the Matemba with the former accounting for ~70% of the total landings (Kanyerere *et al*. 2008). The local experts reported that many of the Matemba seines now incorporate small mesh materials such as mosquito nets and wire gauze, which will have adverse impacts on the fishery since the small mesh size permits indiscriminate harvesting.

Matemba Life Stages in Lake Chilwa

Matemba Fishing Areas in Lake Chilwa





One Year Ago **Five Years Ago** **Ten Years Ago**

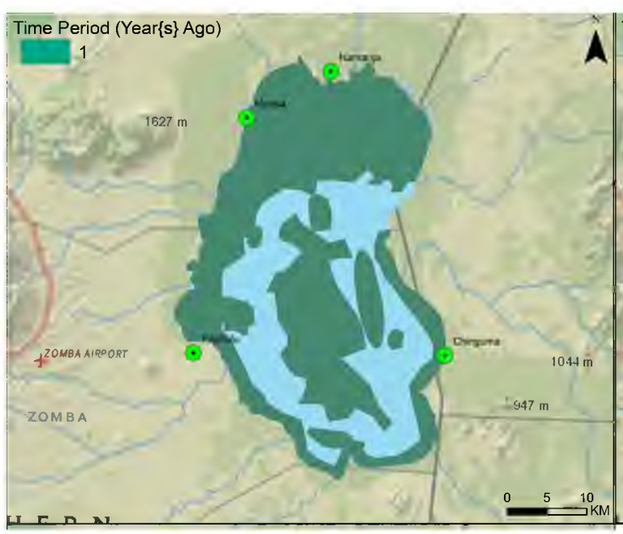
Source of data: Malawi Fisheries Research Unit. Catch is in metric tonnes

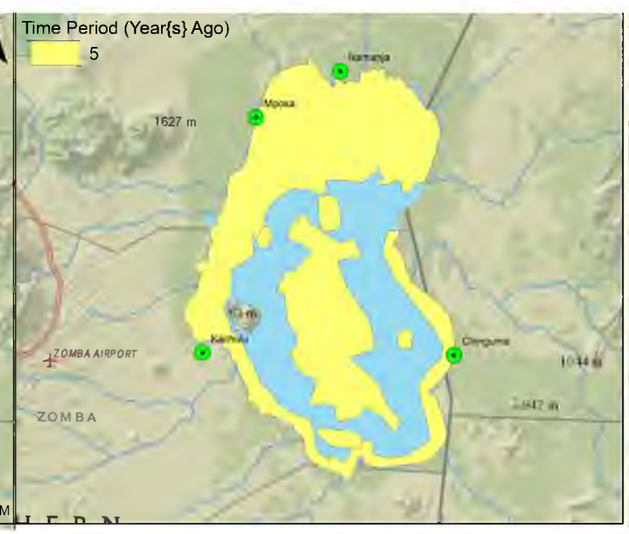
Mlamba

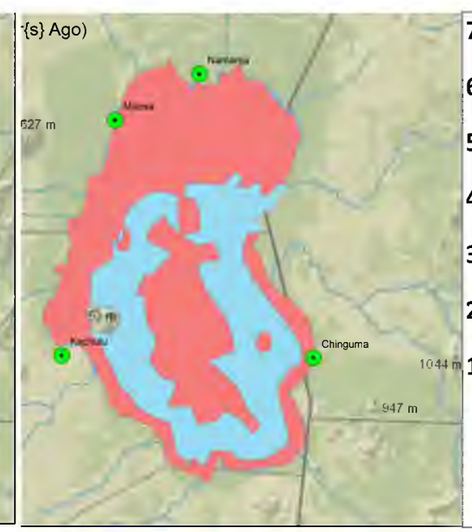
Mlamba *(Clarias gariepinus.)*. Milamba are a catfish that inhabit Lake Chilwa and the surrounding rivers. They spawn from September into the rainy season in the flooded deltas and run-up rivers (Moss 1979). The PRA participants noted that Milamba also breed in the emergent aquatic vegetation and rocky areas within Lake Chilwa. Juvenile and adults inhabit the submerged and emergent aquatic vegetation around the periphery of the lake as well as the middle of Lake Chilwa. Long lines and gill nets are used to harvest Milamba (Njaya et al. 2011). Historically, fishers have sought out Milamba in all habitat types. This pattern is still seen today, but Mliamba catch levels have been declining since the late 1990s.

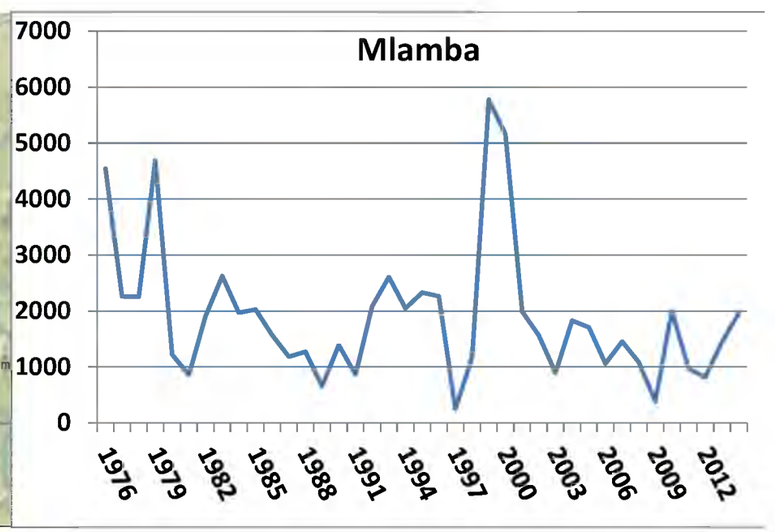
Mlamba Life Stages in Lake Chilwa

Mlamba Fishing Areas in Lake Chilwa









One Year Ago **Five Years Ago** **Ten Years Ago**

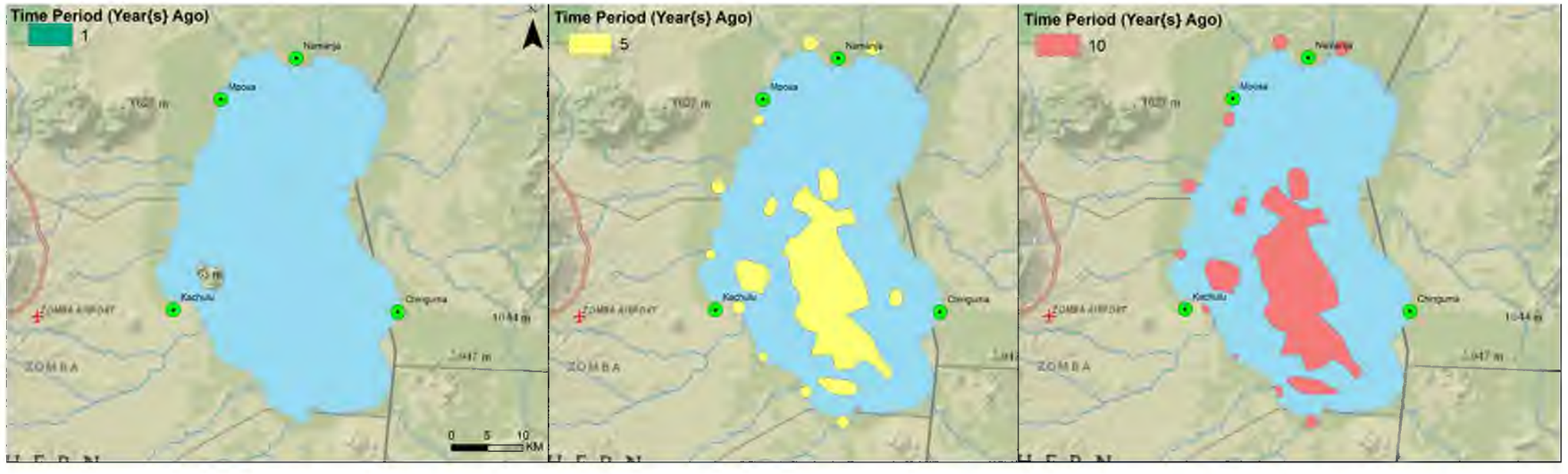
Source of data: Malawi Fisheries Research Unit.
Catch is in metric tonnes

Mphuta

Mphuta *(Marcusenious macrolepidotus.)*. Mphuta are a pelagic species found predominantly in the open, deeper areas of Lake Chilwa. The PRA participants reported that the river mouths serve as important nursery habitat and refugia for juveniles. Until approximately five years ago, Mphuta were harvested around the river mouths, rocky areas, and deeper portion of Lake Chilwa. However, the large decline in the stock caused the fishermen to refocus their efforts on other species within the last year since the Mphuta abundance became too low for efficient harvesting.

Mphuta Life Stages in Lake Chilwa

Mphuta Fishing Areas in Lake Chilwa



One Year Ago | Five Years Ago | Ten Years Ago

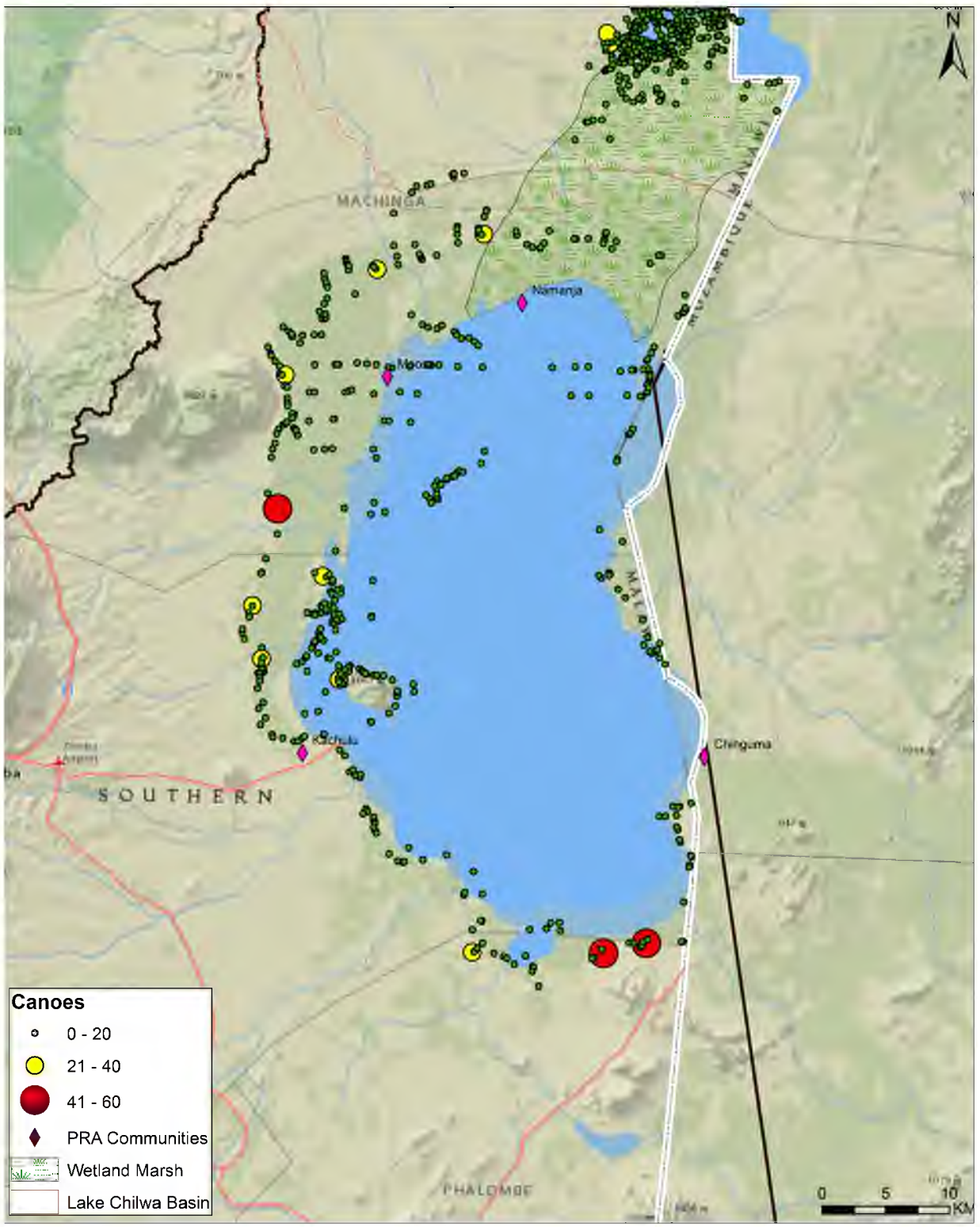
Aerial Survey Gear Maps

The aerial survey mission was conducted between September 13, 2015 and October 13, 2015 to capture a snapshot assessment of the status of gear use within the study area of the Malawi FISH project. The mission covered roughly 600 km of shoreline from Lake Malawi's Southeast Arm, Lake Malombe, Lake Chilwa, and Malawi's portion of Lake Chiuta. Predetermined parameters were created to highlight criteria and guide the targeted flights to designated areas of interest. Survey flights recorded video and photographs, which were later used to locate and assess the gears used in each lake, respectively. These images were then processed and digitized for use in QGIS and ArcGIS. Once the data were ready, maps pertaining to each gear type were created for each of the four lakes within the study area. This provided a snapshot of overall gear use within the project zone to inform further management decisions.

Canoes

Canoes are very common in Lake Chilwa and more widely used than plank boats. Their simplicity allows for greater accessibility and their small frame provides an excellent alternative to larger plank boats that may not fare well in the thickly vegetated northern lake region. During the aerial survey of Lake Chilwa, approximately 1,682 canoes were spotted, which is very close to the total number of canoes reported in the 2014 Frame Survey. The highest numbers of canoes were observed along the western and southern shorelines of the lake.

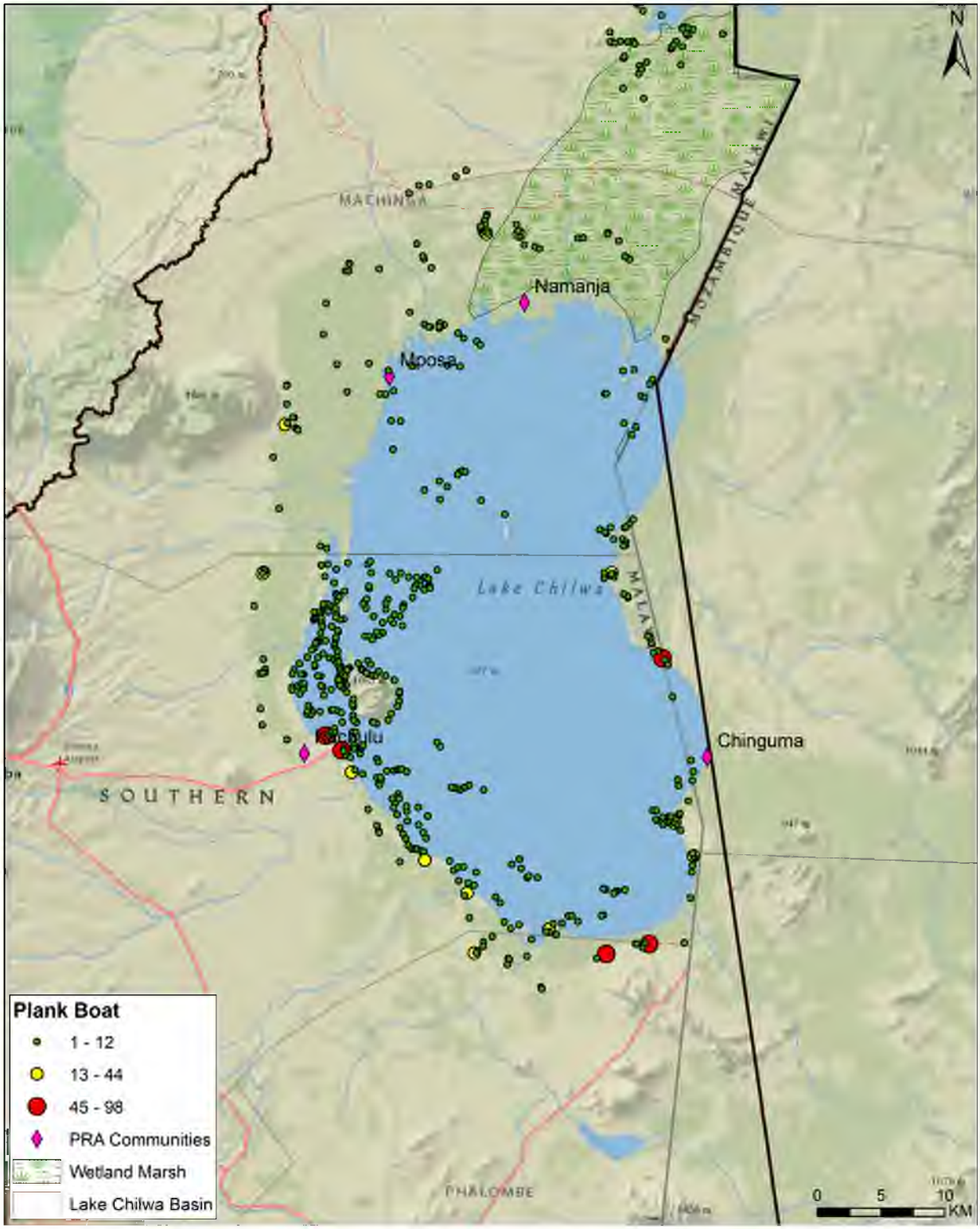
Canoe Density on Lake Chilwa



Plank Boats

There are approximately 1,400 plank boats used by fishers in Lake Chilwa. Being larger than most canoes in operation, plank boats have the capacity to be equipped with an outboard engine. While boats with engines are not very prevalent in Lake Chilwa, they are typically seen as a sign of the status of a community's success within the fishery. The distribution of plank boats on the lake compliments that of canoe use. The majority of the plank boats are operated within the central and southern areas of the lake where there is less aquatic vegetation and more accessible open-water fishing. A high concentration of plank boats were also observed during the aerial survey around the large island located offshore of Kachulu.

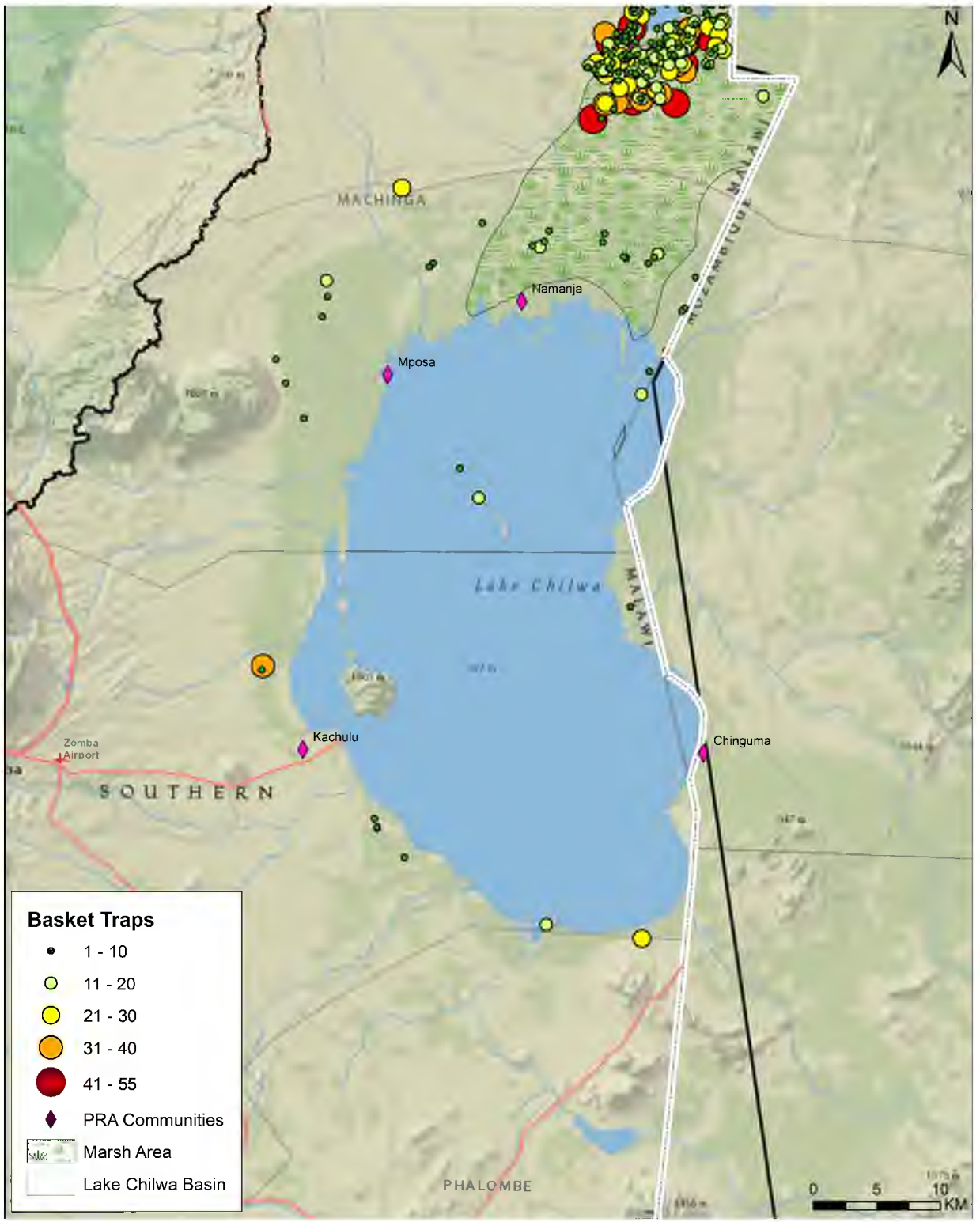
Plank Boats on Lake Chilwa



Basket Traps

Basket traps are commonly used along the shoreline areas where emergent aquatic vegetation is present. The highest concentration of basket traps observed during the aerial survey was in the marsh area northwest of Kachulu. However, due to the ever changing nature of the lake's surface area, areas in which basket traps are viable are constantly changing. The number of basket traps recorded in the annual Frame Surveys in Lake Chilwa rose from 6,669 in 2008 to 31,898 in 2014. Many of the basket traps observed during the aerial survey were wrapped with mosquito netting.

Basket Trap Density on Lake Chilwa



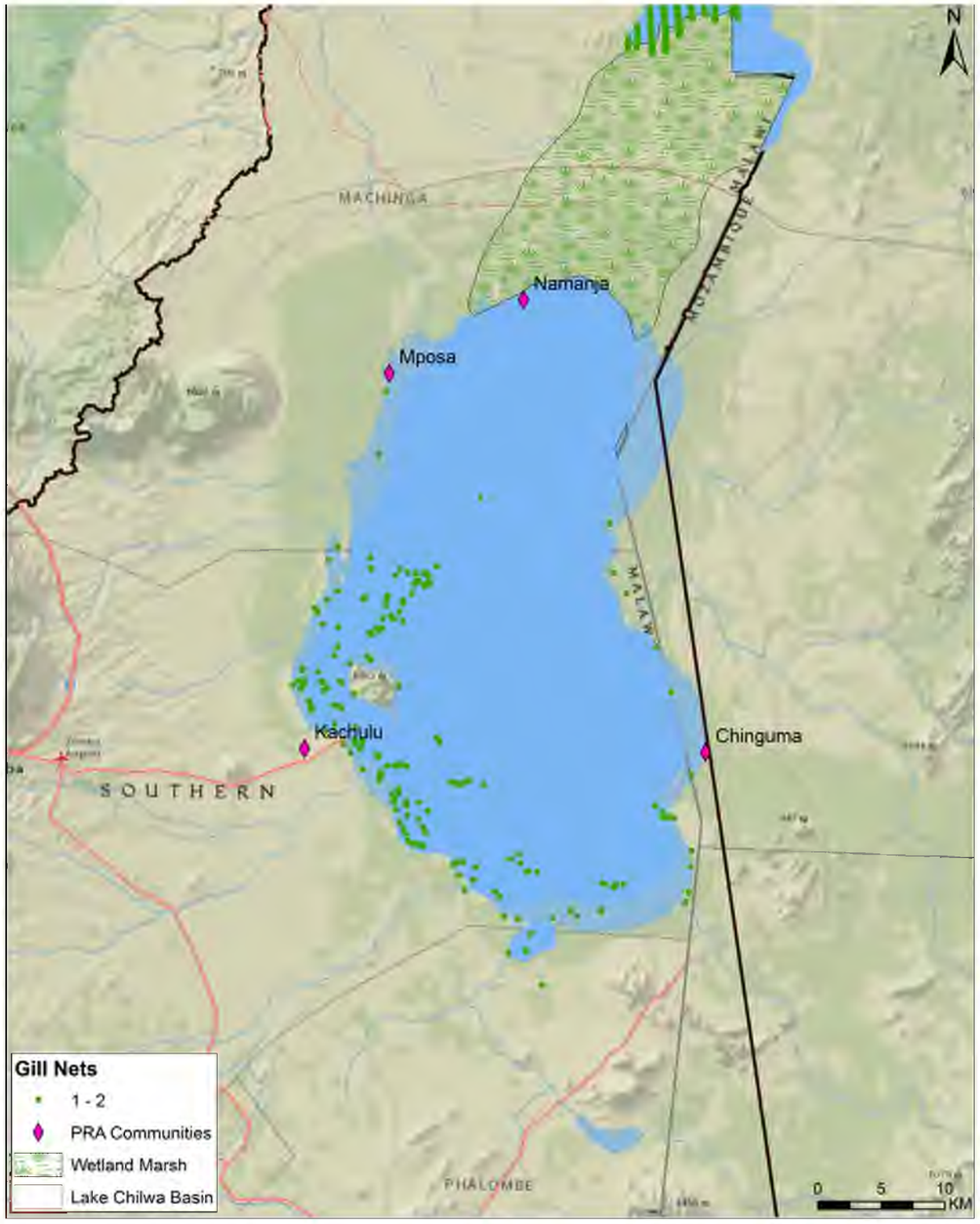
Gill Nets

Gill nets are quite common in Lake Chilwa, especially along the western shoreline near Kachulu. These nets, which account for 90% and 95% of Makumba and Malamba catches, respectively, can be deployed and left in shallow vegetated areas for days at a time until the fishers are ready to harvest (Ngochera et al. 2001). The minimum mesh size is 70 mm and gill nets can be set at a maximum depth of 3 meters (Chandilanga et al. 2013). There have been recent reports that mosquito netting is being incorporated into many of the gill nets. This will have negative impacts on Lake Chilwa's fisheries since the very small mesh size permits indiscriminate harvesting of juveniles and increases bycatch levels.

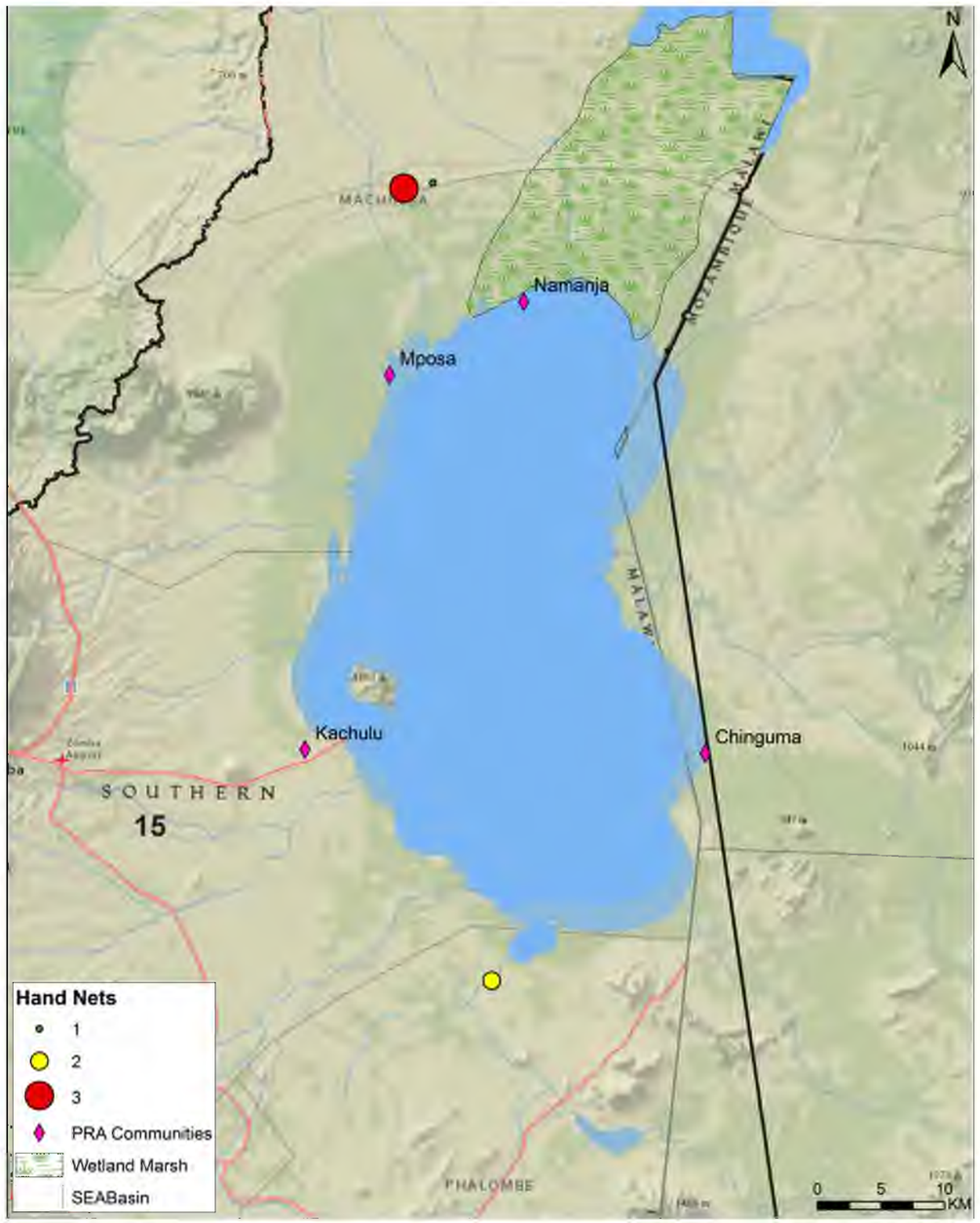
Hand Lines

Only a few hand lines were observed during the aerial survey in the rivers flowing into Lake Chilwa. These results are similar to the 2014 Frame Survey, which documented only two hand lines in operation in the three stratums surrounding Lake Chilwa.

Gill Nets in Lake Chilwa



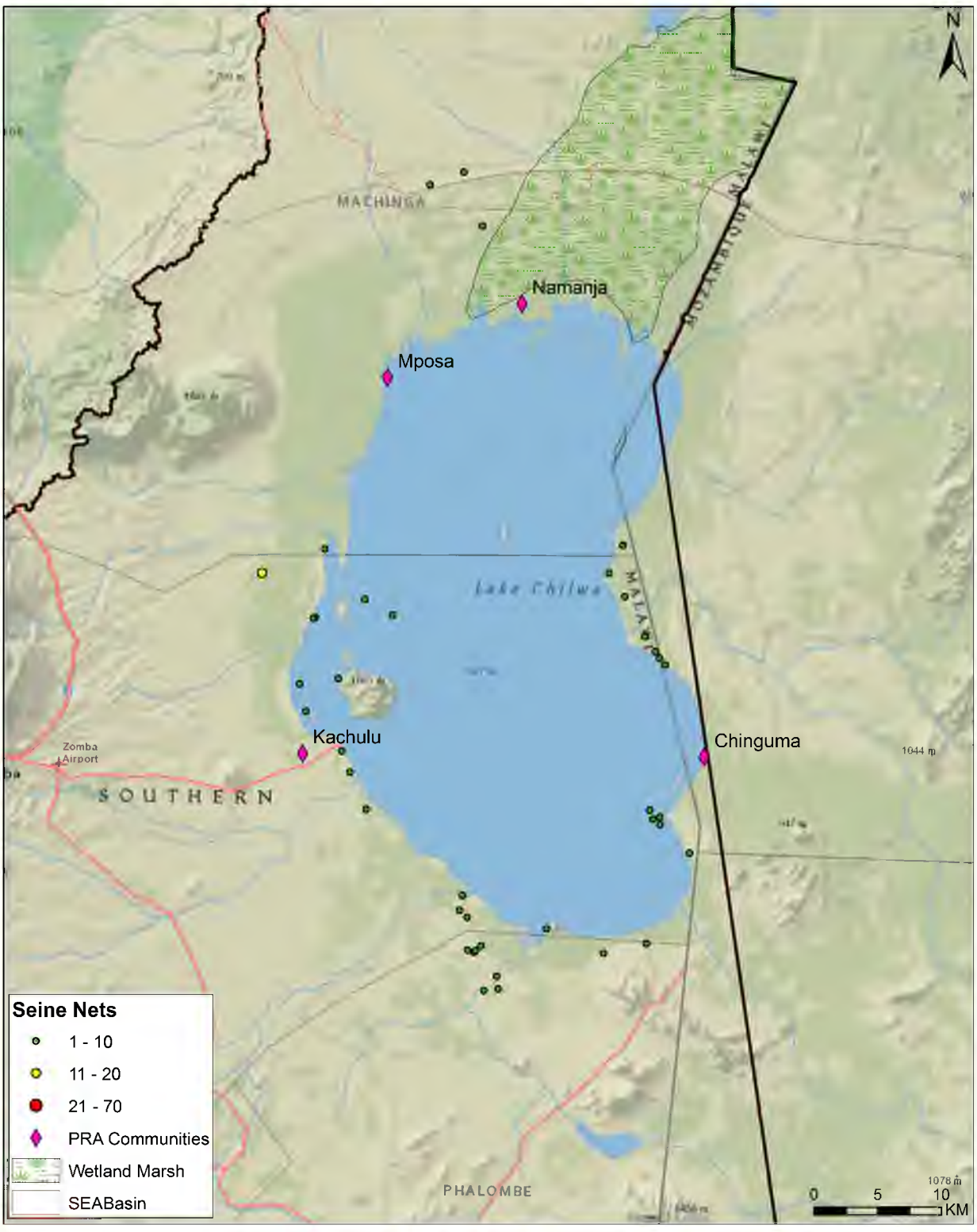
Hand Lines on Lake Chilwa



Matemba Seine Nets

Matemba seines, which target small cyprinids, are deployed mainly along the shoreline. The minimum mesh size, length and depth restrictions are 12 mm, 300 m and 3 m respectively. The seine nets are prohibited from being used in Lake Chilwa from December to February (Fisheries Act 2000). Local experts reported that many of the Matemba seines have been illegally modified to incorporate mosquito nets and wire gauze to seine in deeper open waters. The incorporation of the very small mesh sized materials permits indiscriminate harvesting and targets juveniles before they have the opportunity to reproduce threatening the sustainability of Lake Chilwa's fisheries.

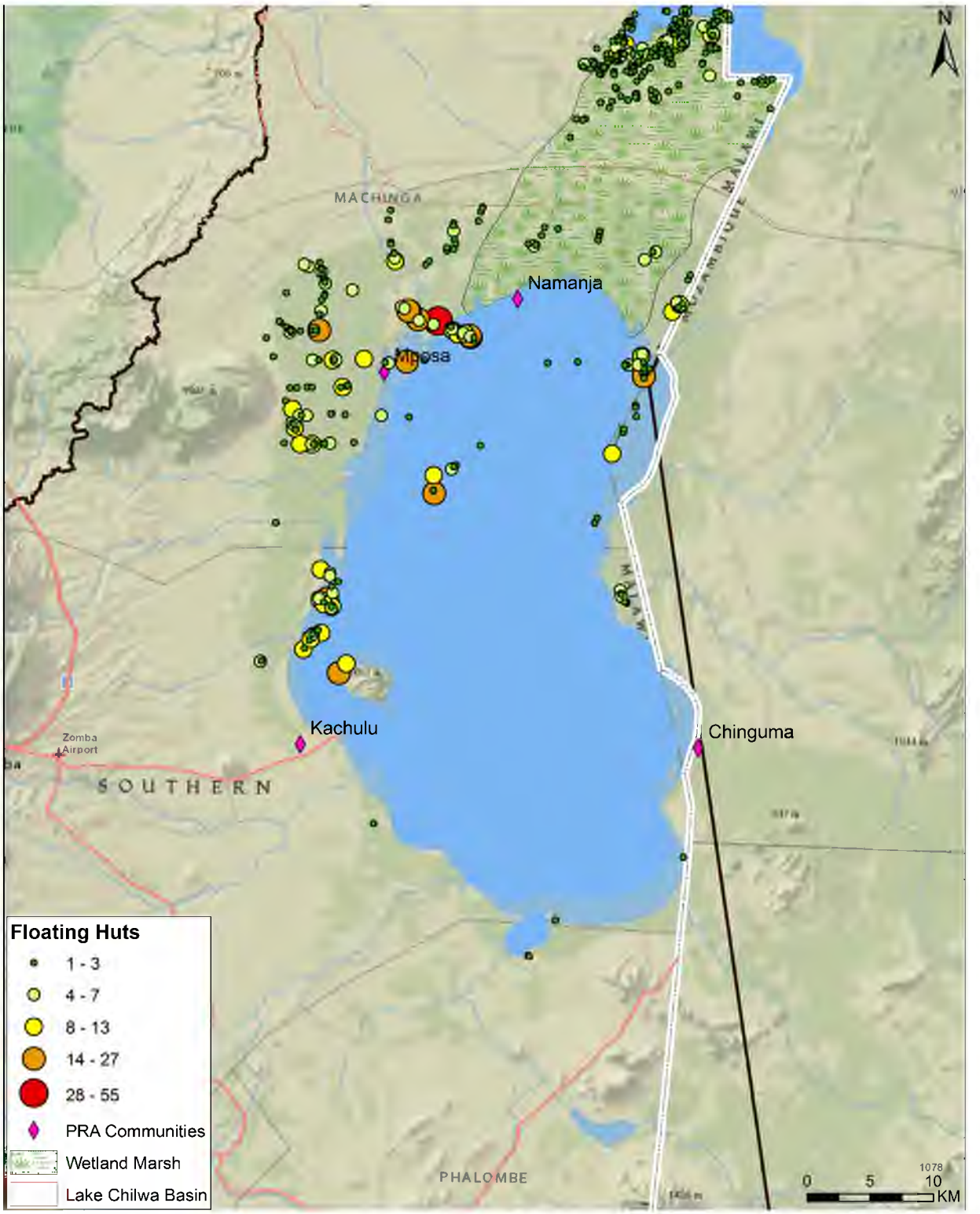
Seine Nets on Lake Chilwa



Floating Huts

Floating huts are most common in the northern and western areas of Lake Chilwa, which exhibit the thickest emergent aquatic vegetation. The vegetation is used to form floating mats, which migrant fishermen construct small huts upon so that they may set their gears, harvest, and process fish all while living on the water for two to three months at a time. The aerial survey activities counted approximately 1,000 floating huts, and the greatest concentrations of these huts were observed near the communities of Namanja, Mposa and Kachulu.

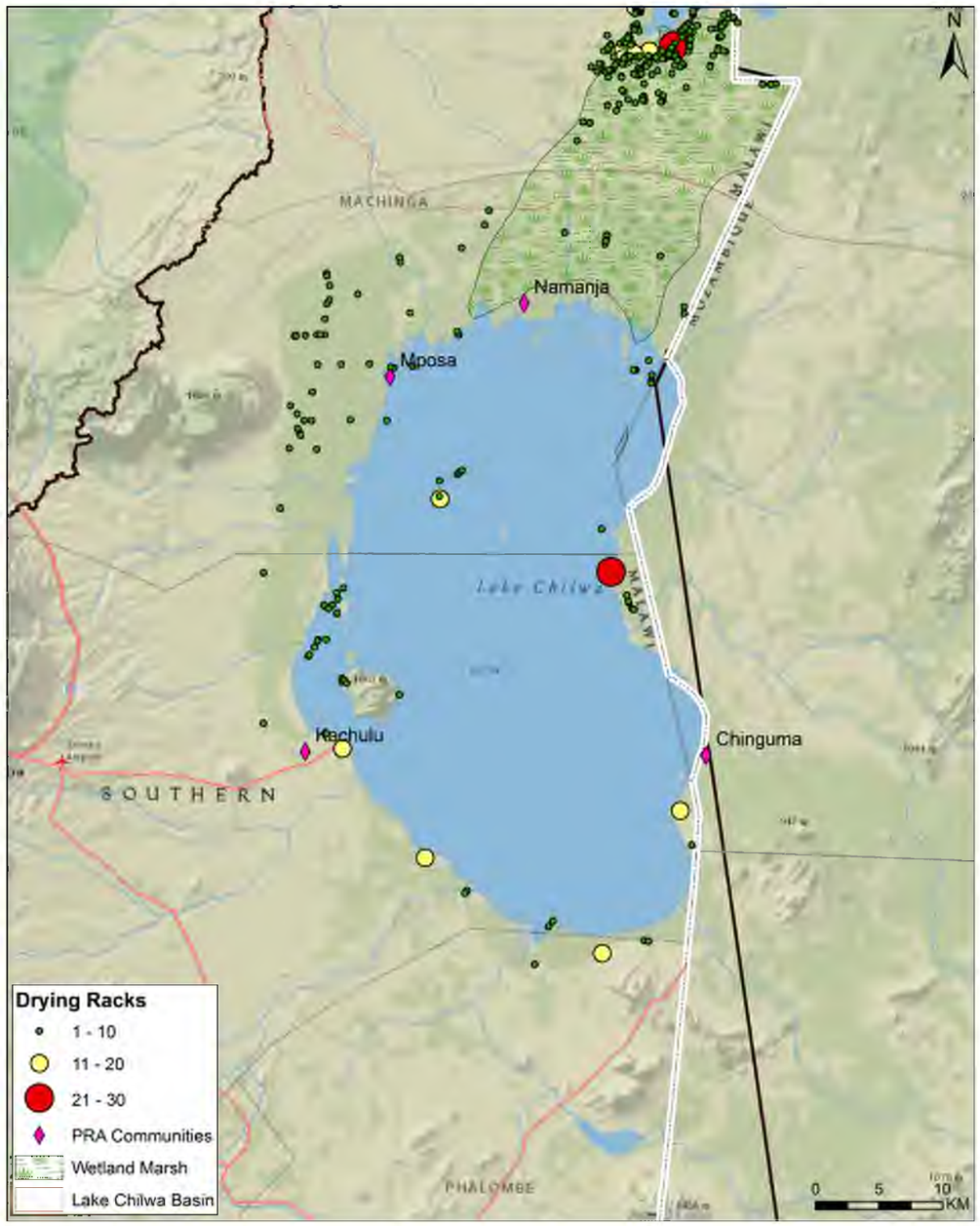
Floating Huts on Lake Chilwa



Drying Racks

One of the main fish processing techniques utilized in Lake Chilwa is to dry harvested fish in the sun. Once dried, they can be transported and sold more safely. There are a number of drying racks present all around the lake. However, the biggest operations occur at the fish landing sites located along the eastern and southern shorelines of Lake Chilwa.

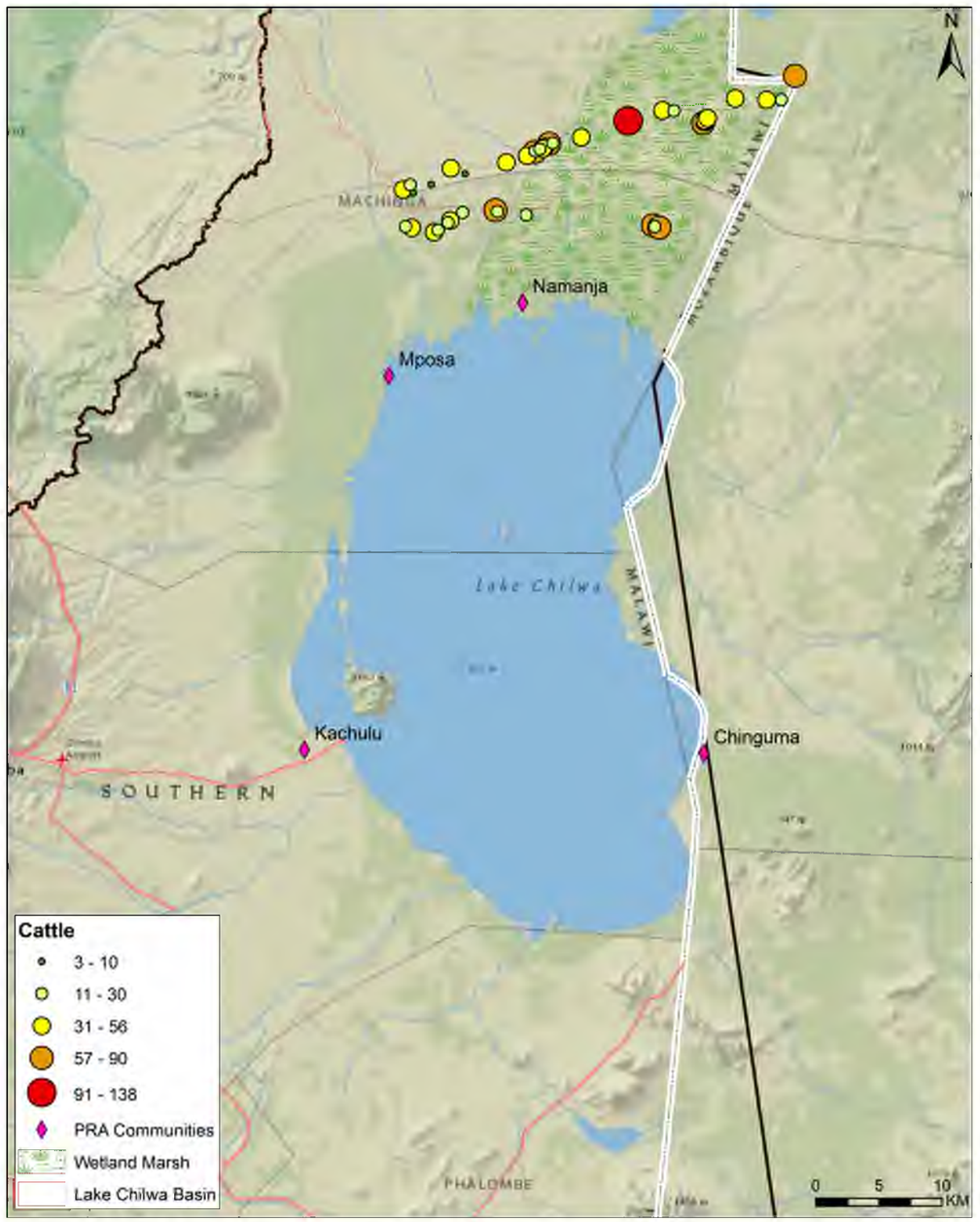
Drying Racks Near Lake Chilwa



Cattle

The only cattle observed in the vicinity of Lake Chilwa lie along the ridge just north of the lake's wetland areas. This band of cattle farms indicates stronger alternative livelihoods for the communities of northern Lake Chilwa, as cattle are a relatively expensive investment. The ability to rear cattle provides fishers with more stability during the dry season and drier years when Lake Chilwa's waters recede.

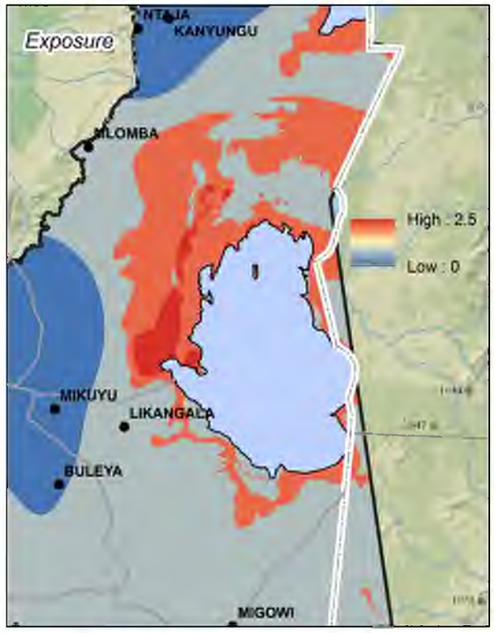
Cattle on Lake Chilwa

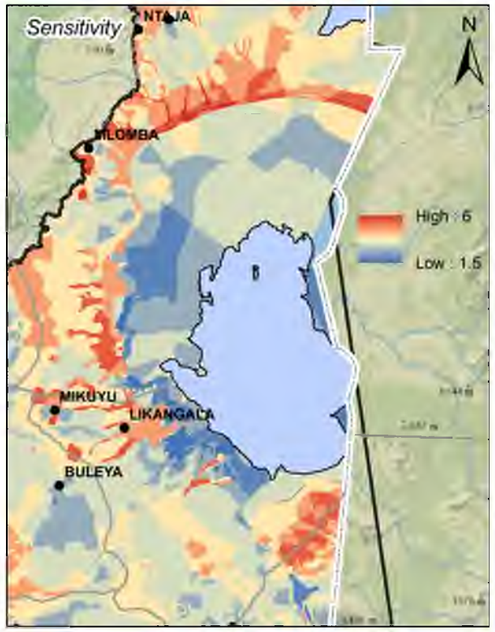


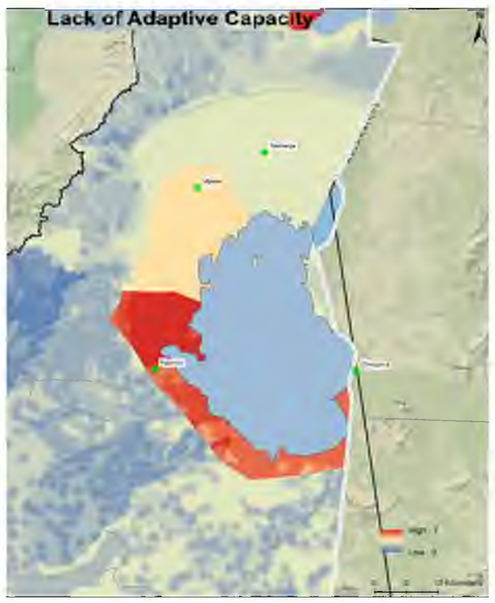
Climate Change Vulnerability Assessment

The FISH project, working with researchers from Chancellor College, piloted a rapid climate change vulnerability mapping exercise in 2015. The Intergovernmental Panel on Climate Change (IPCC) conceptual framework was adopted for the analysis. It separates vulnerability into exposure, sensitivity, and adaptive capacity to climate stressor components. Existing national data sets were combined with data collected during the Environmental Threats and Opportunities participatory rapid assessment visits. The results of this exercise provided a more detailed vulnerability analysis for the areas within the FISH project's boundaries. As seen in the vulnerability map to the right, Lake Chilwa exhibits the highest vulnerability around the southeastern shoreline and the western side of the lake, especially the area north of Kachulu. This metric is based on a series of indicators which will be discussed in greater detail in the subsequent pages.

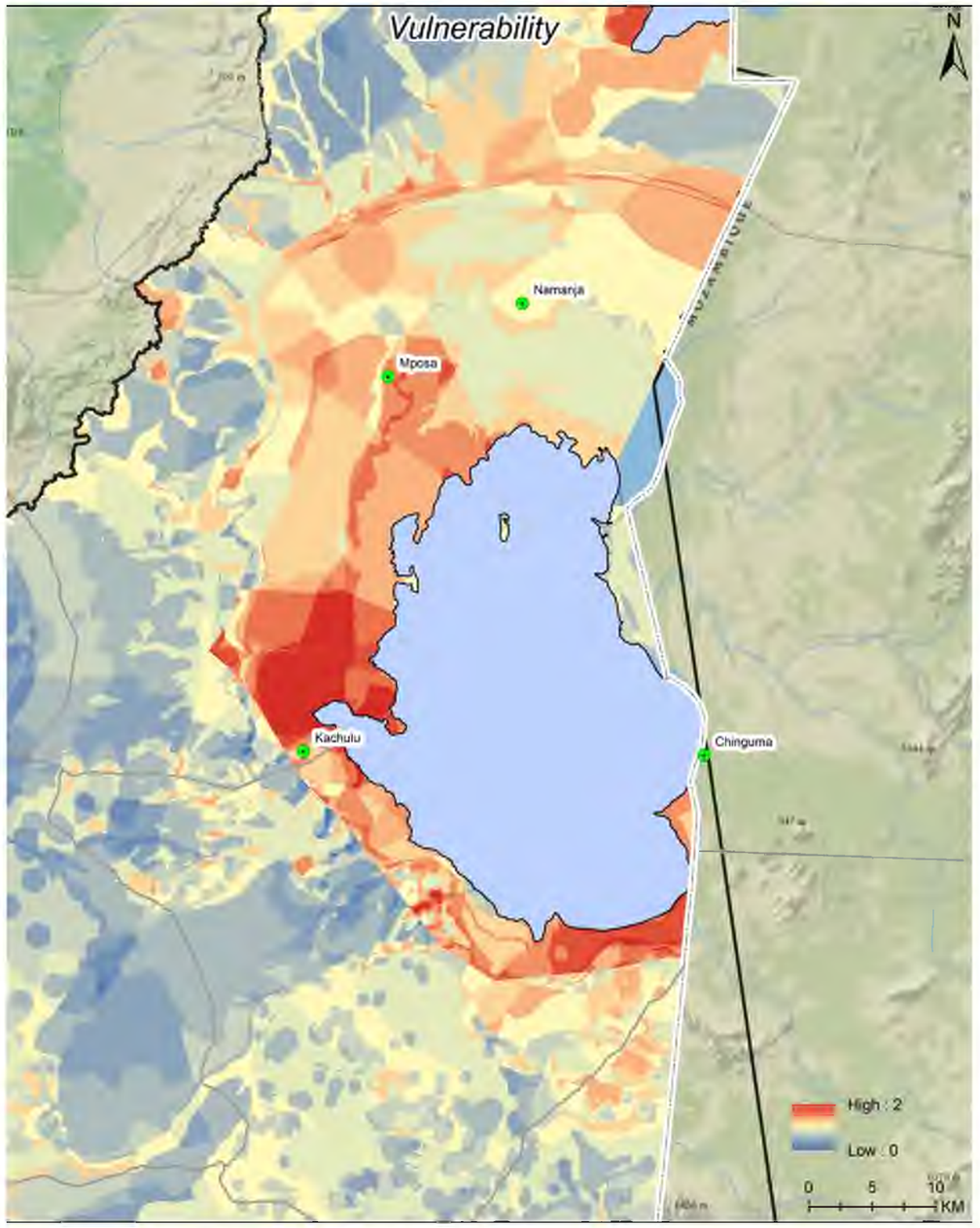
Exposure + Sensitivity + Adaptive Capacity = Vulnerability







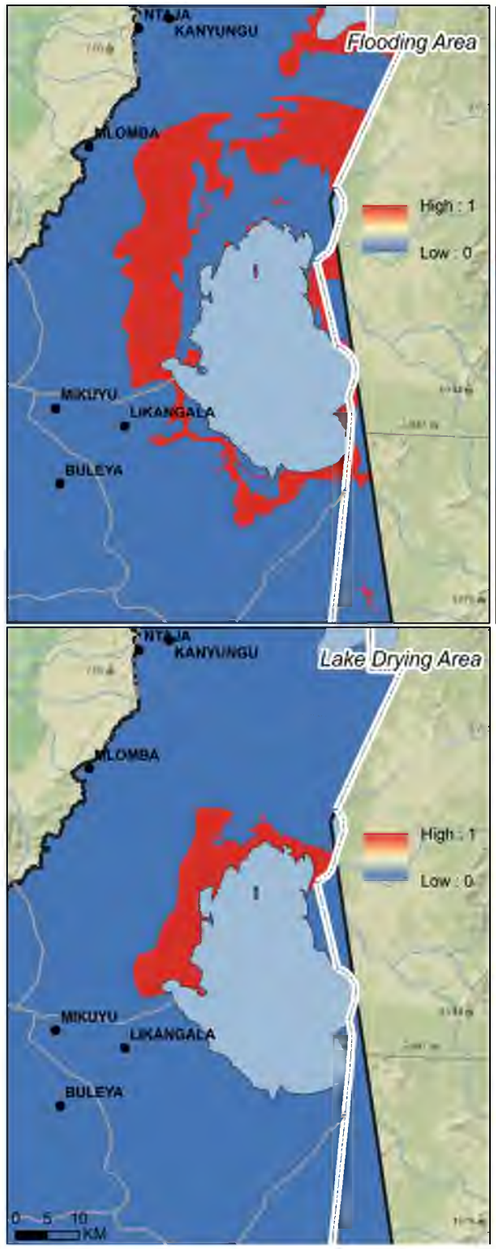
Overall vulnerability for Lake Chilwa

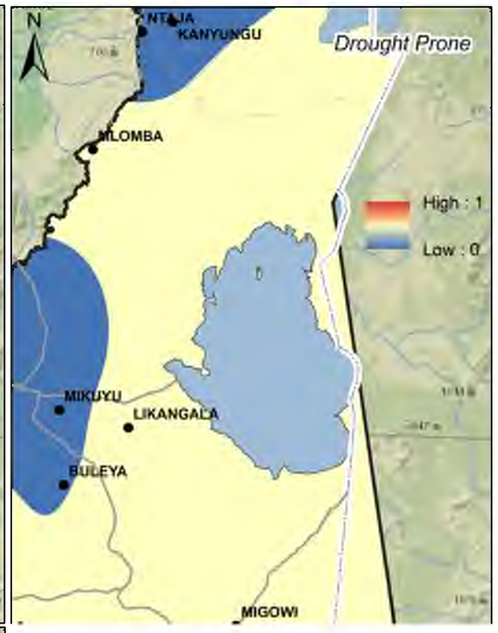


Exposure

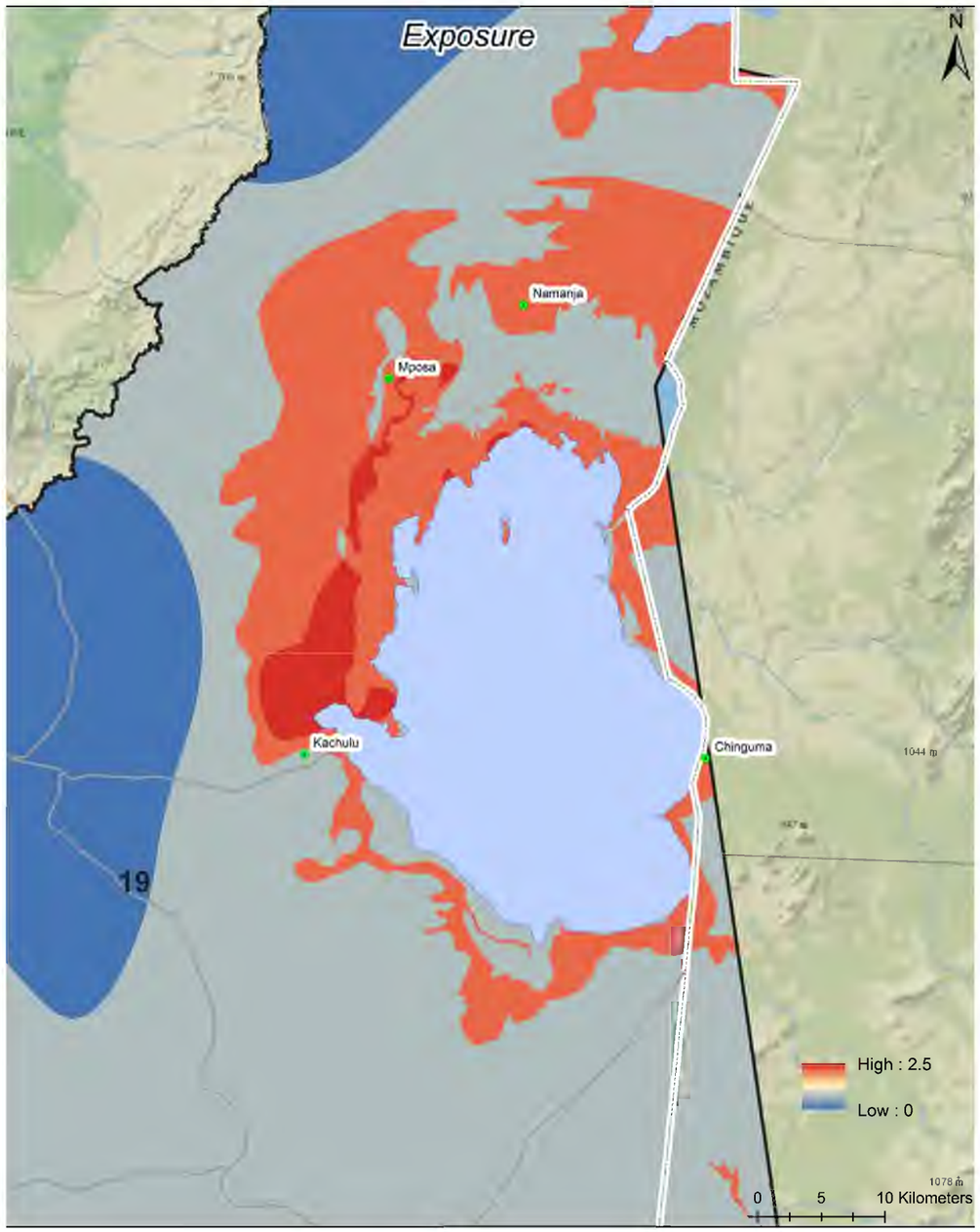
Exposure was measured by flooding areas, drought severity and lake drying areas. A score of '1' indicates high exposure according to the criteria listed and scores were added cumulatively to represent overall exposure. The land surrounding Lake Chilwa is considered very exposed due to the extreme flooding and drying of the lake's shorelines. The vegetated areas and lake areas are constantly in flux, which can have adverse effects on the fishing effort in those lake areas, respectively. The northwestern side of the lake exhibits the highest areas of exposure.

Exposure (E) = f(flooding area + rainfall amount + lake drying area)





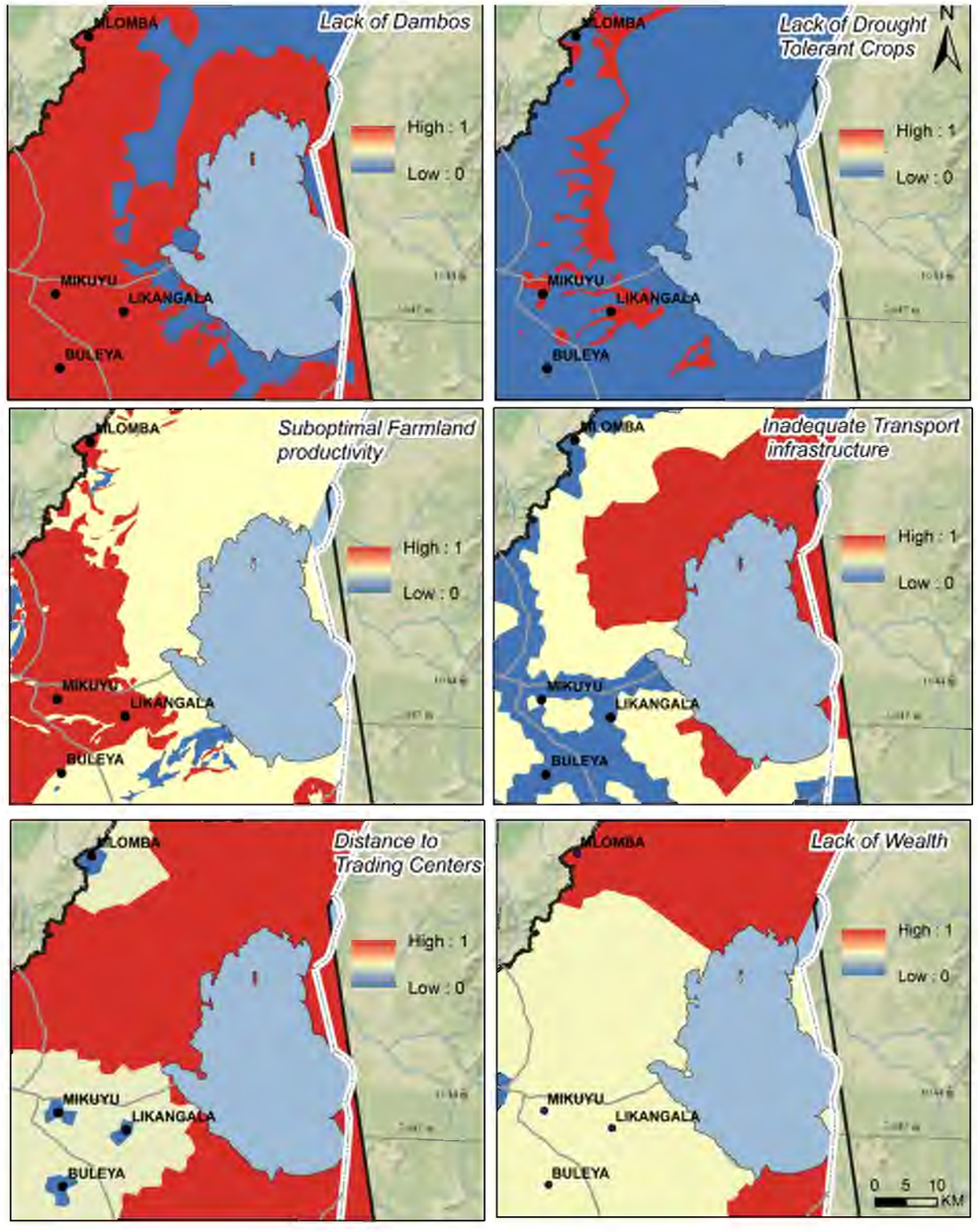
Combined Exposure for Lake Chilwa



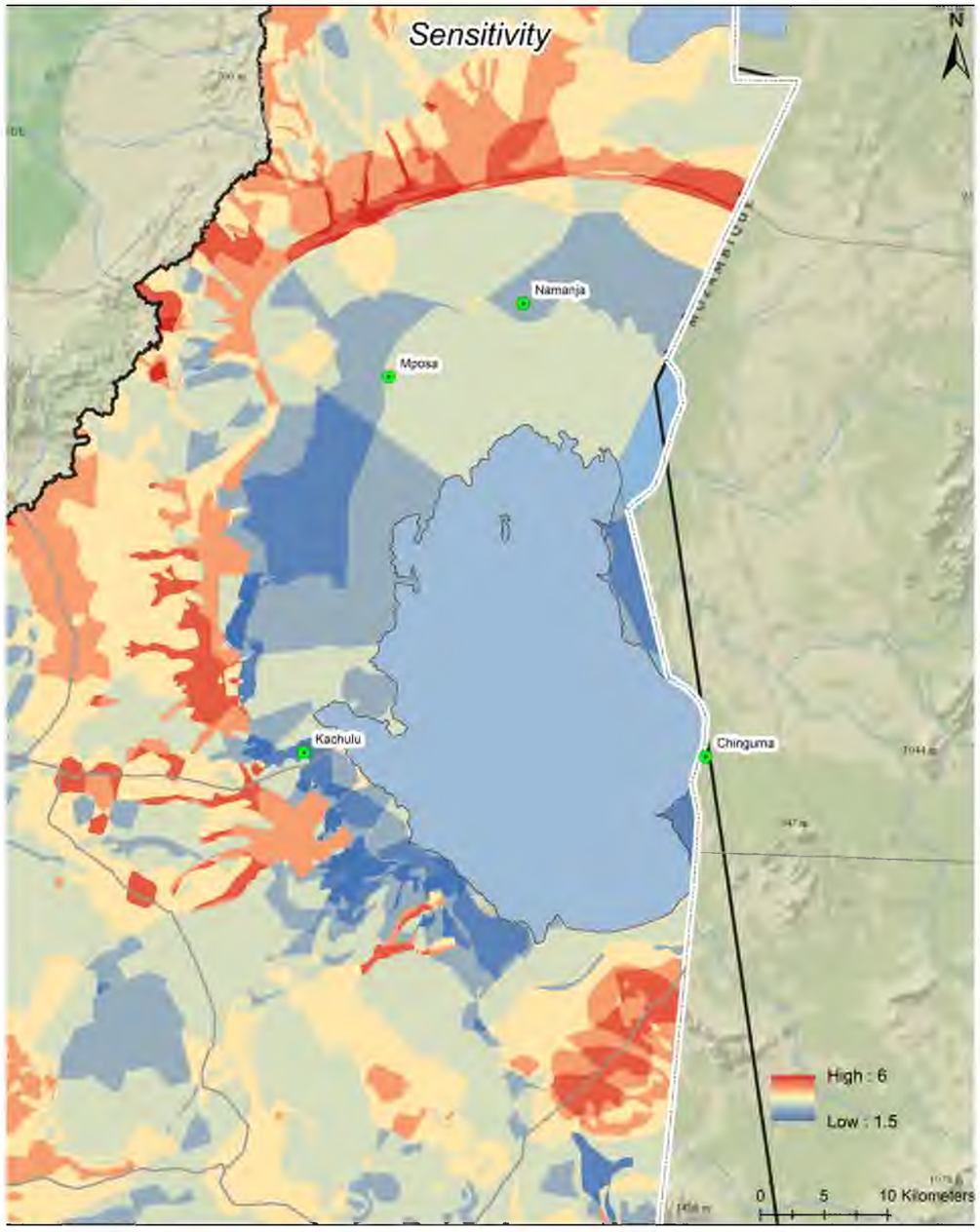
Sensitivity

Sensitivity was measured by indicators deemed appropriate by the climate change team. These indicators included the presence of dambos, drought tolerant crops, farm land productivity, transportation infrastructure, poverty levels, and the distance to trading centers. A score of '1' for any category means the area is sensitive, relative to that indicator. Scores were then added to calculate an overall sensitivity score, which is depicted on the summary map to the right. The land area adjacent to Lake Chilwa is not as sensitive as the areas located farther away from the lake. The proximity to the lake provides increased access to dambos and productive farmland while the areas around Mlomba, Mikuyu, and Linkangala had less drought tolerant crops and suboptimal farmland productivity.

Sensitivity (S) = f(dambos + drought + farmland productivity + condition of transport infrastructure + distance to trading centers + wealth)



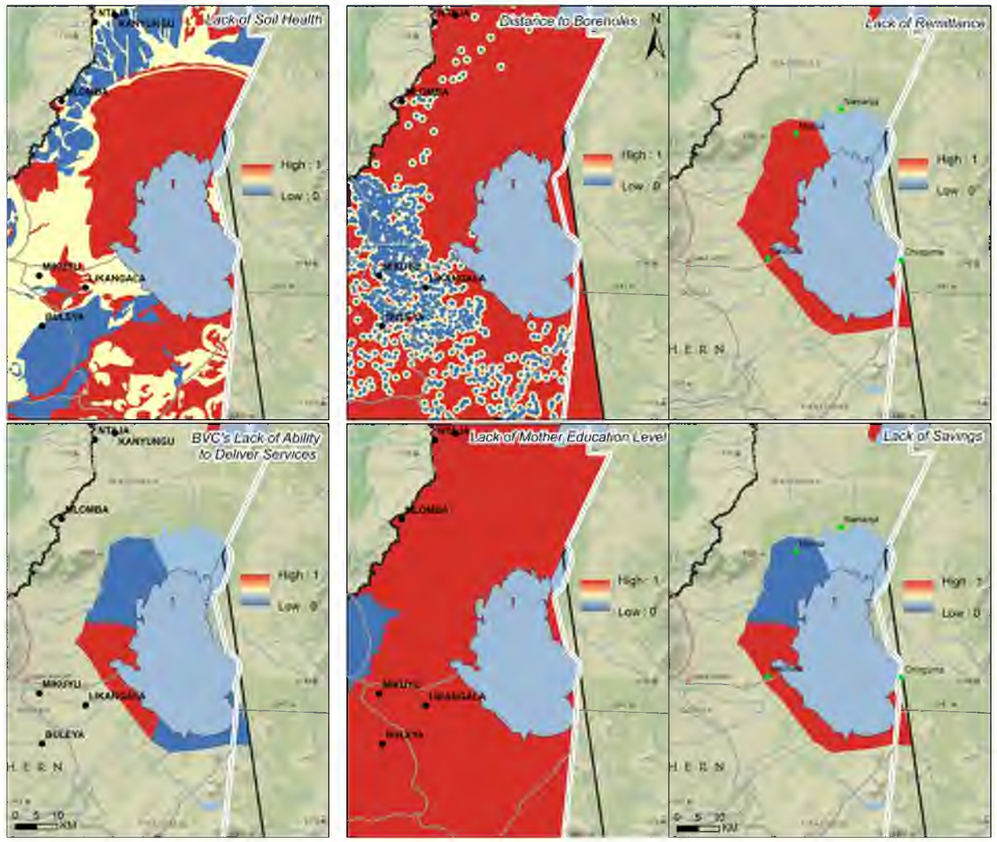
Combined Sensitivity for Lake Chilwa



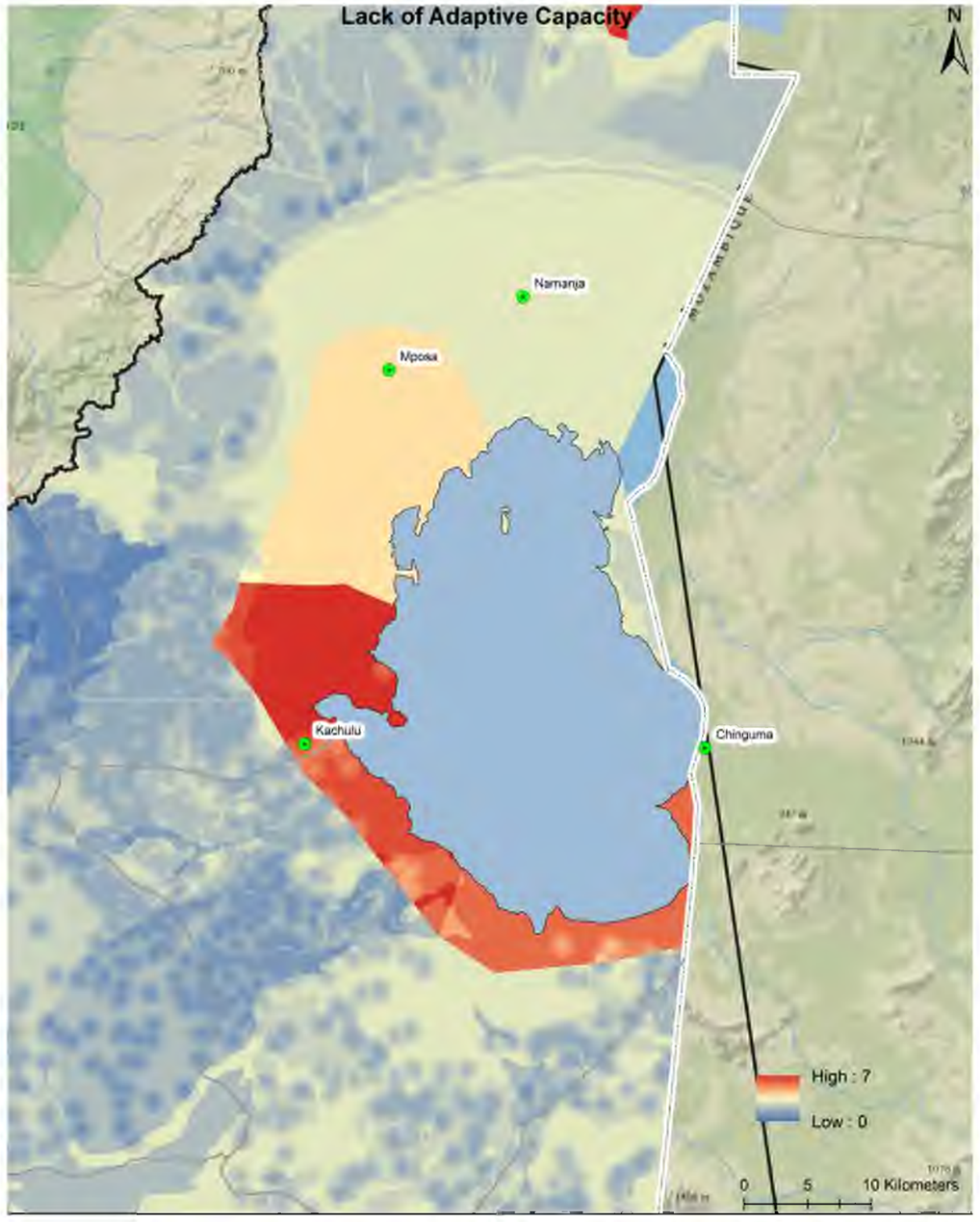
Lack of Adaptive Capacity

Adaptive capacity represents a community's ability to overcome potential threats or stressors. Indicators selected for scoring adaptive capacity included soil health, distance to boreholes, Beach Village Committee's ability to deliver services, mother education level, remittance levels, level of illegal gear use, number of livelihoods per household, and level of savings. High scores indicate the lack of adaptive capacity as measured by the aforementioned criteria. The northern half of Lake Chilwa exhibits much greater adaptive capacity than the southern half as the latter exhibits higher levels of illegal gear use and lower levels of savings.

Adaptive Capacity = f(Soil Health + Borehole Distance + BVC Services + Mother Education + Remittance Levels + Illegal Gear Use + Savings)



Combined Lack of Adaptive Capacity for Lake Chilwa



References

Ambali, A.J.D., Kabwazi, H.H., 1999. The study of fish reproductive biology in Lake Chilwa and Mpoto Lagoon with special reference to fishery conservation measures and in relation to changes in lake regime. State of the Environment Study No. 6.Lake Chilwa Wetland Project. Zomba, Malawi.

Cantrell, M.A., 1988. Effect of lake level fluctuations on the habitats of benthic invertebrates in a shallow tropical lake. Melack, Saline Lakes 125–131.

Chandilanga, B., Chiphwanya, M., Jazza, A., Joshua, B., Manhani, H., Meja, S., Mtafya, Y., Tonho, B., Sambakunsi, D., Zulu, S., 2013. Climate proofing local development gains in rural and urban areas of Malawi, Machinga District Profile.

Environmental Affairs Department, 2000. Lake Chilwa wetland state of the environment.

FISH (2015). Environmental Threats and Opportunities Assessment (ETOA) of Four Major Lakes in Malawi. USAID/FISH Project, Pact Publication, Lilongwe, Malawi: 248 pp.

Furse, M.T., Morgan, P.R., Kalk, M., 1979. The fisheries of Lake Chilwa, in: Lake Chilwa: Studies of Change in a Tropical Ecosystem. Dr. W. Junk Publishers, pp. 209–229.

Kalindekafe, M., 2014. Lake Chilwa Basin Environmental Status in relation to the biodiversity, pollution and habitat change, in: Towards Defragmenting Management System of Lake Chilwa Basin, Malawi. Chapter 2.

Kanyerere, G.Z., Banda, M.C., Chilora, B., Nyasulu, T.E., Ngochera, M.J., Kaonga, D., 2008 . Annual Frame Survey. Fisheries Department, Fisheries Research Unit P.O. Box 27, Monkey Bay, Malawi.

Macuiane, M.A., Kaunda, E.K., Jamu, D.M., Kanyerere, G.Z., 2009. Reproductive biology and breeding of Barbus paludinosus and B. trimaculatus (Teleostei: Cyprinidae) in Lake Chilwa, Malawi: implications for fisheries management. African Journal of Aquatic Science 34, 123– 130. doi:10.2989/AJAS.2009.34.2.2.889.

McLachlan, A., Morgan, P.R., Howard-Williams, C., 1972. Aspects of the recovery of a saline African lake following a dry period. Archiv fur Hydrobiologie 325–340.

Moss, B., 1979. The Lake Chilwa ecosystem: a limnological overview, in: Lake Chilwa Studies of Change in a Tropical Ecosystem. Dr. W. Junk Publishers, p. 41.

Msiska, O.V. 2001. 'A Review of Limnology of Malawi', pp.121-189, in: Wetzel RG and Gopal B (eds.) Limnology in Developing Countries 3. International Association for Limnology, New Delhi, India.

Ngochera, M., Namoto, W., Mponda, O.C., Bay, M., 2001. Analysis of Catch and Effort Data for the Fisheries of Lake Chiuta 1976-1999. Government of Malawi Department of Fisheries 20.

Njaya, F.J., 2001. Review of management measures for Lake Chilwa, Malawi: final project. Fisheries Training Programme. United Nations University (http://www.unuftp.is/fellows/view/172).

Njaya, F., Snyder, K.A., Jamu, D., Wilson, J., Howard-Williams, C., Allison, E.H., Andrew, N.L., 2011. The Natural History and Fisheries Ecology of Lake Chilwa, Southern Malawi. Journal of Great Lakes Research 37, 15–25. doi:10.1016/j.jglr.2010.09.008.

UNESCO, 2015. Lake Chilwa Wetland (Description) [WWW Document]. URL http://whc.unesco.org/en/tentativelists/5604/