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FISHERIES INTEGRATION OF SOCIETY AND HABITATS (FISH) PROJECT

An Atlas of the Fisheries Resources of Lake Chiuta in Malawi

THE UNIVERSITY OF RHODE ISLAND GRADUATE SCHOOL OF OCEANOGRAPHY
CRC COASTAL RESOURCES CENTER
christian aid
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EMMANUEL INTERNATIONAL MALAWI

For more information on the report and the Malawi Fisheries Integration of Society and Habitats (FISH) Project contact:

Dr. Daniel Jamu FISH, Deputy Chief of Party (Programs): djamu@crc.uri.edu

Dr. Elin Torell, Associate Coastal Manager: elin@crc.uri.edu

Alan Brooks FISH, Chief of Party: abrooks@pactworld.org

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

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Contact:
Pact Inc.
1828 L Street NW, Suite 300
Washington, DC 20036, USA
+1-202-466-5666
info@pactworld.org

Pact Malawi
1st Floor, Amina House
P.O. Box 1013
Lilongwe, Malawi
Phone: 1751220; 1751201
e-mail: infomw@pactworld.org

Preface

This map book chapter presents a series of maps with accompanying text for Lake Chiuta 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.

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Introduction to Lake Chiuta

Lake Chiuta, the smallest of the four lakes within the Malawi FISH project, is located between 14° 30'S and 15° 00'S and between 35° 30'E and 35° 55'E, and has a total surface area of ~190 km^2, about 49 km^2 of which lie in Mozambique. At an altitude of 620m, the lake is ~60 km long and ~20 km wide with an average depth of 3 to 4 meters. Lake Chiuta's pan-shaped basin lies on the eastern side of the Mlomba Upland area (Dawson 1970, Dulanya et al. 2013). Drainage from the basin flows directly into the lake through a series of affluent streams, controlling both lake level and volume (Njaya et al. 1999). The water level of the lake is influenced by the inflow from the Mpili River on the western side of the lake. In the northeast, Lake Chiuta has an out-flow into the Mozambican Lake Amaramba during times when the water level is high, and no outflow (endorheic) when the water level is low (Dawson 1970). Lake Chiuta's wetlands are sep-arated from those of Lake Chilwa by a sandbar about 20m above lake levels. It has been shown that the two lakes were once connected separating sometime in the last 15,000 years (Dawson 1970, Njaya et al. 1999, Njaya 2008).

Satellite Image of Lake Chiuta

Habitat of Lake Chiuta

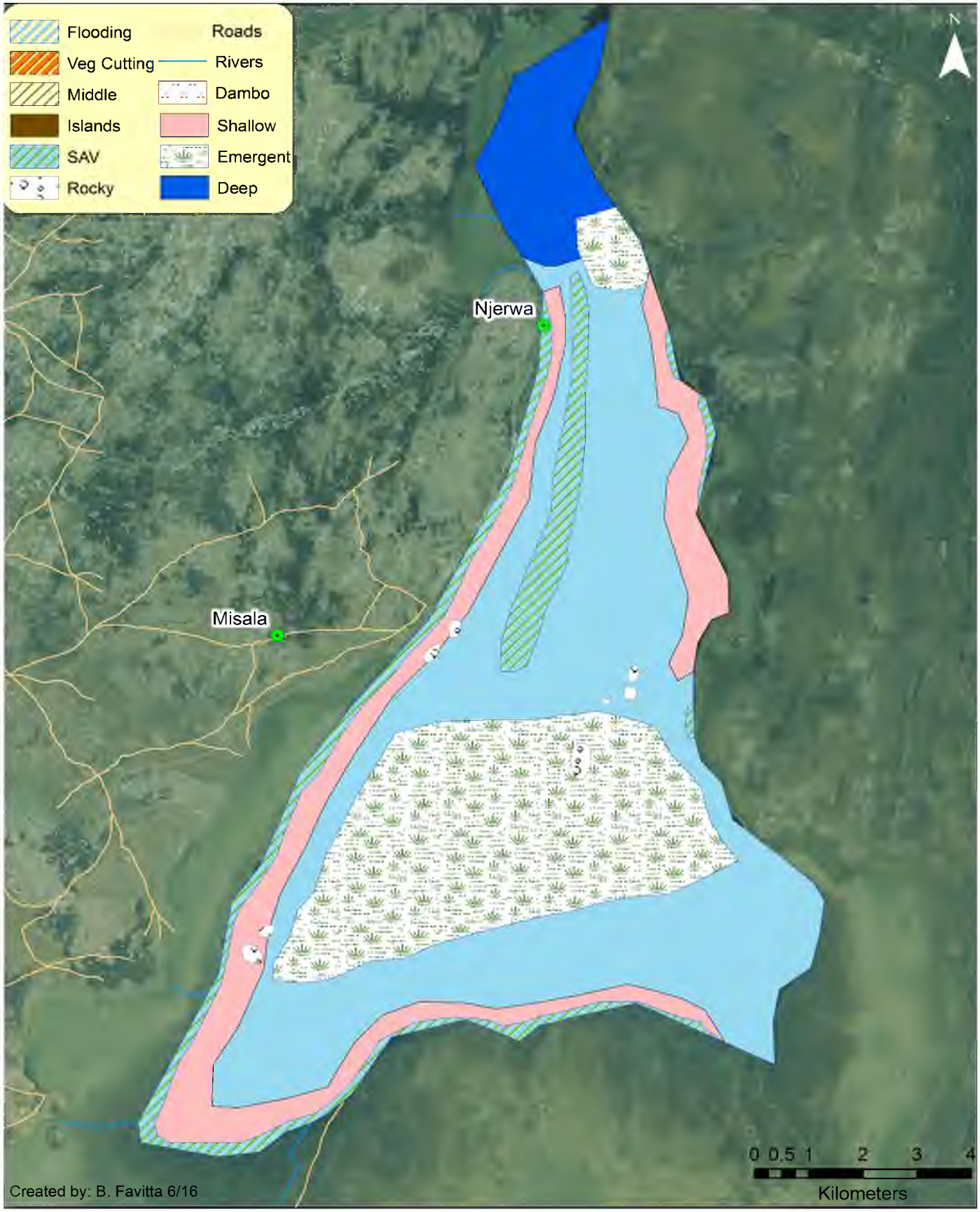
METHODS

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 Chiuta's shallow waters are dominated by thick vegetation, both emergent and submerged. These dynamic habitats serve as refugia for breeding adult fish and juveniles alike, while simultaneously limiting fishing access. In the central part of the lake, in the midst of the abundant emergent vegetation, there are two main islands: Big Chiuta and Little Chiuta. These islands also provide safe breeding grounds for many endemic fish species. Submerged aquatic vegetation (SAV) typically follows the shallow areas and shorelines of the lake. The western and southern banks have the most SAV, second to a large strip of vegetation running north-south along the northern half of the lake. Historically, SAV and emergent aquatic vegetation (EAV) areas have been cut to facilitate the use of what are known as illegal gears. Currently, reeds are actively harvested on both the Malawian and the Mozambique sides of Lake Chiuta. These areas include the southeast border of the large central EAV zone and the eastern side of the central SAV strip.

Habitat Types within Lake Chiuta



Species Richness in Lake Chiuta

METHODS

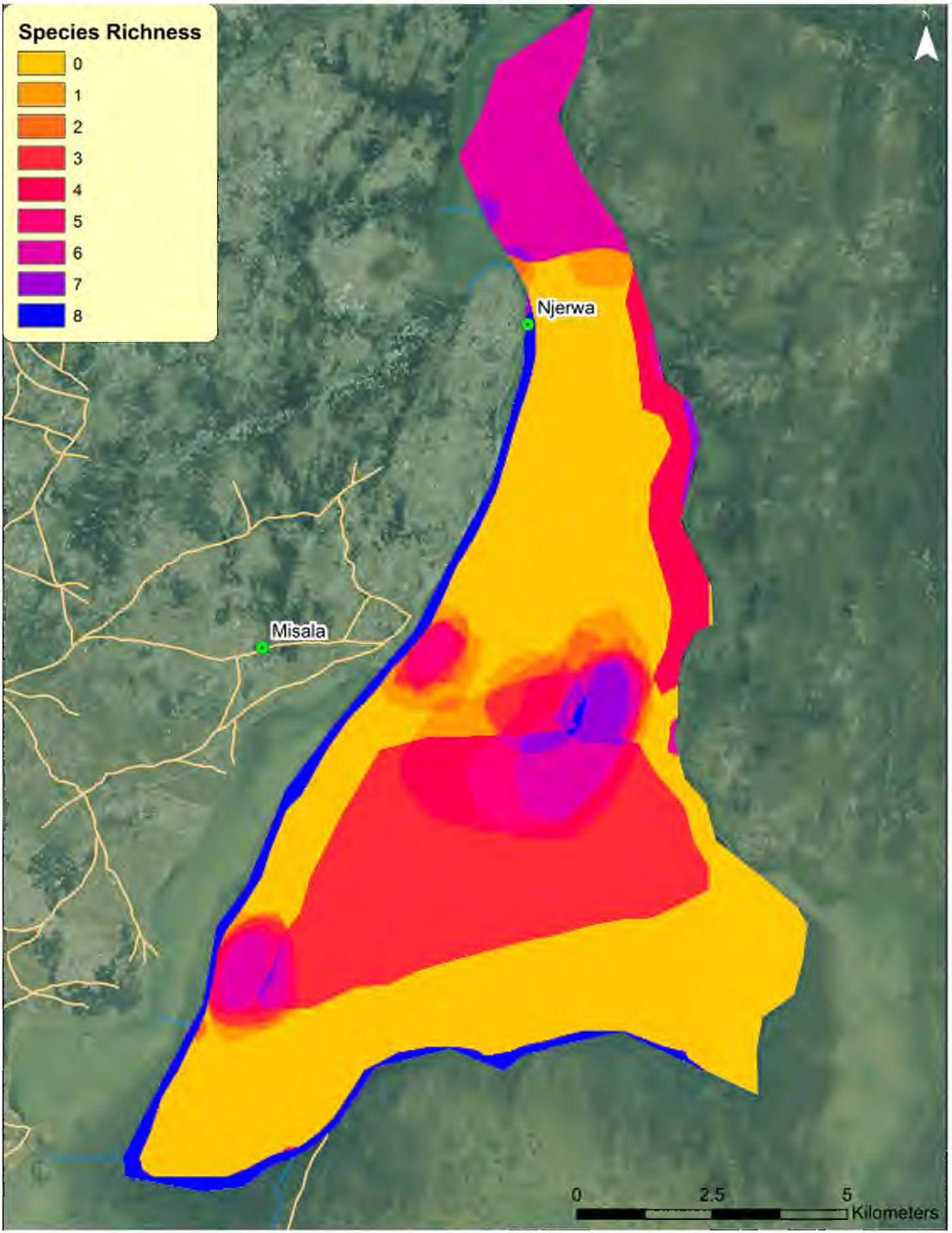
This map was created by conducting a series of focus group discussions and mapping activities with local fishermen living in communities distributed around the lake. The fishermen were first asked to list the species that they harvest for subsistence and generating income. For each individual species, 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 as perceived by the local fishermen.

This map highlights the harvested fish species-rich zones within Lake Chiuta. The different colors on the map represent the cumulative score of fish species with darker colors denoting higher richness.

The highest fish species richness was present in the central island areas of the lake and along the submerged aquatic vegetation (SAV) zones, specifically the western and southern banks. Emergent aquatic vegetation (EAV) zones also exhibited high species richness, second only to the aforementioned areas.

Follow-up visits were held with the communities to validate the results. In general, they felt that it was a good representation of species distribution in the lake and expressed that critical habitats such as the shallow nearshore SAV areas and the rocky areas adjacent to Big Chiuta and Small Chiuta islands need better protection.

High Biodiversity Areas within Lake Chiuta



Species of Lake Chiuta

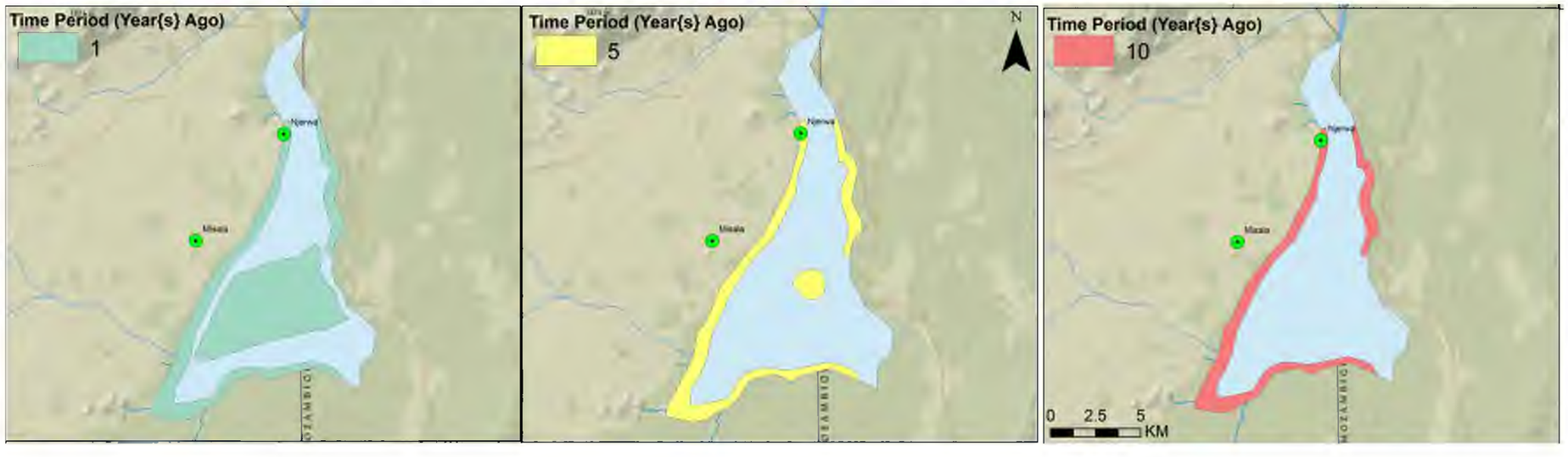
Chidondolo

Chidondolo (*Haplochromine spp.*) is an endemic species to Lake Chiuta. The PRA participants reported that the shallow submerged aquatic vegetation (SAV) located along the periphery of the western and southern shorelines serve as critical habitat for all life stages. Breeding, nursing, and juvenile populations all seek refuge within the SAV and shallow area along the eastern shoreline. Once they have reached maturity, the adult chidondolo venture to the deeper area in the northern tip of Lake Chiuta as well as the rocky outcrops surrounding the central islands.

As seen in the accompanying maps for fishing areas, the most consistently fished areas over the past ten years are within the SAV zones bordering the lake. In more recent years, however, the fishers have extended their search to the rocky area and larger emergent aquatic vegetation (EAV) zone located in the center of the lake. The latter areas provide a greater probability of capturing only mature Chidondolo since the fry and juveniles also inhabit the SAV areas.

Chidondolo Life Stages in Lake Chiuta

Chidondolo Fishing Areas in Lake Chiuta



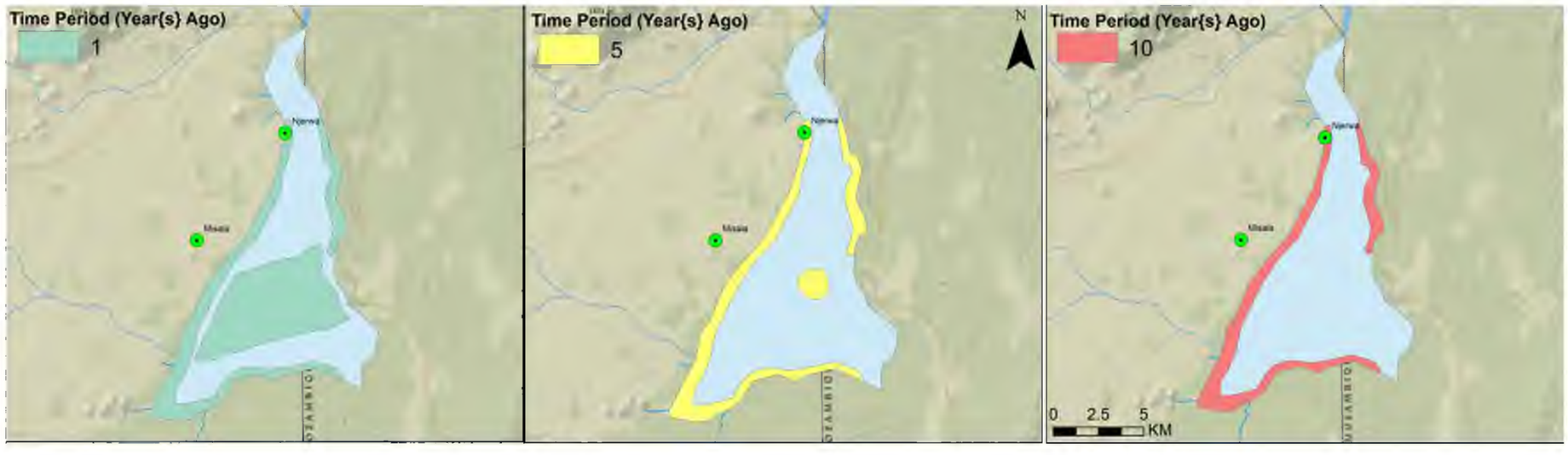
One Year Ago | Five Years Ago | Ten Years Ago

Chilenje

Chilenje is a less prevalent species in Lake Chiuta, and not as much is known about their biological tendencies given their more elusive nature. While the chilenje continues to be a somewhat regular occurrence in local catches, it is not a staple in terms of food. The local communities were able to provide the PRA teams with some information, but there was variation which indicates the need for ecological sampling. During the community mapping activity, the submerged aquatic vegetation (SAV) and shallow waters were identified as critical habitats for the breeding, nursery, and juvenile life stages. However, in follow-up visits the community members identified rocky areas and river inlets as the critical habitat for these life stages. Adult Chilenje were reported to reside within river inlets, SAV, rocky areas and the deeper northern section of Lake Chiuta. The fishermen reported exclusively harvesting chilenje within SAV and shallow areas ten years ago. Five years ago, they began fishing for Chilenje near rocky areas and then further expanded their efforts to the emergent aquatic vegetation one year ago.

Chilenje Life Stages in Lake Chiuta

Chilenje Fishing Areas in Lake Chiuta



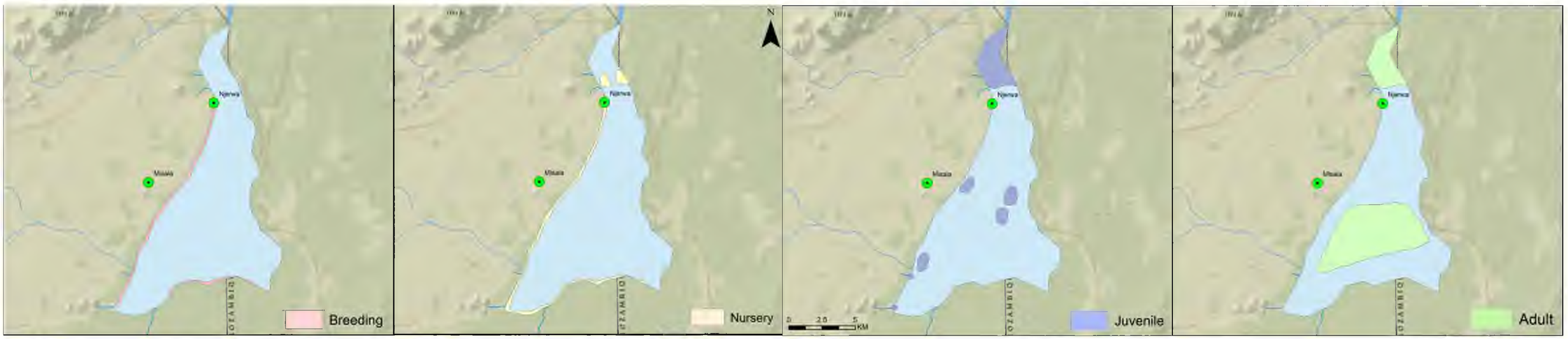
One Year Ago | Five Years Ago | Ten Years Ago

Makumba

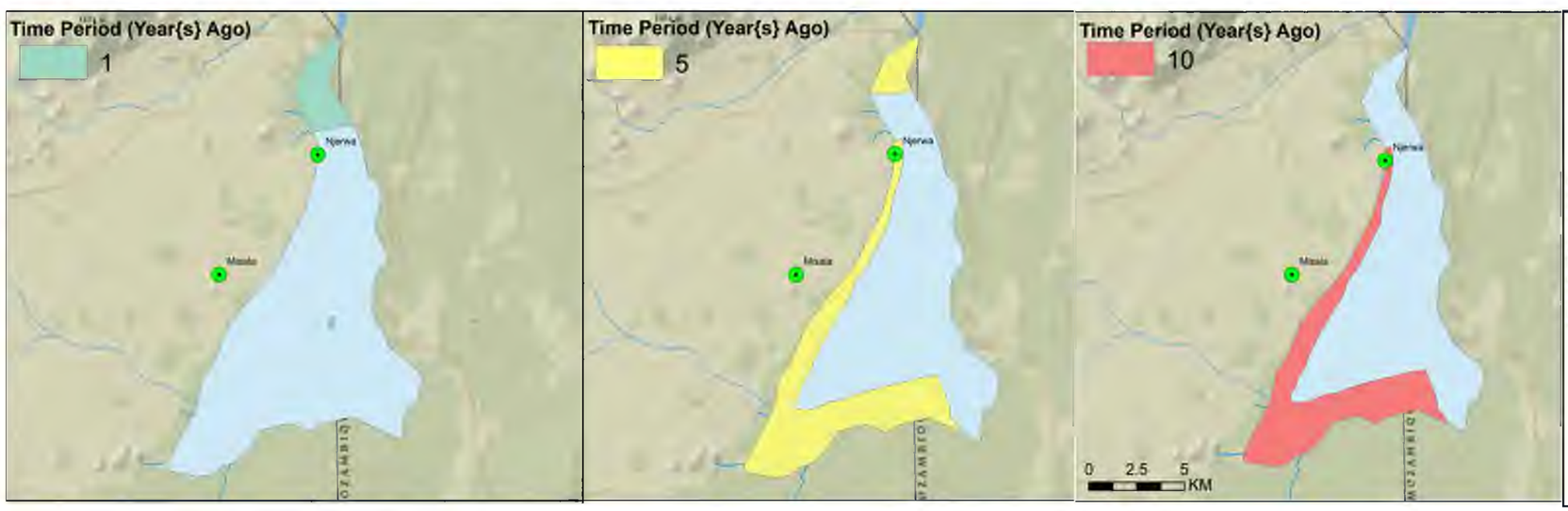
Makumba (*Oreochromis shiranus*), which is known as Chambo in Lakes Malawi and Malombe, has been a staple of the Malawian diet for decades. During breeding and nursing stages, Makumba remain in the shallows under the protection of thick submerged aquatic vegetation (SAV). As juveniles, they venture to rocky outcrops and river inlets and then ultimately migrate to deep areas and emergent aquatic vegetation (EAV) patches as adults. Makumba have been one of the highest producing species in Lake Chiuta, but the overall catch has declined considerably since 2004.

The PRA participants reported fishing for Makumba within the SAV and shallow areas on the western and southern banks ten years ago. Five years ago, they expanded their efforts to include the deepest zone in the lake which occupies the northern tip of Lake Chiuta. All fishing effort was focused in this deeper area in 2014.

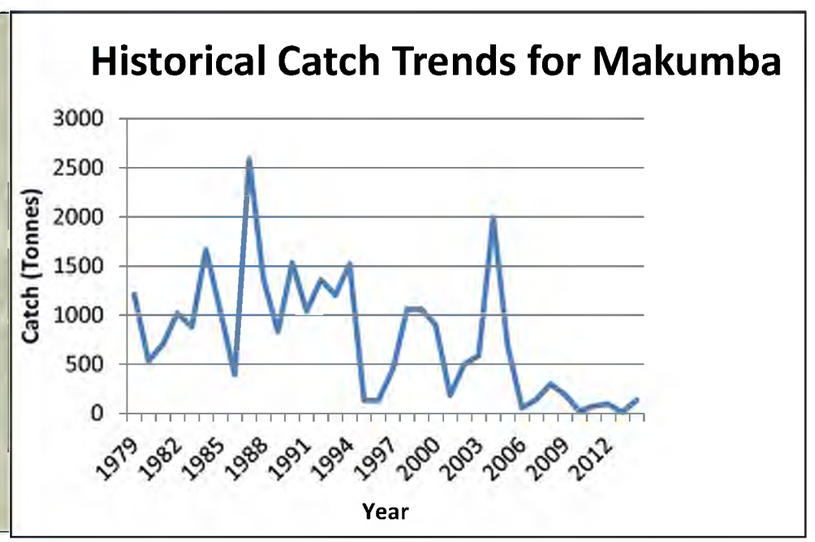
Makumba Life Stages in Lake Chiuta



Makumba Fishing Areas in Lake Chiuta



One Year Ago | Five Years Ago | Ten Years Ago



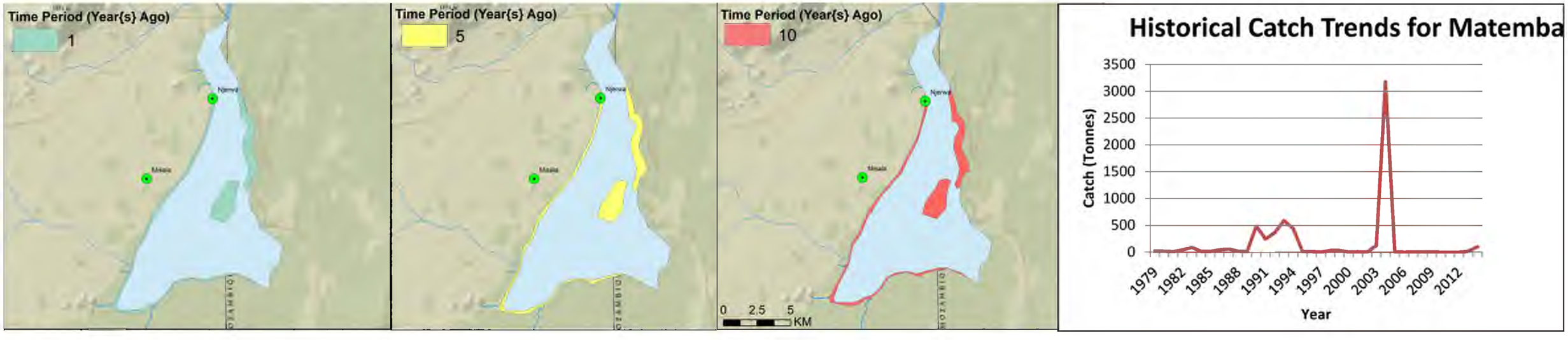
Source of data: Malawi Fisheries Research Unit.
Catch is in metric tonnes

Matemba

The fish *Barbus paludinosus*, locally known as Matemba, is an important source of food and income in Lake Chiuta. Matemba seines were exclusively used in Lakes Chiuta and Chilwa to catch them in the past, but are now prohibited. In contrast to other fish in the lake, Matemba breed throughout the year. The PRA participants reported Matemba breeding in shallow areas with submerged aquatic vegetation as well as rocky areas and river mouths. Nursery habitats overlap with breeding grounds while the juveniles inhabit submerged aquatic vegetation (SAV), river inlets and shallow areas until adulthood. When the matemba become large enough, they venture out into open waters to reach the emergent aquatic vegetation (EAV) and deeper area of the lake. The highest Matemba catches were observed in the mid-2000s, and the areas within the lake where the fishing activities are concentrated have not changed within the past ten years.

Matemba Life Stages in Lake Chiuta

Matemba Fishing Areas in Lake Chiuta



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

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

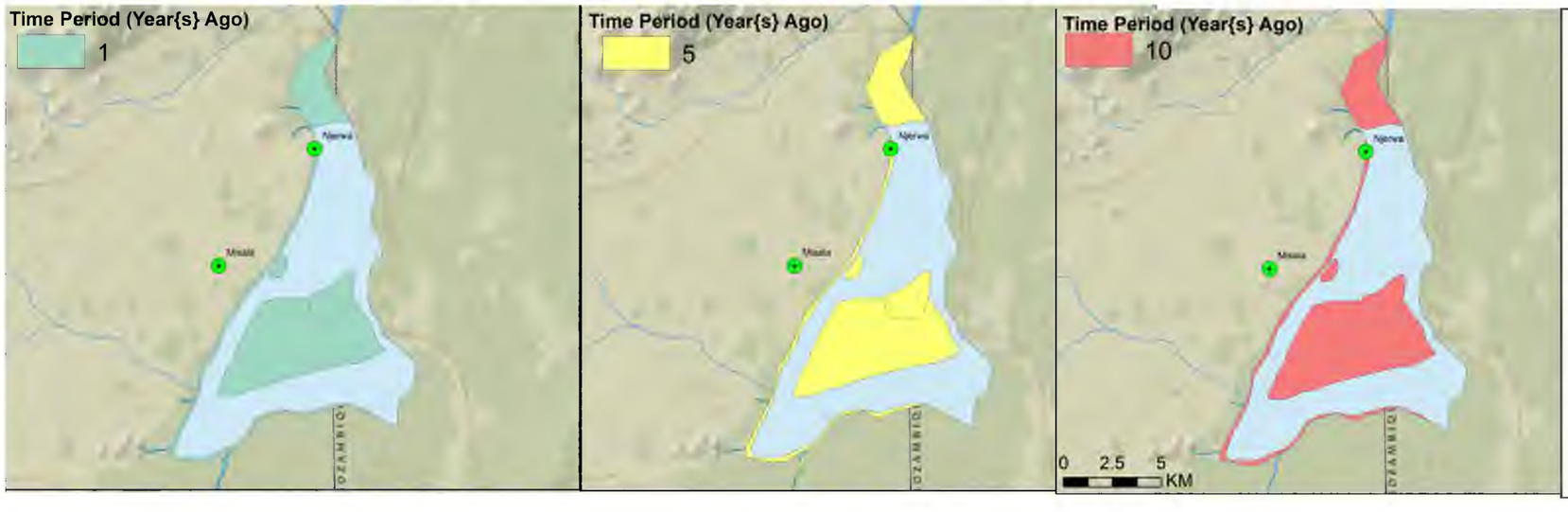
Mlamba

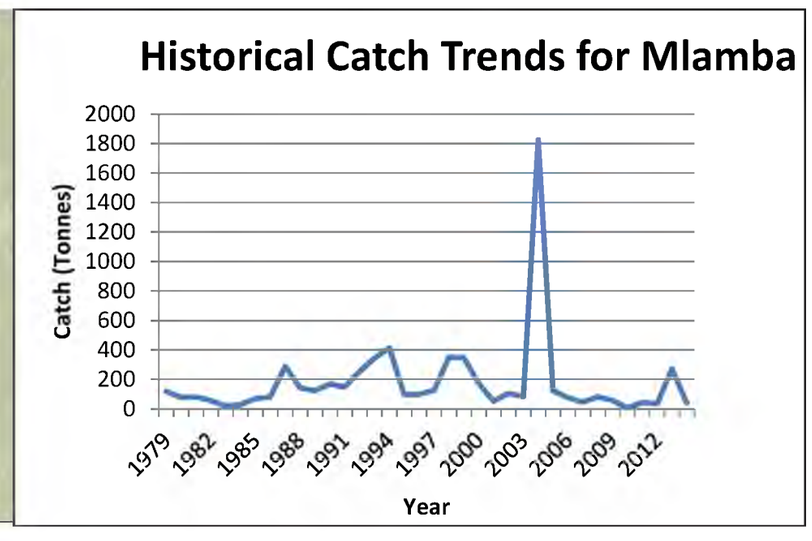
Mlamba *(Clarias gariepinus)* is another one of Lake Chiuta's primary fishing targets. As one of the more versatile species in Lake Chiuta, it is present in many different types of habitat ranging from open water to thick emergent aquatic vegetation (EAV) to river mouths and the rocky areas around Big and Little Chiuta islands. The PRA participants reported that the Mlamba breed in submerged aquatic vegetation (SAV), rocky habitats, and the deeper northern section of the lake. The shallow SAV serves as critical nursery habitat. Juveniles were reported to also inhabit the shallow SAV as well as rocky areas on the western edge of the lake, shallow areas along the eastern shoreline, and the deeper northern section. Once they reach the adult stage, the Mlamba migrate towards the EAV in the center of the lake and/or remain in the northern deep area.

According to the interviewed community members, fishers have harvested Mlamba from the same SAV and EAV areas, river mouths, rocky areas, and deep areas over the past ten years. The total catches have varied over time with the greatest level observed in 2004.

Mlamba Life Stages in Lake Chiuta

Mlamba Fishing Areas in Lake Chiuta





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

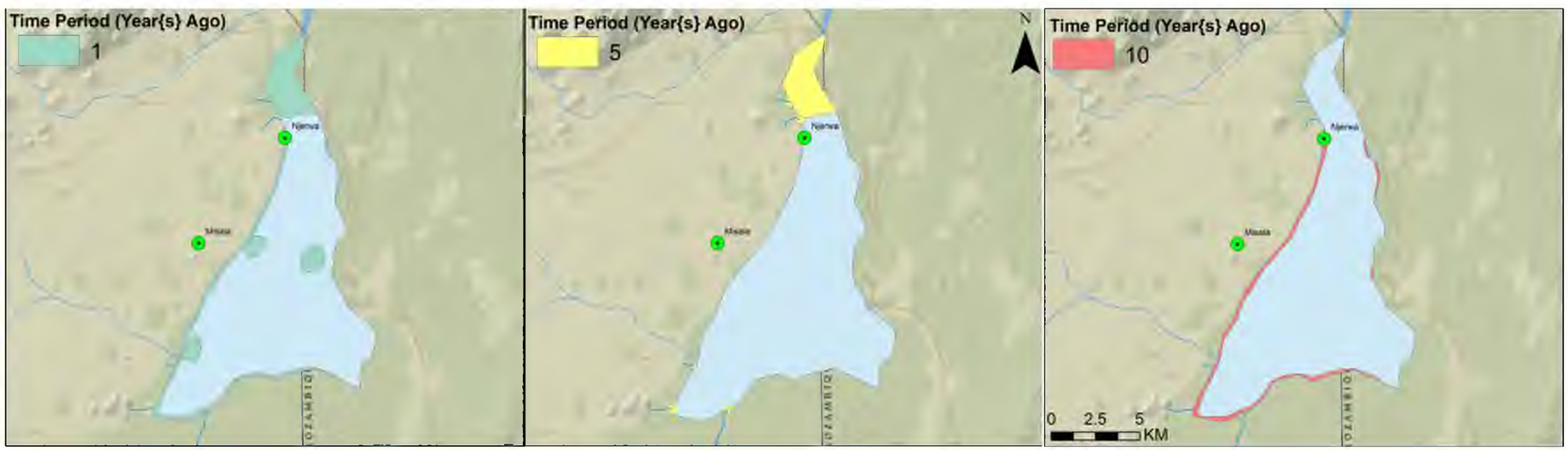
One Year Ago **Five Years Ago** **Ten Years Ago**

Mphuta

Mphuta (*Marcusenius macrolepidotus*) is one of the rarer species in Lake Chiuta, and little is known about this species. The PRA participants reported that the river inlets and submerged aquatic vegetation (SAV) along the shallow edge areas of the lake serve as important breeding, nursery and juvenile habitat. Unfortunately, the PRA activities were unable to highlight more specific information about adult mphuta biology, but during the ETOA workshop, fisheries personnel noted that adult mphuta feed in the deeper, more open water in the northern end of the lake near the outlet. Mphuta were historically caught in the SAV located along the shallow periphery of the lake. Five years ago, the target area shifted to the deeper, northern tip of the lake and the river inlets. One year ago, the fishing effort was concentrated in the SAV areas along the edge of the lake, the deeper section of the lake, and the rocky outcrops and island areas.

Mphuta Life Stages in Lake Chiuta

Mphuta Fishing Areas in Lake Chiuta



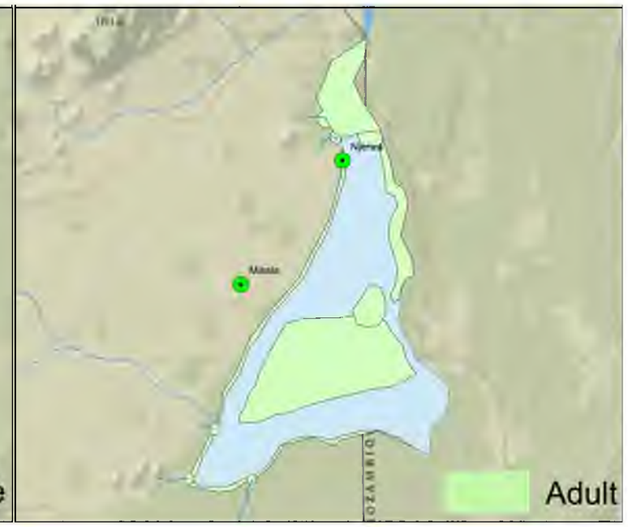
One Year Ago | Five Years Ago | Ten Years Ago

Nkhalala

Brycinus imberi, known locally as Nkhalala, is found in the shallow waters or swampy areas of rivers, lagoons and floodplain pans. Nkalala breeds in the summer and migrates to spawning sites after the rains. It utilizes the submerged aquatic vegetation for breeding areas, which provides ample refugia during mating and for subsequent juvenile protection. Communities visited by the PRA teams confirmed this adding that the nkhalala also breeds in areas where emergent aquatic vegetation is present and near river inlets and outlets. The shallow areas provide more refuge from predators during the nursing and juvenile life stages. Like other fish species in Lake Chiuta (e.g., Chambo, Matemba, Mlamba, Mphuta,), the adult Nkahlala transitions to the deeper, more open water in the northern end of the lake near the outlet, and migrates to floodplains and tributary rivers when the water level in the lake recedes.

The local communities have identified strategies for better managing fisheries losses, and the return of the Nkhalala serves as an example of successful management by the Njerwa community. The community established bylaws banning the fishing of juvenile fish, and have suggested putting into place a series of larger mesh size limits to better protect juvenile fish from inadvertent capture. Regulations of this nature could also help prevent the local extinction of other species in Lake Chiuta.

Nkhalala Life Stages in Lake Chiuta



Nkhalala Fishing Areas in Lake Chiuta

One Year Ago

Five Years Ago

Ten Years Ago

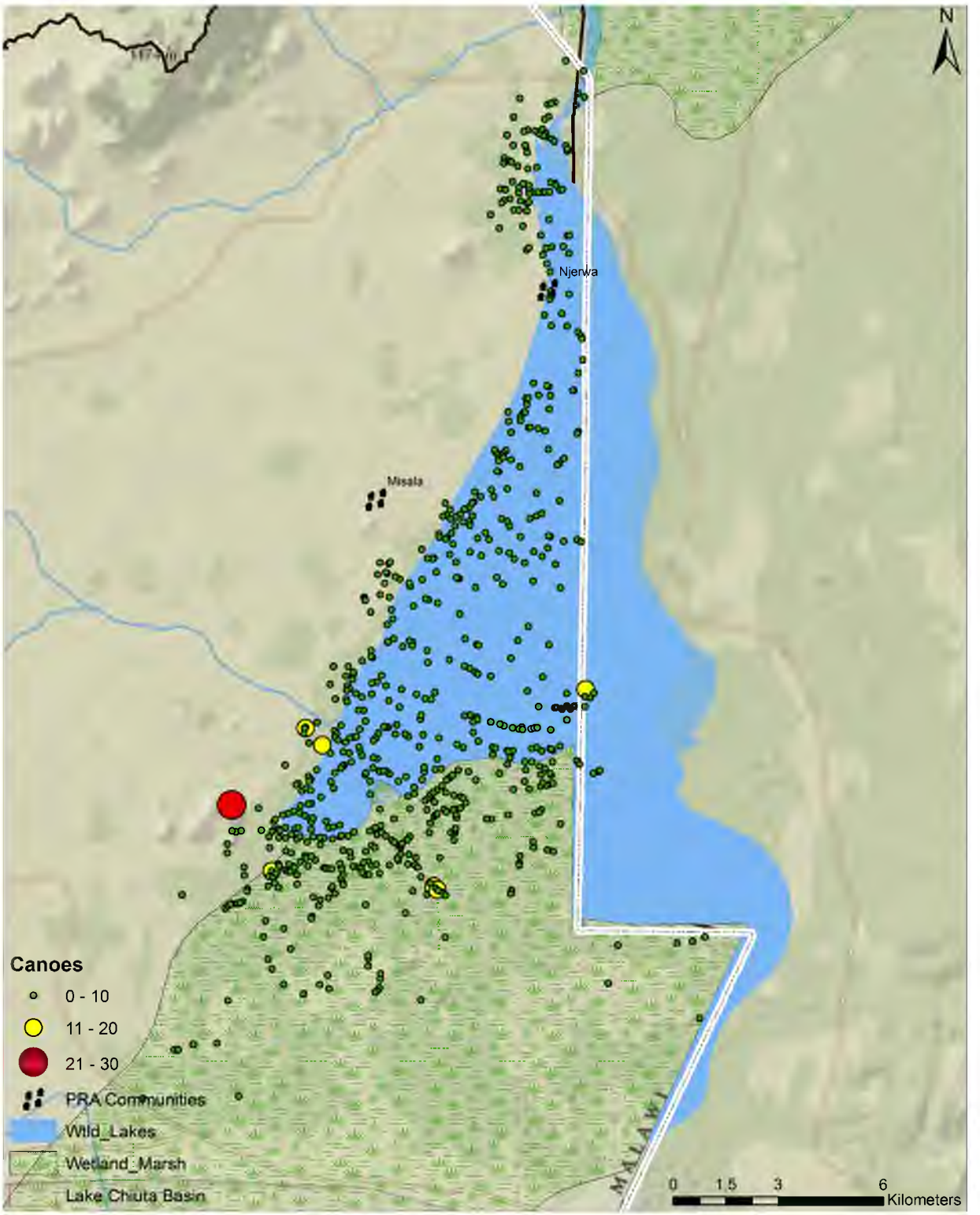
Aerial Survey Gear Maps

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

Canoe density is high throughout Lake Chiuta and along the shoreline, and 1,283 canoes were spotted in the aerial survey. These canoes serve as a staple of both fishing and transportation activities given that they are less expensive and more easily acquired than their plank boat counterparts. The high abundance of canoes in the southern wetland areas indicate usage of manmade channel systems that are cut as passageways to give fishers access to thickly vegetated areas. Canoe abundance is also correlated with village locations and concentrations of canoe activity are seen in the vicinity of PRA community areas.

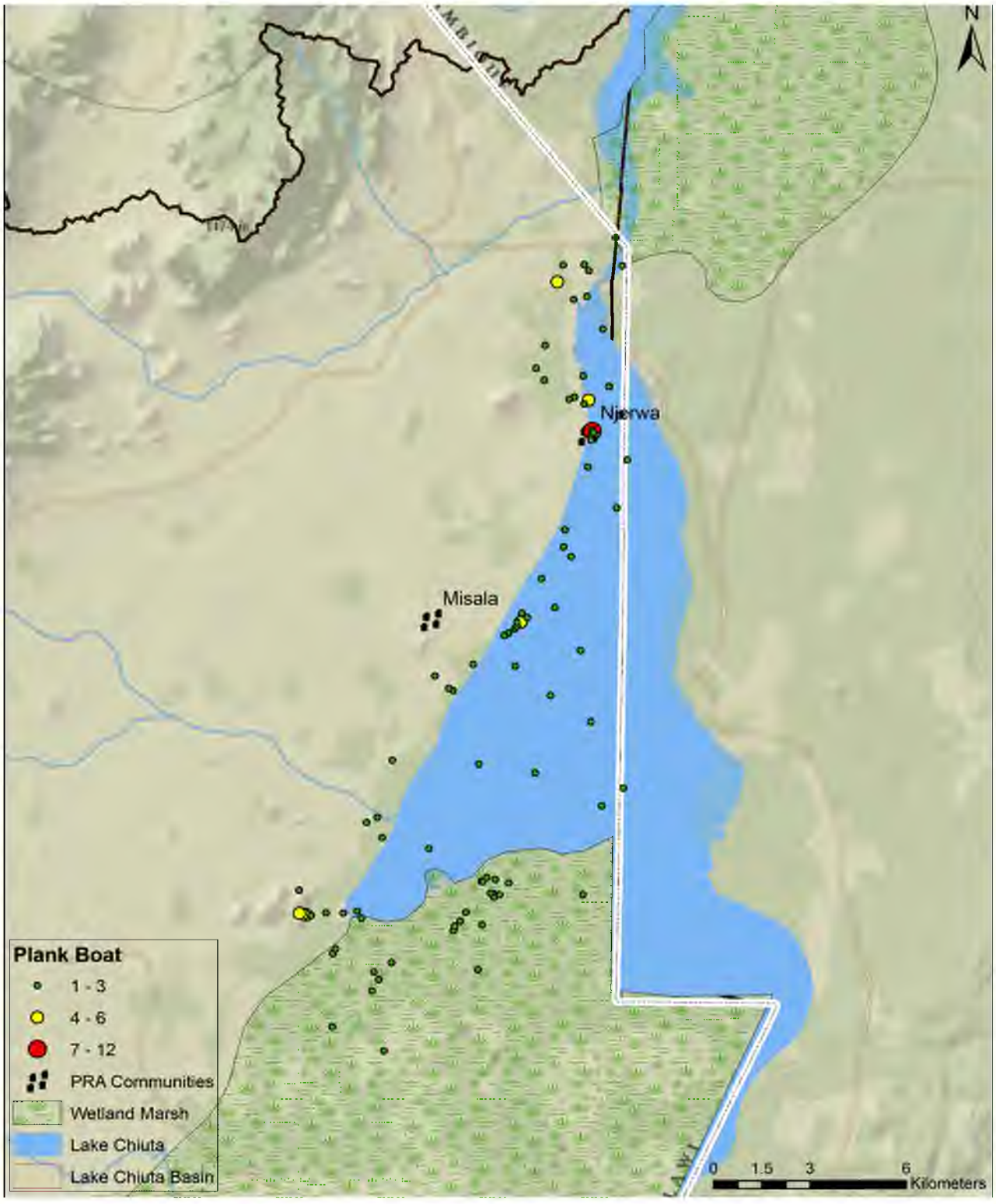
Canoe Density on Lake Chiuta



Plank Boats

Plank boats require more resources to acquire than their smaller canoe counterparts, but they provide greater stability and allow for larger crews of fishermen. This makes the setting and harvesting of gill nets on the main lake much easier, and often plank boats will operate in pairs to more efficiently manage the fishing gears. According to the recent aerial survey, there are approximately 144 plank boats on Lake Chiuta, none of which have outboard engines.

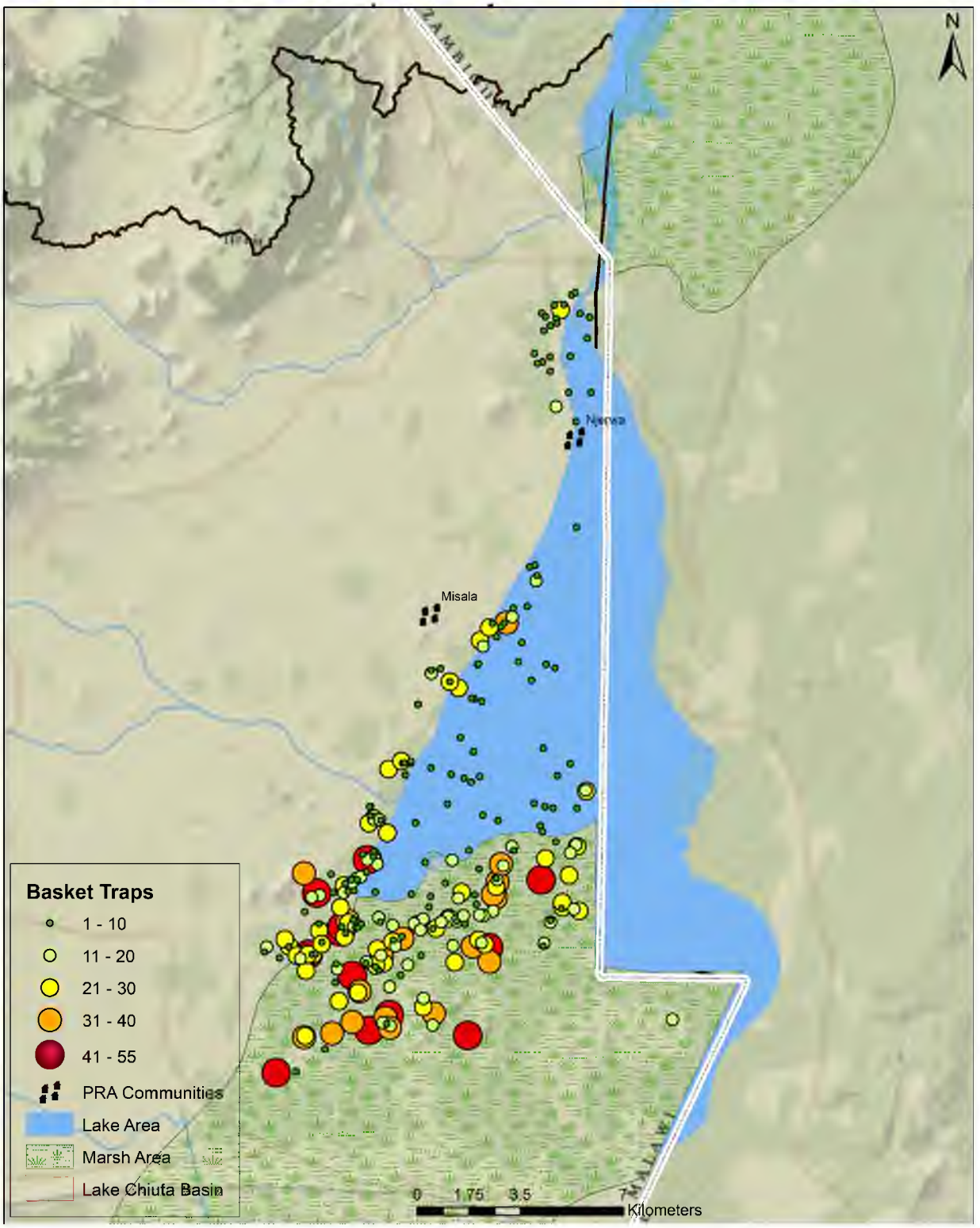
Plank Boats on Lake Chiuta



Basket Traps

Passive gears such as basket traps are extremely prevalent in Lake Chiuta and its surrounding wetland areas. As documented in the map depiction of the recent aerial survey, the highest concentrations of basket traps are seen in the southwest section of the lake and in the southern wetland areas. Many of these areas are lined with fish fencing and traps prior to the wet season in anticipation of rising water levels. High concentrations of traps are correlated with higher fishing pressure in specific habitat areas, thus significantly impacting certain vegetation-dwelling species.

Basket Trap Density on Lake Chiuta



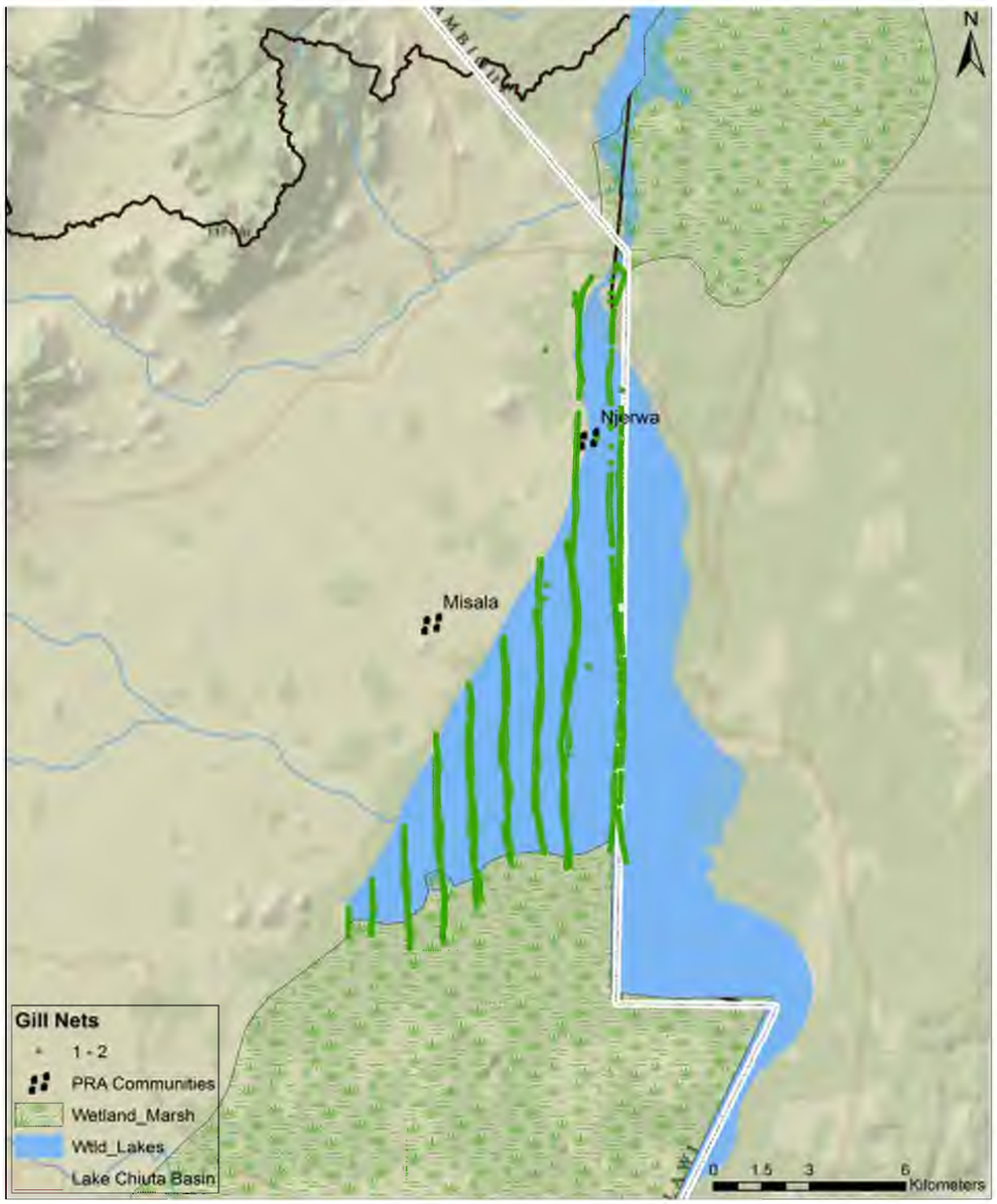
Gill Nets

Gill netting consists of long strips of netting deployed in the lake as a passive gear. The nets remain in the water for days at a time capturing the fish swimming through it, provided the fish are large enough to get caught in the mesh. Passive gears, such as gill nets and basket traps, are the most frequently used gear types in Lake Chiuta since the use of the actively deployed seine nets is illegal. As seen in the aerial survey map, gill netting is commonly deployed throughout the entire lake. It is the responsibility of the gear owners and fisheries managers to ensure proper net sizes are used to prevent overharvesting and bycatch of juvenile fish.

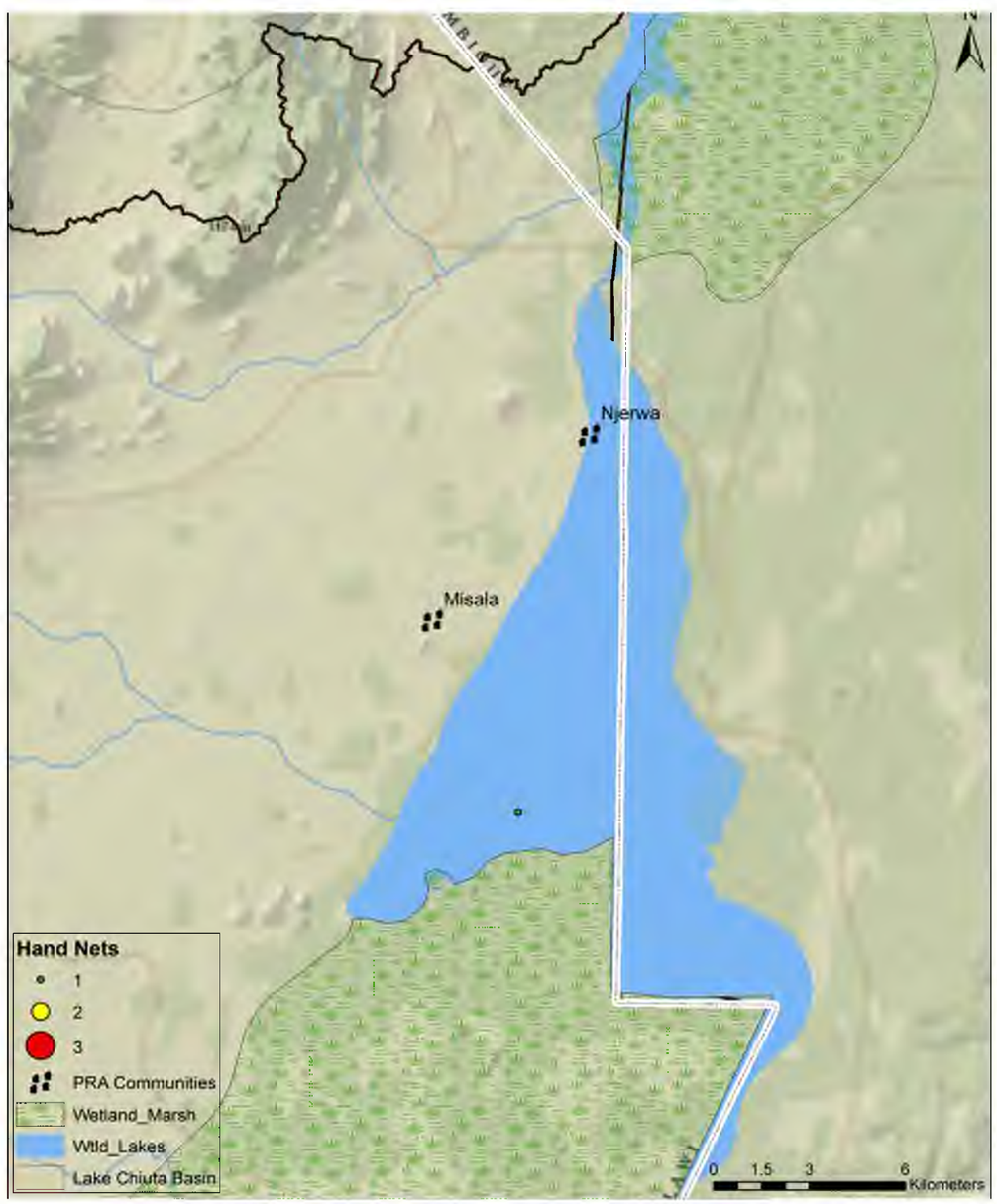
Hand Lines

Hand lines and hand nets are easily afforded fishing methods for fishers on Lake Chiuta. However, the effort tends to outweigh the yield so their popularity has fallen over the years. During the aerial survey only one hand net was spotted in the entire lake. This could be a random occurrence or indicative of the gear's decline.

Gill Nets in Lake Chiuta



Hand Lines on Lake Chiuta



Seine Nets

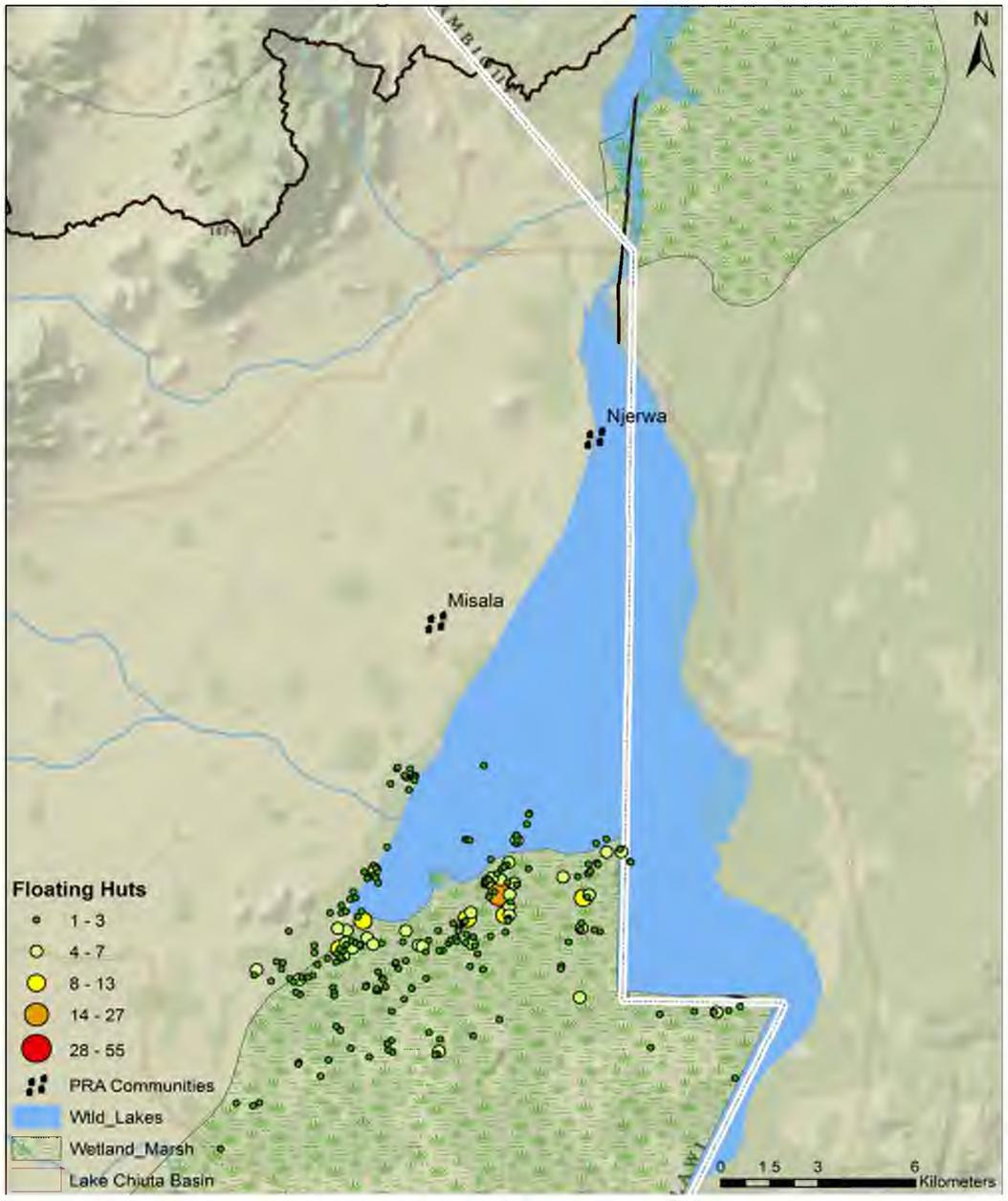
All active gears have been banned from use in Lake Chiuta for years. During the aerial survey, one illegal seine net was observed. It remains unclear whether or not more illegal gears are owned and used on the lake or if this was a stochastic occurrence.

Floating Huts

Floating huts are temporary fishing hubs utilized by fishers to allow for better monitoring of passive gears such as fish fences and basket traps. They are constructed on platforms of thick emergent vegetation which form small rafts, upon which huts are built to accommodate a single fisher. These huts are often constructed nearby one another to form small fishing communes. Floating huts are usually seen within the thick emergent aquatic vegetation (EAV) of the southern wetland area, but they have also been observed on the main lake. Floating huts are typically accompanied by drying racks as well so that fishers can process their catch without leaving the marsh area.

Seine Nets on Lake Chiuta

Floating Huts on Lake Chiuta



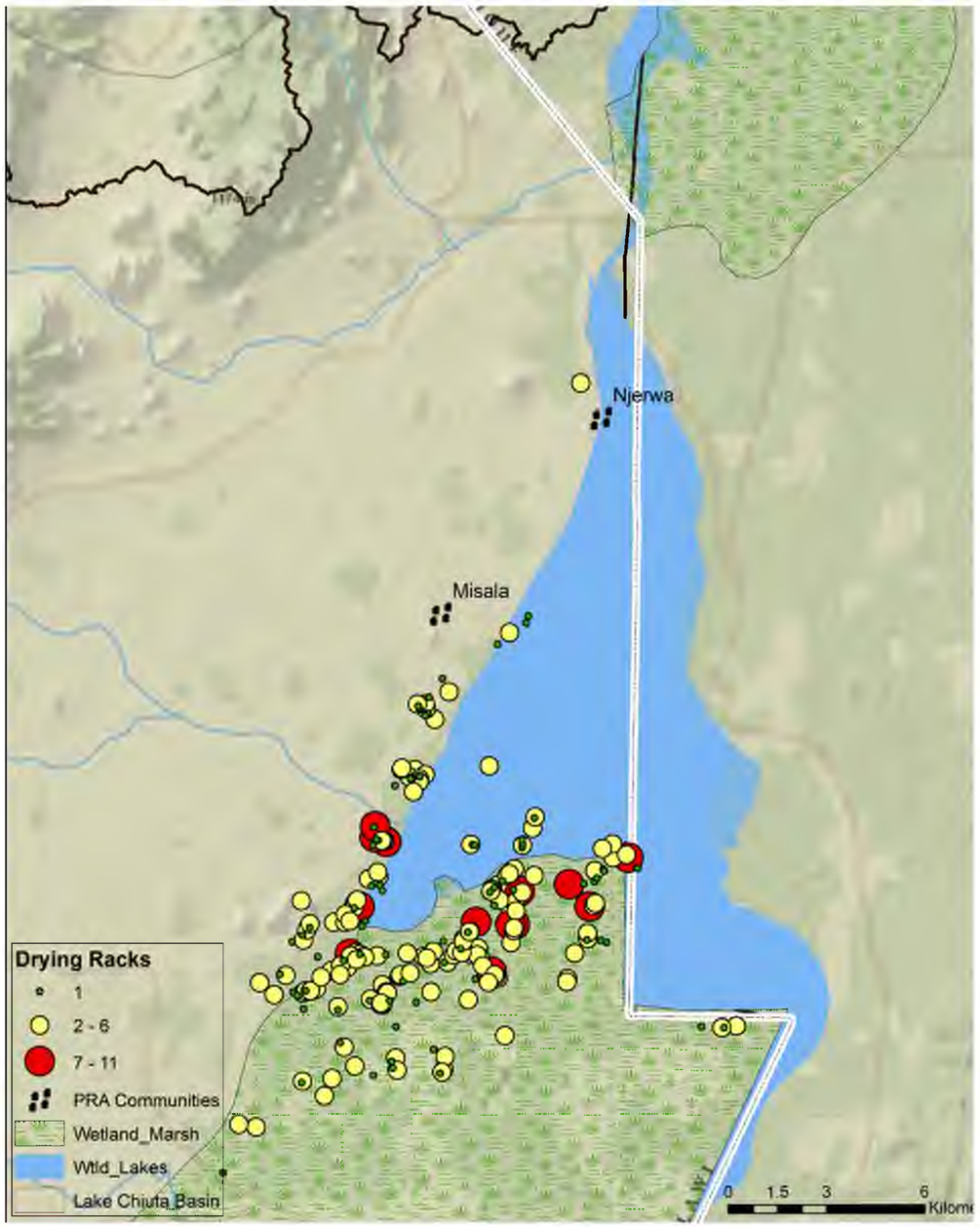
Drying Racks

Drying racks typically consist of long strips of mesh netting elevated off of the ground or water where fish can be dried for processing. While there are some drying rack areas used for public processing operations, many are privately owned and utilized specifically by individual families. The southern marsh area exhibits the highest abundance of drying racks, likely due to their widespread usage by floating hut fishers.

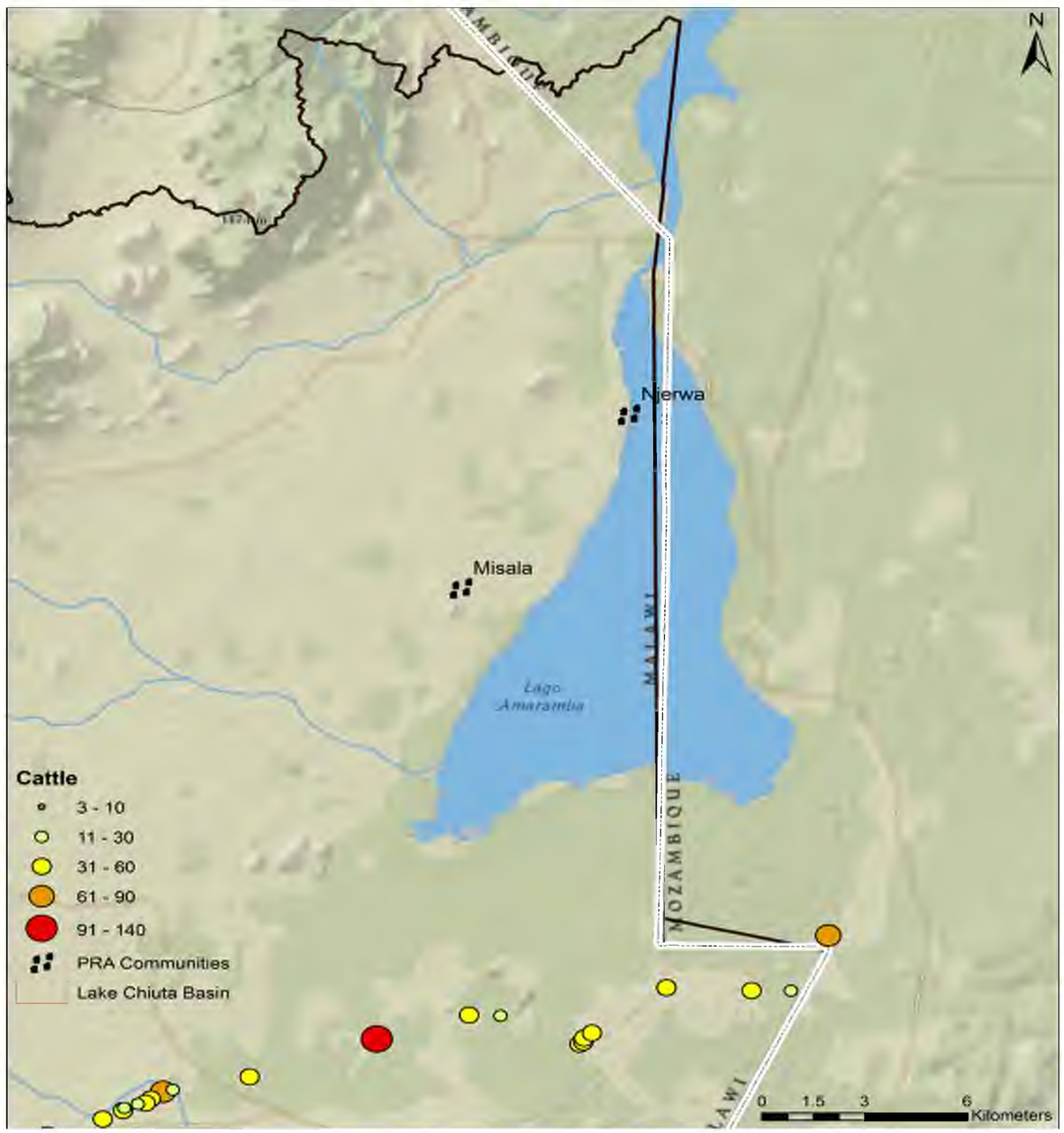
Cattle

Lake Chiuta exhibits sporadic flooding and drying periods, which necessitates community members turning to alternative livelihoods throughout the year for sustenance and income generation. Agriculture surrounding the lake is common, and there is a significant presence of cattle farmers along the southern edge of the lake's wetland areas. Cattle indicate a more stable and financially independent alternative livelihood as compared to others. While they are more expensive to acquire they have the potential for a much greater yield than comparable agricultural endeavors.

Drying Racks Near Lake Chiuta



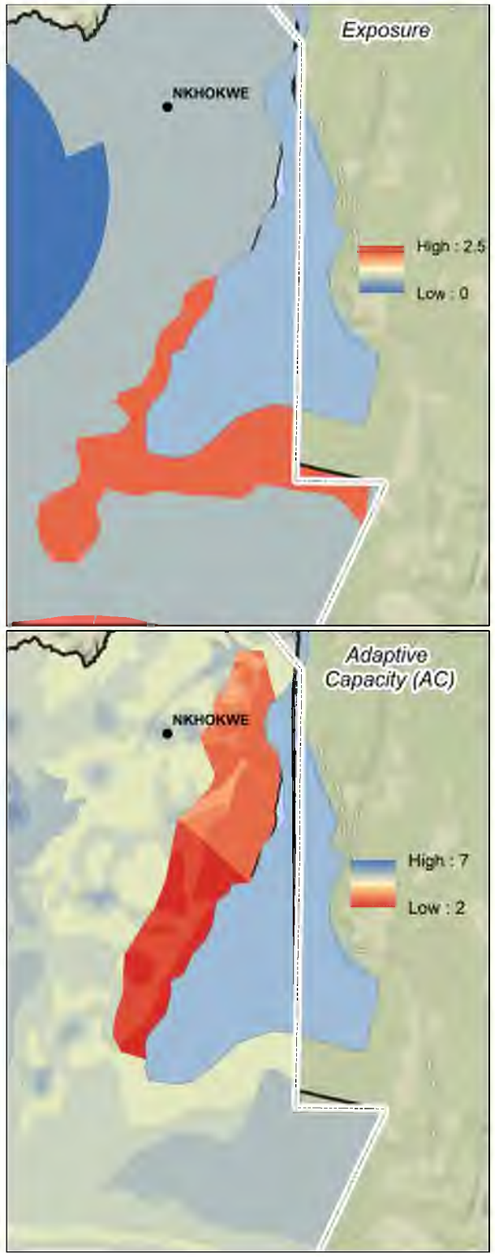
Cattle Near Lake Chiuta

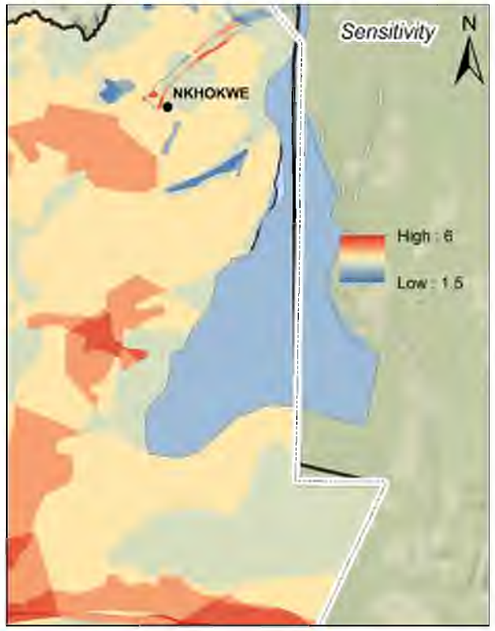


Climate Change Vulnerability Assessment

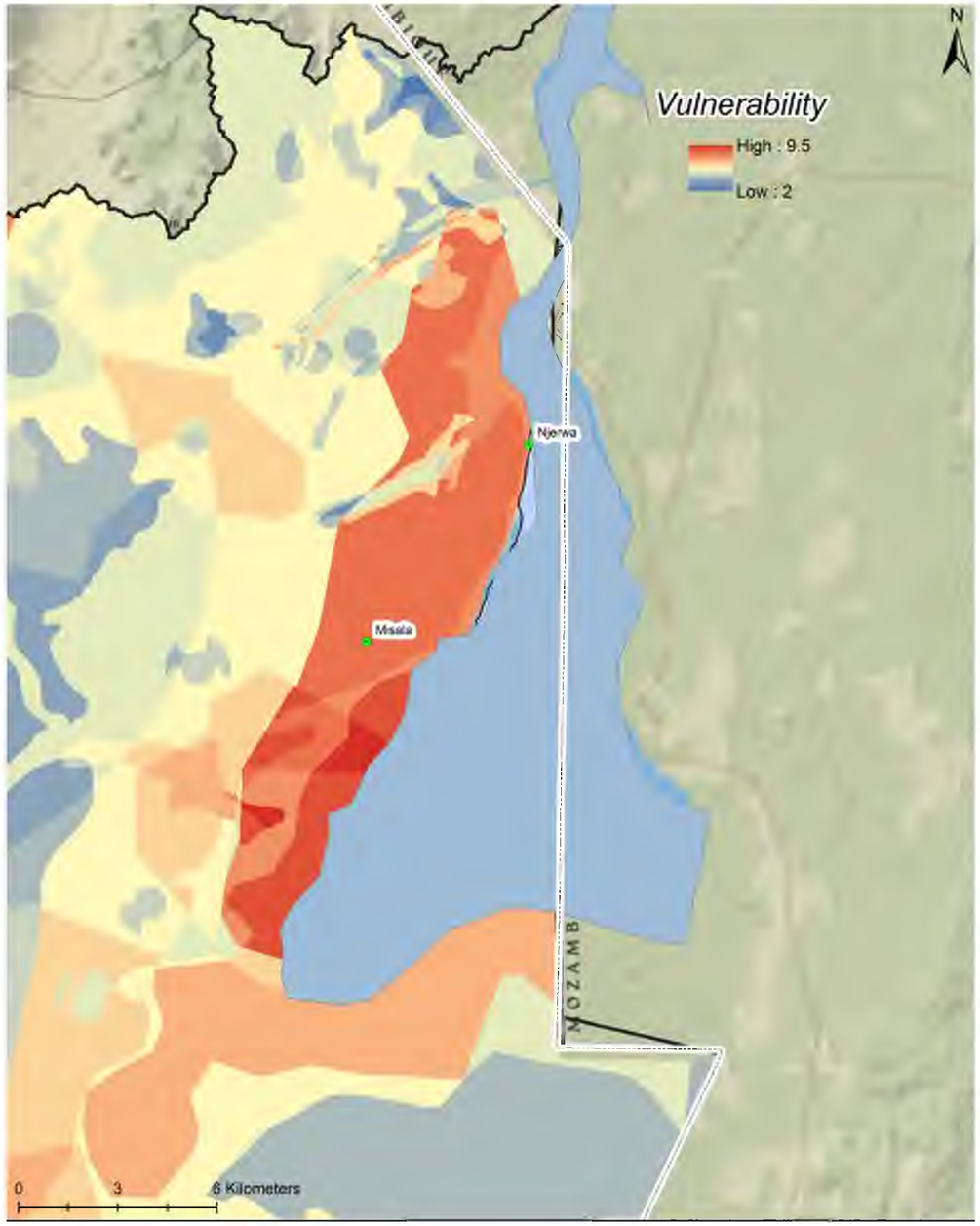
The FISH project, working with researchers from Chancellor College, piloted a rapid climate change vulnerability mapping exercise in 2015. The Intergovernmental Panel on Climate Change (IPCC) conceptual framework was adopted for the analysis. It separates vulnerability into exposure, sensitivity, and 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 Chiuta exhibits high vulnerability around the western side of the lake, especially the area south of Misala. 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





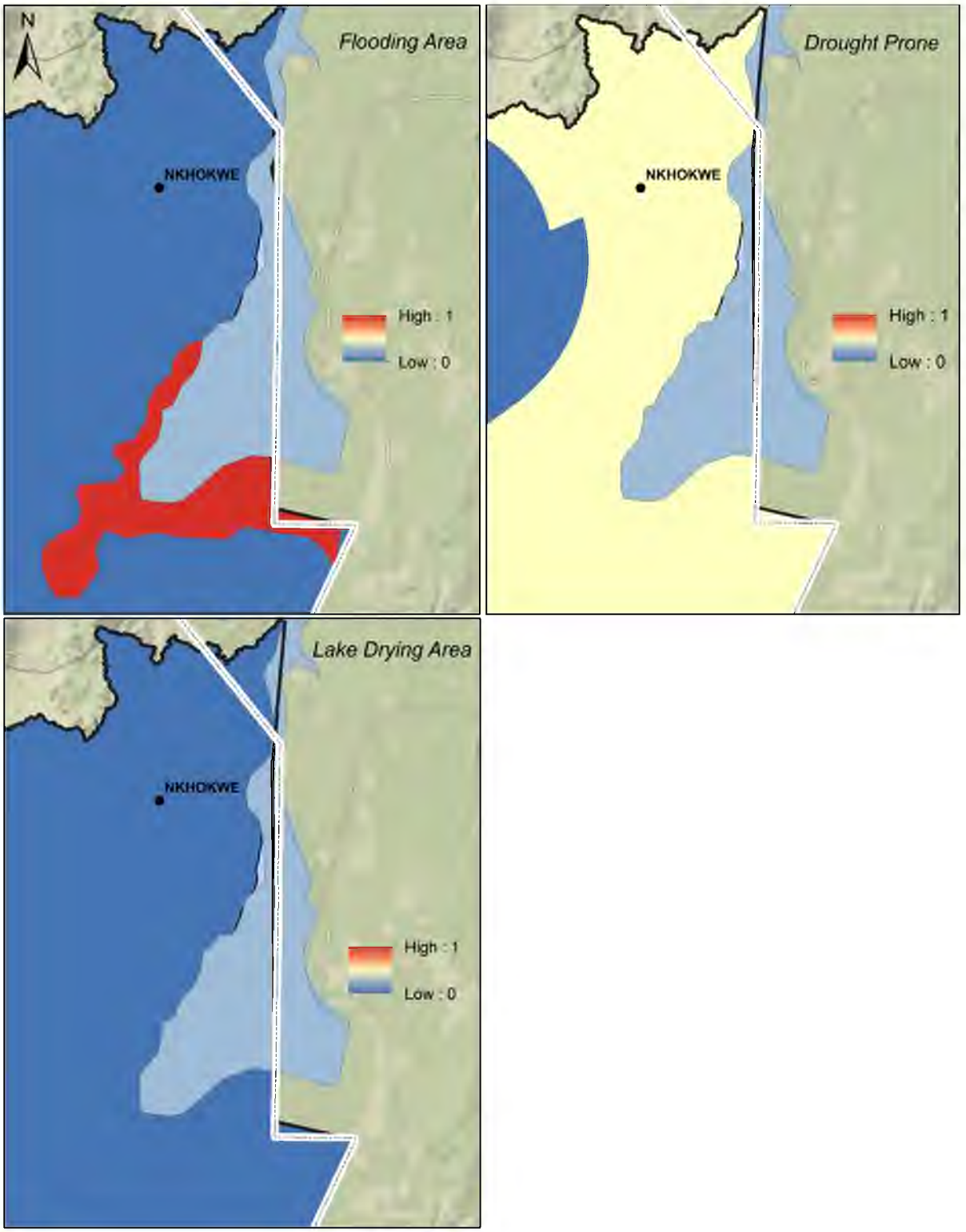
Overall vulnerability for Lake Chiuta



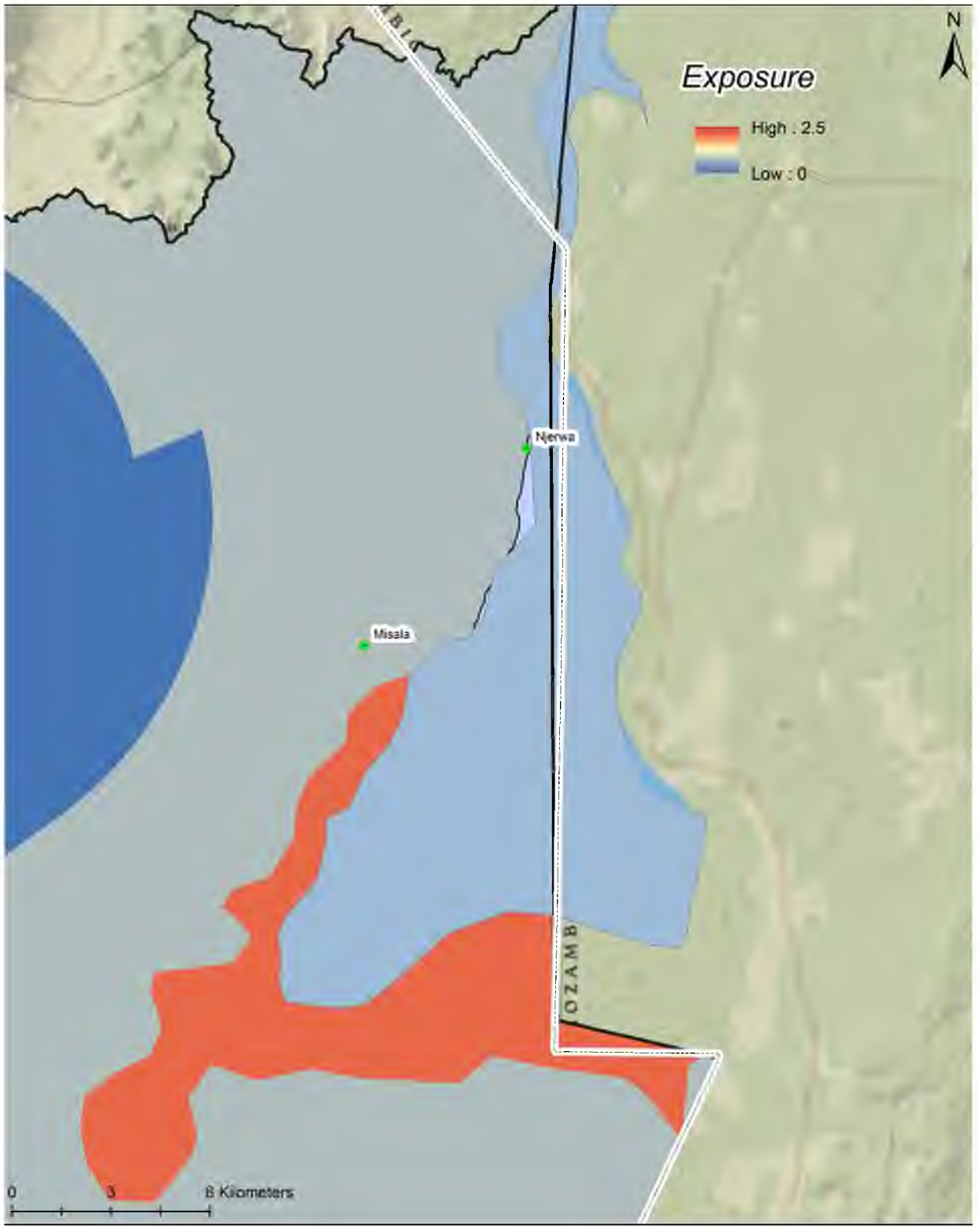
Exposure

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 only indicator exhibiting variation along the shoreline was flooding area with the southwestern shoreline of Lake Chiuta more prone to flooding.

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



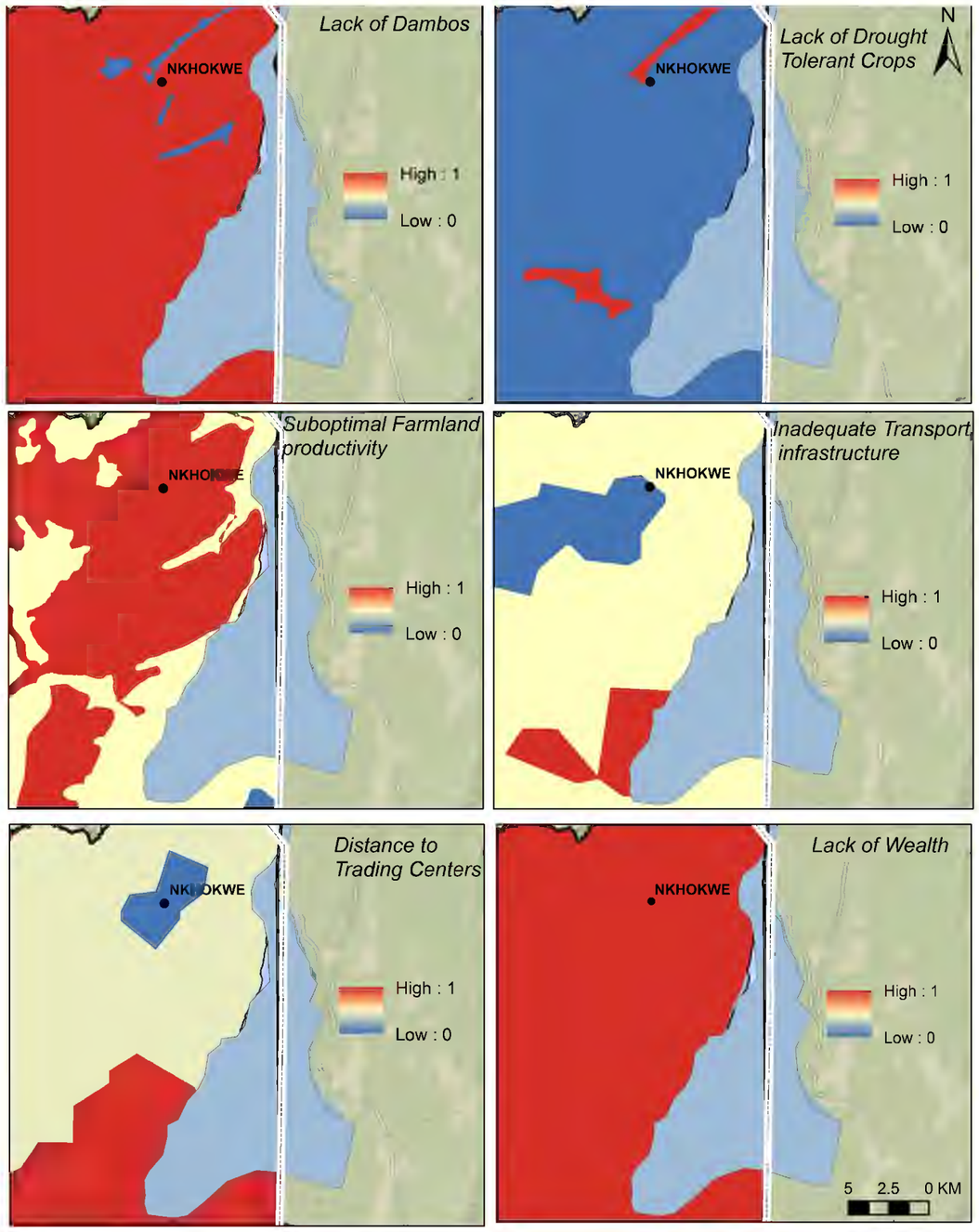
Combined Exposure for Lake Chiuta



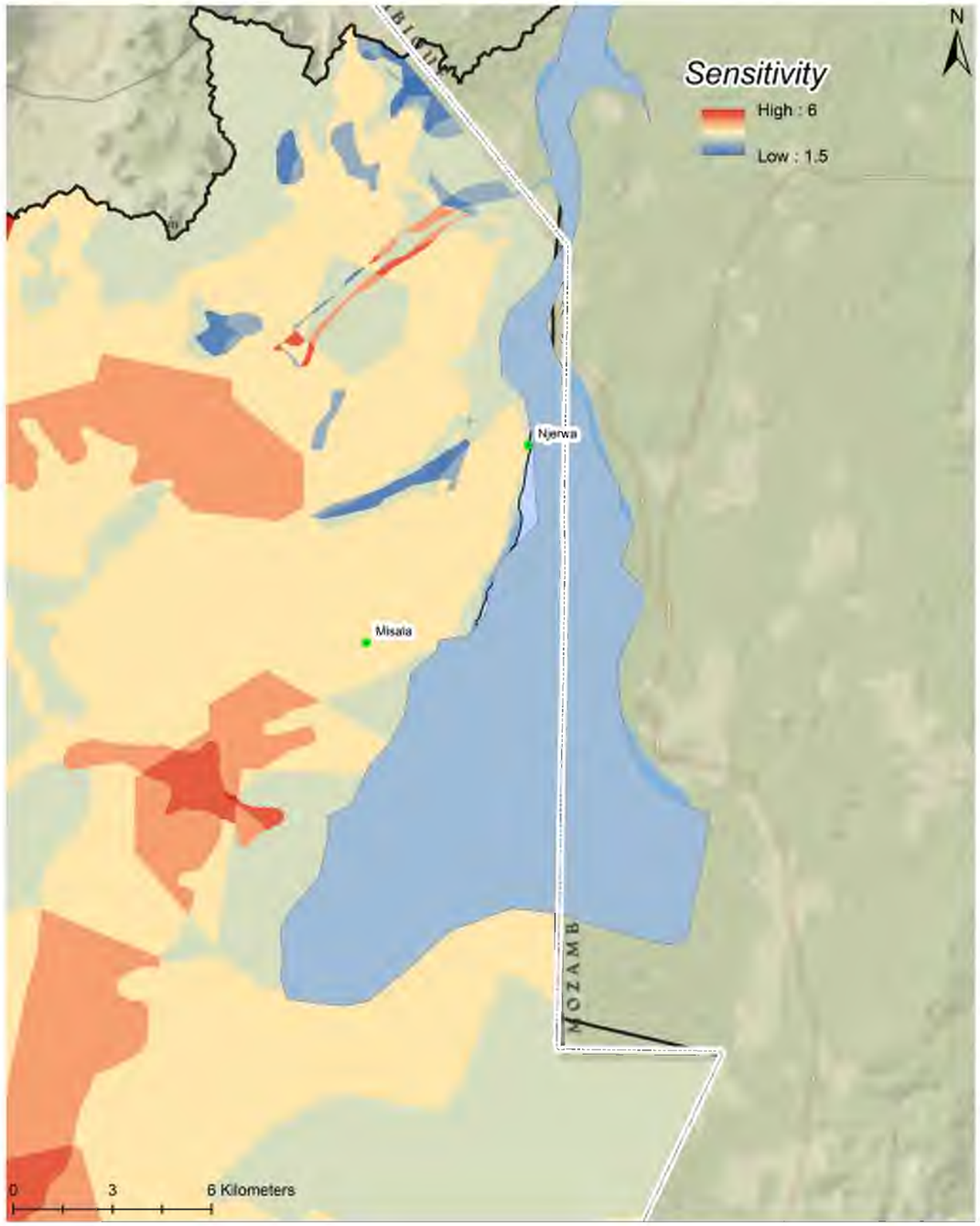
Sensitivity

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 most sensitive areas are located inland of the northwestern and southwestern corners of the lake.

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



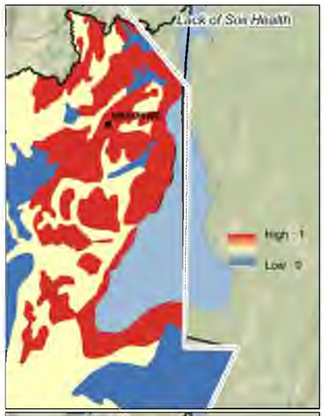
Combined Sensitivity for Lake Chiuta

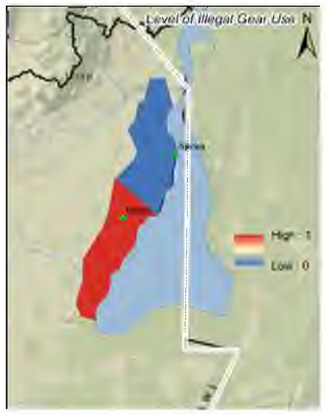


Lack of Adaptive Capacity

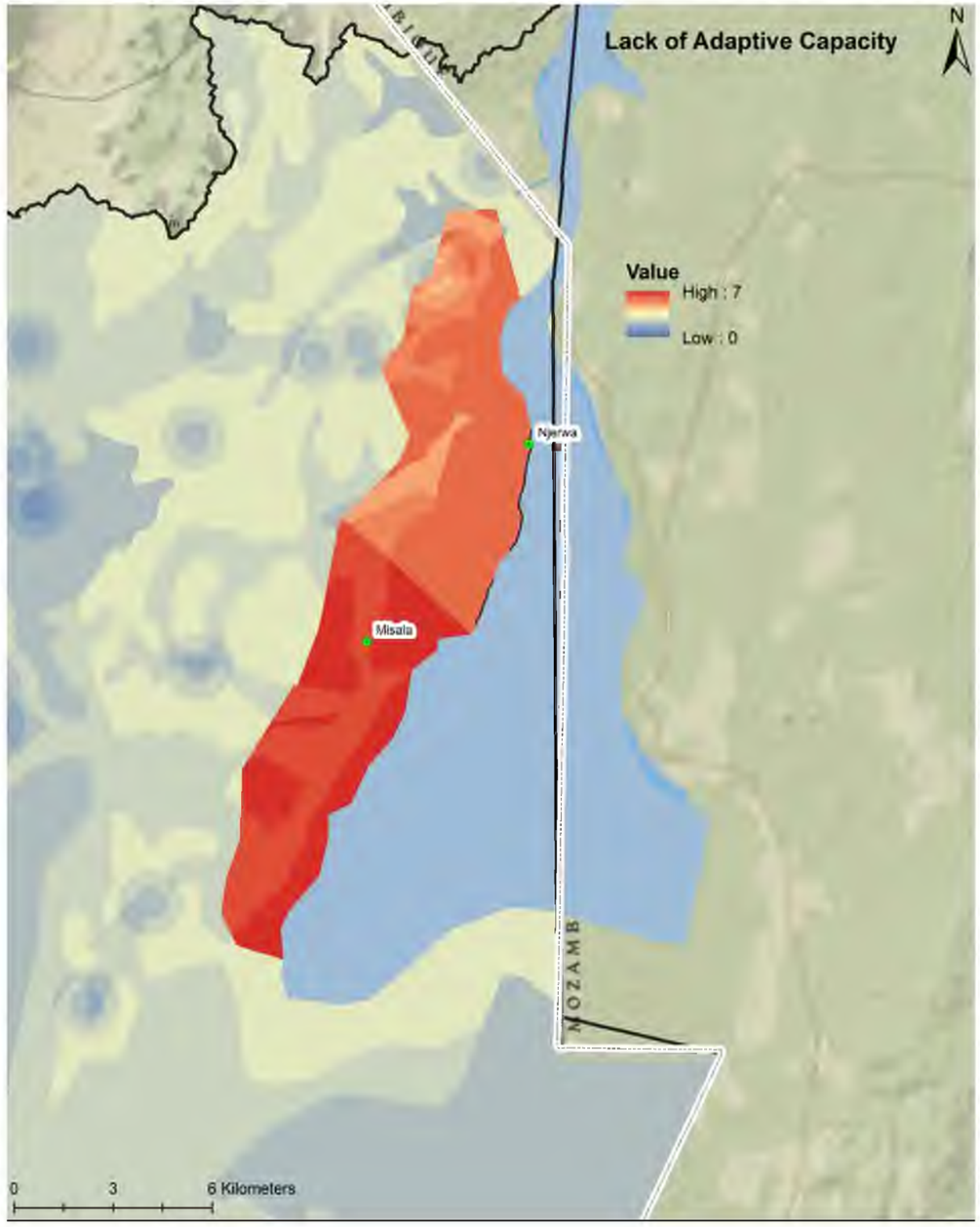
Adaptive capacity represents a community's ability to overcome potential threats or stressors. Indicators selected for scoring adaptive capacity included soil health, distance to boreholes, Beach Village Committee's ability to deliver services, mother education level, remittance levels, level of illegal gear use, and level of savings. High scores on the individual indicator maps below denote lower levels of adaptive capacity as measured by the aforementioned criteria. The scores were added to calculate an overall lack of adaptive capacity score, which is depicted on the summary map to the right. While the entire western shoreline of Lake Chiuta exhibits a high lack of adaptive capacity, the southwestern section has the highest levels driven by poorer soil health and greater incidences of the usage of illegal fishing gear in comparison to the northwestern section.

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





Combined Lack of Adaptive Capacity for Lake Chiuta



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