Environmental Threats and Opportunity Assessment (ETOA) of Four Major Lakes in Malawi

Fisheries Integration of Society and Habitats (FISH)

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Cover Page photograph: Left: participatory mapping exercise conducted during the ETOA fieldwork. Right: A boat sits on the edge of Lake Malawi. **Credit**: CRC/Glenn Ricci.

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ACRONYMS

ADC	Area Development Committee
AEDO	Agricultural Extension Development Officers
ASPIRE	Girls' Empowerment through Education and Health Activity
AV	Aquatic Vegetation
BVCs	Beach Village Committees
CADECOM	Catholic Development Commission in Malawi
CBDA	Community-Based Distribution Agents
CBOs	Community Based Organizations
CISER	Community Initiative for Self-Reliance
CPUE	Catch Per Unit Effort
CSA	Climate Smart Agriculture
DFO	District Fisheries Officer
DoF	Department of Fisheries
EAD	Environmental Affairs Department
EAV	Emergent Aquatic Vegetation
EI	Emmanuel International
ETOA	Environmental Threats and Opportunity Assessment
FAO	Food and Agriculture Organization
FG	Focus group
FGD	Focus Group Discussions
FINCA	Foundation for International Community Assistance
FISH	Fisheries Integration Societies and Habitat
FP/SRH	Family Planning and Sexual and Reproductive Health Program
FRU/s	Fisheries Research Unit/s
DPs	Gross Domestic Product
GIS	Geographic Information System
GoM	Government of Malawi
GPS	Global Positioning System
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome
IAA	Integrated Aquaculture Activities
IFAD	International Funds for Agricultural Development
IGAs	Income Generating Activities
IHS	Integrated Household Survey

IUCN	International Union for Conservation of Nature
LCBCCAP	Lake Chilwa Basin Climate Change Program
LEK	Local Ecological Knowledge
MOAIWD	Ministry of Agriculture, Irrigation, and Water Development
MOU	Memorandum of Understanding
MSY	Maximum Sustainable Yield
MT/yr	Metric tonnes per year
NGOs	Non-governmental Organizations
NRBE	Natural resource based enterprises
NRM	Natural Resource Management
PERFORM	Protecting Ecosystems and Restoring Forests in Malawi
PFM	Participatory Fisheries Management
PRA	Participatory Rapid Assessment
RMC	River Management Committees
RSCA	Rotating Savings and Credit Associations
SAV	Submerged Aquatic Vegetation
SEA	Southeast Arm [of Lake Malawi]
SWOT	Strengths, Weakness, Opportunities and Threats
TAs	Traditional Authorities
UNDP	United Nations Development Program
UNESCO	The United Nations Educational, Scientific and Cultural Organization
US$	The United States Dollar
USAID	United States Agency of International Development
VDC	Village Development Committee
VNRMC	Village Natural Resource Management Committee
VSLA	Village Saving and Loans Association
VSLAs	Village Saving and Loans Associations
VSLs	Village Saving and Loans
WESM	Wildlife and Environmental Society of Malawi

EXECUTIVE SUMMARY

The biodiversity and sustainability of Malawi's four major lakes and their freshwater ecosystems are vital to the well-being and resilience of this densely populated, land-locked nation. These large African Rift Valley lakes support hundreds of fish species that provide food and livelihoods to the freshwater district's 2.3 million people, many of whom are deeply impoverished.

The objective of this Environmental Threats and Opportunity Assessment (ETOA) is to expand on the 2012 United States Agency for International Development (USAID) ETOA. It examines the freshwater fisheries of the Southeast Arm (SEA) of Lake Malawi and lakes Malombe, Chiuta, and Chilwa through the lenses of climate change, biodiversity, environmental and manmade threats, and fisheries management. Some of the threats, stressors, drivers, and contributing factors facing these ecosystems and communities include overfishing/illegal fishing, deforestation, climate variability, and population growth. This ETOA enhances existing scholarship by placing significant value on local knowledge gathered first-hand and identifying areas of high biodiversity and climate change vulnerability. This ETOA also emphasizes lessons learned and identifies potential opportunities for successful intervention.

The ETOA team conducted an extensive literature review and evaluated fishery Frame Surveys, using this comprehensive body of work to inform two-stage participatory rapid assessments (PRA) and Strengths, Weakness, Opportunities and Threats (SWOT) assessments. Local knowledge gathered from villagers and fishers through multiple on-site visits validates much of the literature and adds insight. A workshop with local experts strengthened the robust nature of this assessment. Local community knowledge, existing literature, and input from local experts—combined with habitat, fishery and land-feature maps and GIS layers—provide an extensive and current picture of the areas studied.

The team has determined that the sustainability of the fisheries and ecosystems depends on urgent action to address economic, social, health, and environmental/climate factors. Possible measures include moving the fishery from open to managed access, from input controls to catch controls, from top-down control to co-management, and from static to adaptive management. In addition, resources must be managed across the value chain, with women included in decision-making and livelihood development, and stakeholders engaged throughout the process.

Already, the field visits, PRA exercises, and work with partners have resulted in the design of follow-up studies to assess the feasibility of scaling up good practices in some places. These include using solar fish dryers, modern packaging, and marketing techniques to increase the value of fish products and examining the ability of brush parks to enhance fisheries production and deter illegal fishing. Lasting success, however, ultimately depends on the capacity and will of the government and local stakeholders.

1 INTRODUCTION

1.1 Purpose of the Fish Biodiversity Environmental Threats and Opportunities Assessment

This ETOA focuses on the Southeast Arm (SEA) of Lake Malawi, Lake Malombe, Lake Chilwa and Lake Chiuta. It builds upon and complements the fishery chapter of the USAID ETOA produced in 2012 and serves to ensure alignment with USAID's Biodiversity Code. It examines the fisheries in much greater depth than the 2012 ETOA from the lens of multiple disciplines, including climate change. It also expands upon the previous efforts to identify the location of key areas of high fish biodiversity and highlights some of the greatest environmental and anthropogenic threats and climate change stressors to those areas and their fish stocks. Additionally, this ETOA provides a review of past and current activities and fisheries management measures adopted within the four lakes with a particular focus on lessons learned (i.e., which measures have been effective or ineffective and why) for the purpose of recommending mitigation actions for future fisheries co-management strategies.

1.2 Methodology and Data Collection

The ETOA is based on an extensive literature review of peer-reviewed materials as well as gray literature, project documents, and evaluations that draw heavily on the fishery Frame Surveys. A complementary two-stage PRA engaged local stakeholders and fishers in mapping biodiversity and climate change stressors and high biodiversity areas threatened by human actions. A participatory Strengths, Weakness, Opportunities and Threats (SWOT) assessment of the four lakes also was conducted to augment and verify the reviewed literature. The PRAs were conducted with members of the Beach Village Committee (BVC) and fishers in 18 villages in May and June 2015 (Figure 1.1). The field team visited communities and BVC members on multiple occasions. The number of participants was large enough to break into two groups per BVC for a total of 36 focus group discussion results. Thus, a substantial database of local ecological and societal knowledge emerged from the fieldwork with many opportunities for validation and triangulation.

The University of Rhode Island's Coastal Resources Center supervised the PRA community profiles, and a trained local assessment team composed of FISH project staff and district fisheries officers from the Department of Fisheries conducted them. The status, trends, threats, stressors and drivers in each of the lake systems were evaluated separately using a uniform methodology that included:

- A comprehensive review of both formally published and gray literature
- Collection of all available layers of spatially coded data
- Collection and follow-up validation of extensive local ecological knowledge in 18 communities through focus group discussion with BVC members on a) spatial features of each lake in terms of key habitat and fisheries, b)biodiversity threats, c) climate stressors, d) drivers, e) contributing factors, f) impacts, and e) responses
- A two-day workshop with approximately 30 lake system experts who provided key informant validation and inputs to the findings from the fieldwork.

The goals of the PRA exercise were twofold: 1) to gather local ecological knowledge related to threats and opportunities, which help verify, triangulate, and fill in gaps in the peer-reviewed scientific literature, project reports, and other materials; and 2) identify areas of high fish biodiversity and climate change vulnerability. Appendices A through E provide a more detailed description of the PRA activities and the type of information gathered from the fishers and Beach Village Committees (BVC).

The maps, trend-lines, SWOT, and other information synthesized in the ETOA can pinpoint specific fisheries management and climate change adaptation actions and the most appropriate geographic locations for fisheries management activities, taking into account the likelihood of project activities to reduce or reverse the priority risks. The ETOA can also help to identify micro-catchment areas where pilot and demonstration projects could occur in collaboration with BVCs, village natural resources management committees (VNRMC), and village savings and loans associations (VSLA), farmer groups, fish value chains, etc., as well as scope for integration with other projects being carried out in the upper catchment area.

The PRA-designed habitat, fishery, and land feature maps and GIS layers produced in the ETOA exercise are unprecedented and provide an important baseline on local perceptions of environmental condition, trends, and threats. The community profiles and spatial data represent a valuable resource complementary to science-based data, or in lieu of missing baseline data, for planning and setting priorities for ecosystem management. The participatory process, dialogue among the 2015 Fish ETOA team and communities, and the validation exercise also provide the important benefit of capacity and awareness building across lakes and across issues.

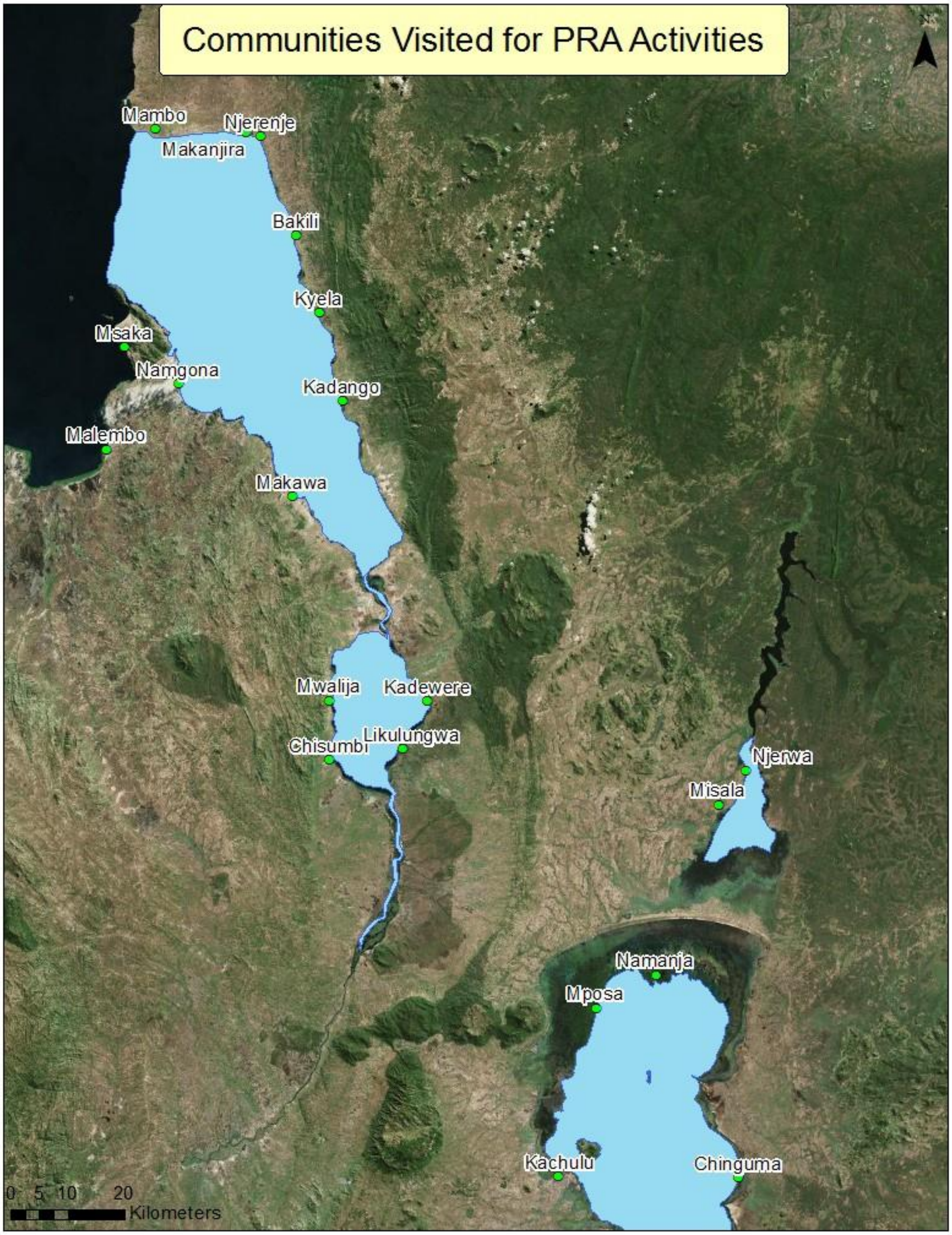

Figure 1.1: Locations of the 18 communities visited during the two-stage PRA activities implemented as part of the development of this ETOA

1.3 Overview of the Four Lakes

Although landlocked from the ocean, Malawi has multiple important waterbodies including Lake Malawi, which is the third largest African Rift Valley Lake, and Lakes Malombe, Chilwa, and Chiuta, which are smaller but very productive lakes. Lake Malawi is the most southern of the Rift Valley lakes. It hosts over 1,000 species of fish, most of which are endemic to the lake. Lake Malawi has a total surface area of approximately 22,490 km,^{2} total length of 568 km, width ranging between 16 and 80 km and mean depth of 264 meters (Donda 2011). The lake's southeastern arm is shallower, which makes it more productive than the deeper main portion of the lake. This shallow nature provides rich habitats for various stages of fish life cycles, making it the major fishing area of Lake Malawi. This area in particular supports a multi-species fishery with commercial and artisanal fishers using equipment ranging from pair trawlers and ring nets to fish traps and handlines operated from dugout canoes.

Lake Malombe connects to the SEA of Lake Malawi through the Upper Shire River, which is the only outlet of Lake Malawi. Lake Malombe has approximately 390 km^2 of surface area with an average depth of 4 meters. The lake is highly productive because the water column mixes freely recycling nutrients from the bottom (Donda 2011). It once produced about 17% (15,500 tons) of Malawi's total fish catch, but as shown in Figure 3.3, catches decreased dramatically following the depletion of the local tilapia species *Oreochromis lidole* known as chambo (Hara 2015).

Lake Chiuta is the smallest of Malawi's four lakes. Located along the eastern border of Malawi, this lake has a total surface area of about 200 km^2 of which about 25% lies in Mozambique, and a mean depth of 5 meters. A number of rivers flows into Lake Chiuta, and during the wet season, the lake sometimes connects to Lake Amaramba in Mozambique by a swampy channel (Njaya 2005). Emergent vegetation covers the southern part of the lake. Lake Chiuta, which is more remote than the other lakes, supports a smaller sector of local fishers that use dugout or planked canoes.

At 624 meters above sea level, Lake Chilwa is located in the center of the Chilwa-Phalombe plain in southern Malawi. It is the second largest lake in Malawi, but it is very shallow with a maximum depth of about 6 m at peak water levels (Donda 2011). Lake Chilwa has a reed belt that is 15 km wide in the north and 1-2 km wide on the northeastern side. The basin is an important wetland, which was designated as a Ramsar site in 1997. The lake goes through cyclic recessions that often last three to four years. Since 1897, the lake has dried up completely multiple times. When this happens, the fishery collapses. However, historically the fishery has been able to bounce back within three to four years (Donda 2011).

1.4 Climate and Hydrology

The topography of Lake Malawi and the Rift Valley greatly influences the three three climate categories of Malawi (USAID 2014): (1) semi-arid, (2) semi-arid to sub-humid and (3) sub-humid. The lakeshore plain areas belong to the semi-arid category (USAID 2014). Climate change and its impacts are expected to vary depending on the climate category. The climate of the Lakes region is highly influenced by the seasonal migration and strength of the Intertropical Convergence Zone (ITCZ) and the Congo Air Boundary (Dulanya et al. 2013). The northerly (*Mpoto*) winds blow during the warm and rainy months of November to April while the southeasterly (*Mwera*) winds blow over the lakes during the cool and dry months of May to October. The local topography also influences the amount of rainfall with lower amounts of precipitation and lower lake levels occurring during El Niño years, while the opposite pattern occurring during La Niña years.

The mean annual rainfall in the catchment areas surrounding the SEA of Lake Malawi is 887 mm. Given the very large water volume of Lake Malawi, rainfall contributes trivially to the total water balance of the lake and has little influence on cycles of stratification, mixing, or the redistribution of nutrients (FAO 1993). The lake levels typically fluctuate between 600 and 2500 mm (Jury & Gwazantini 2002), and about 12% flows out the Shire River. However, between 1915 and 1935 the level fell below the Shire River outlet and stopped flowing almost to the outlet in 1997 (van Zwieten et al. 2011).

The mean annual rainfall in the Lake Malombe catchment is 902 mm. In this lake, the runoff contributes significantly to the productivity of the lake (FAO 1993) as does the nutrient-rich outflows from Lake Malawi. During the early part of the 20th century, the majority of the lakebed area was used for agricultural production due to the exceptionally low water levels within Lake Malawi that resulted in the cessation of outflow to the Upper Shire River. The surface area has remained relatively constant, fluctuating around 390 km^2 since 1973.

The mean annual rainfall in the Lake Chilwa catchment area ranges between 1,100-2,000 mm in the highlands and between 800 to 900 mm in the lowlands (Kalindekafe 2014). Seven perennial rivers (i.e., the Domasi, Likangala, Namadzi, Naisi, Phalombe, Thondwe and Sombani) all flow into Lake Chilwa, and the lake levels fluctuate considerably based on the quantities of precipitation that fall within the upstream catchment each year. Since the beginning of the 20th century, the lake dried up completely in 1903, 1913-1916, 1922, 1934, 1943-1944, 1967, 1973, 1975, 1995-1996 and 2012 (Kafumbata et al. 2014).

The mean annual rainfall in the Lake Chiuta catchment area ranges from 600 mm in the lowlands to roughly 1600 mm in the highlands, and the inflow of water from the Mpili River comprises the greatest contribution to the water budget. When the water levels are high within Lake Chiuta, water from the lake flows northeast into Lake Amaramba in Mozambique. During times of lower lake levels, it is endorheic, and the lake almost completely dried up in 1973 and 1975 (Dulanya et al. 2013).

Heavy rain has the potential to produce increased sedimentation in rivers and inlets due to high rates of catchment runoff and soil erosion resulting from poor catchment management from either deforestation or poor agricultural practices that affect the fisheries and fish migration patterns (USAID 2014). Sediment loading affects both biotic assemblages and their ecological functions, which are important to sustain biological diversity (Donohue & Garcia-Molinos 2009). Although turbid environments can increase nutrient levels in the water and decrease the predation of planktivorous fish in the lakes (De Robertis et al. 2003), an increase in turbidity has also been shown to interfere with some of the rock dwelling cichlid (the mbuna) reproduction and fish mate choice, influencing mechanisms of diversification (Seehausen et al. 1997). Studies in Lake Victoria found that female cichlids that originated from turbid waters had evolved to have a weaker preference for male coloration (Maan et al. 2010). On the other hand, decreased rainfall can contribute to the diversion of streams for agriculture, reducing the water level in the streams that would facilitate the migration of fish (USAID 2014).

1.5 Local Fishing Communities

The four lakes cover four districts: Mangochi, Balaka, Machinga, and Zomba, which together host a population of about 2,300,000 people. Out of these, approximately 750,000 people live in the FISH project's area of interest, which is within 10 kilometers of the lakeshores. Over 500,000 of the project's target population (68%) live in Mangochi District (Table 1.1).

Over 90% of the people living along the lakes reside in nucleated or scattered villages clustered into traditional authorities (TAs). Several tribal groups, including the Yao, Nyanja, Mang'anja, Tonga, Tumbuka, and Chewa, live in the lake areas (Hara 2014). The Muslim Yao tribe is most common in the project area, and about 70% of those living in the Mangochi District are Muslims (GOM 2006). However, in Zomba, Christians make up 78% of the population and only 20% are Muslim (Zomba District 2007).

Table 1.1: The FISH project's area target population by district and lake

District - Lake	Growth rate/year	HH Size	2008	2014	HH Numbers	Area (km^2)
Mangochi - SE Lake Malawi	1.03	4.30	148,191	174,896	40,673	124,342
Balaka - Lake Malombe / Middle Shire	1.02	4.20	66,374	76,076	18,113	37,160
Machinga - Lake Malombe / Middle Shire	1.03	4.20	29,113	34,560	8,229	39,817
Machinga - Lake Chiuta	1.03	4.20	53,885	63,968	15,231	48,171
Zomba - Lake Chilwa	1.02	4.10	58,520	65,903	16,074	34,724
Machinga - Lake Chilwa	1.03	4.20	1,181	1,402	334	7,895
Mangochi - Lake Malombe	1.03	4.30	153,724	181,427	42,192	80,474
Mangochi - SW Lake Malawi	1.03	4.30	131,167	154,804	36,001	86,548
FISH Zone of interest Total			642,155	753,037	176,847	459,131

Source: WorldPop Africa: *http://www.worldpop.org.uk/data/summary/?contselect=Africa&countselect=Malawi&typeselect=Population*

The land tenure system in Malawi includes public and private land, with public land including customary and government land. Customary land is most common and is used primarily for subsistence farming, but it also includes communal forests. Traditional leaders at group, village, or traditional authority level control and allocate customary land, which is passed down from one generation to the next through the maternal lineage of traditional leaders (Matiya and Donda 2014). The government holds public land on behalf of the people, and it includes public space, protected forests, and wildlife areas as well as waterbodies. Private land includes freehold land, primarily owned by religious institutions. Hotels and private individuals can also lease customary land through leasehold, which provides them with landownership for between 21 and 99 years (GOM 2006).

1.5.1 Economy of the Local Communities

Most of the people who live along the lakes are dependent on natural-resource based livelihoods. Agriculture and livestock production contribute significantly to the local districts' economy. Farming is by far the most important livelihood, with 85 to 90% of the households engaging in subsistence farming. However, farms are on average less than one hectare (Matiya and Donda 2014), and the earnings from subsistence farming are very low. Smallholder farmers focus on a small range of products including maize, sweet potato, cassava, groundnuts, and other legumes, fruits, and vegetables. Tobacco, cotton, tea, and coffee are the main cash crops farmed on upland estates around the four lakes. Local communities also engage in minor cash crops, including beans, pigeon peas, and soya beans (Matiya and Donda 2014).

Fishing is also a major source of income for people living along the lakes. Out of the approximately 14 million individuals who live in Malawi, around half a million (3.5%) earn their income directly from fisheries or a related livelihood. The fisheries sector provides employment through fishing, processing, and trading. Most of the fish caught (90%) is processed by smoking or roasting (40%) or by sun-drying (50%). The rest is sold fresh, chilled, or frozen (FAO 2005). Currently, there is very little capital available locally to invest in small-scale fisheries to improve the value chain and boost earnings (Matiya and Donda 2014). However, it is one of the few livelihoods in the region that has the potential to generate surplus cash and, therefore, it is seen by many as a viable economic activity. Due to increased demand and low supply, the beach price of chambo and utaka has gone up in recent years, while usipa prices stabilized in 2008, probably due to high catches (Table 1.2). Because it is relatively lucrative and generates cash, fishing and fishing-related activities provide an economic safety net for the 450,000 individuals who engage in the fisheries sector Matiya and Donda 2014).

Table 1.2: Changes in fresh fish price (US$) per kilo of selected fish species

	Price (US$/kg)										
Fish species	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**		**2012**	**2013**	**2014**
Chambo	1.0	1.2	1.1	1.6	1.7	1.8	2.3	3.1	2.2	2.7	3.3
Utaka	0.4	0.4	0.5	0.5	0.6	0.7	0.6	0.9	0.8	0.9	1.0
Usipa	0.4	0.5	0.5	0.5	0.8	0.8	0.7	0.9	0.7	0.9	0.8
Exchange Rate (MK/US$)	108	118	136	139	140	148	150	157	249	364	425

Source: Mangochi District Fisheries Office

The SEA of Lake Malawi is one of the prime tourist destinations in Malawi, with Lake Malawi National Park, sandy beaches, and numerous locations for scuba diving. Several large-scale hotels and smaller guesthouses line the shoreline from Monkey Bay to Mangochi Town. There are no hotels on the eastern side of Lake Malawi (Matiya and Donda 2014). The tourism industry provides foreign exchange earnings and creates jobs in hotels, restaurants, and related areas such as traditional dancing, handicrafts, and scuba diving. However, this is also in direct conflict with the fishing industry as the two sectors compete for the use of beaches. Hotel owners often prefer to keep fishers out, and most tourist resorts fence off access to the beaches, leaving fishers dependent on non-privatized lands for landing and processing their catches (Matiya and Donda 2014).

Lake Malawi and Liwonde National Parks, which are located in Lake Malawi and Lake Malombe respectively, are tourism attractions and provide employment for some individuals from the local communities. In Zomba, a few lodges and clubs provide bird watching tours around the Ramsar site. From a community perspective, the parks and other protected areas are important because they provide non-timber forest products and food, including honey, termites, caterpillars, and fruit. However, the parks are also a source of conflict when, for example, animals such as elephants, hippos, crocodiles, and primates disrupt people's daily livelihoods by destroying crops.

Some individuals engage in microenterprises related to manufacturing, trade, and other service sectors. Common microenterprises include baking, pottery, dress-making, beer-brewing, growing and selling vegetables, beekeeping, fish processing, fish trading, and fish transport (Matiya and Donda 2014). Firewood collection and charcoal making are also common livelihoods—putting pressure on the forest reserves that are scattered around the four lakes.

1.5.2 Ecosystem Goods and Services

The four lakes provide a myriad of ecosystem goods and services as well as livelihood benefits to the adjacent local communities. Some examples of the goods and services supplied include fishing for consumption and income generation; water for domestic use, agriculture, livestock, hydropower generation, transportation and industry; and recreation and tourism.

As discussed in the preceding section, artisanal fisheries play a critical role in both food security and income generation within the lakes region. As a food source, a high percentage of the fish harvested from the lakes is consumed within the communities, providing an important source of protein that contributes greatly to the nutritional needs of the rural poor.

Over time, the annual fish production has declined from 7.9 kilos per capita in the 1990s to 3.6 kilos in 2001. Since then, fish production has rebounded to about 8 kilos per capita per annum, largely due to the increased production of usipa. In 2014, the usipa constituted approximately 70% of the total catch of 117,000 tons. While higher than the value recorded in 2001, the current value is still less than the 13-15 kilos per capita recommended by the World Health Organization (FAO 2005).

On a larger scale, the fisheries sector provides income and a direct employment opportunity to ~60,000 people and indirectly engages over 450,000 people in fish processing, trading, distribution, and other associated trades (GoM 2009; GoM 2014). The average annual value of the fisheries was estimated at US $6767 million in 2008 (Schist 1999; Yarn et al 2011). Recent figures put the value of the fishery at US $172 million (GoM, 2015). Fish processing (e.g., sun-drying, smoking, frying or roasting) and trading are common livelihoods among women living in fishing communities, and through the various links and ancillary services associated with the lakes, the livelihoods of many people that live away from the basin are also sustained (Phipps 1973, Kalk et al. 1979). Furthermore, fishing often provides a safety net. For example, when other sources of employment are unavailable, or during climate failure (i.e. drought years) fishing becomes one of the most popular livelihood alternatives within the Lake Chilwa Basin (Chandilanga et al. 2013). Similarly, other ecosystem goods such as water birds are hunted during the rainy season to generate food and income when other resources are low (Bhima 2006).

Water resources for sanitation and health services are linked to the lake waters and tributaries. Although a Water Resources Management Policy and Strategy has been in place since 1969, as explained in more detail in section 1.8.8, good sanitation, water provision, and the lack of potable water are of great concern in lakeshore areas (FAO-AQUASTAT 2005). As the health risks for water-related diseases such as bilharzia or cholera increase, the well-being of the local communities and the long-term viability of tourism and recreation are threatened (Chipofya et al. 2012).

1.6 Fisheries Governance and History

The Constitution of Malawi (Republic of Malawi 1994; as amended 2010) recognizes that responsible environmental management can make an important contribution towards achieving sustainable development, improved standards of living and conservation of natural resources. Throughout the years, different forms of governances have emerged. Presently, the fisheries in Malawi have three parallel systems responsible for its governance: traditional, government led, and co-management (Hara 2006, Jamu et al. 2011). The traditional authorities are custodians of fisheries resources. At least informally, traditional chiefs control the rights to harvest resources within their geographical zone of authority, and the Fisheries Act recognizes them as local fisheries management authorities (LFMAs). For some fisheries, the traditional authorities have their own informal fisheries rules that are dependent on tenure rights and taboos (Jamu et al. 2011). The traditional management stems from precolonial times when the lake resources were managed under a common property regime in which the fishery was regulated by family heads, village headmen, and chiefs (Kasulo 2006).

The first fishing regulations were introduced by the colonial government in the 1930s when traps, fish weirs, and poisoning were prohibited, and foreign commercial fisheries were excluded from operating within two miles of traditional fishing grounds (Hara 2014, Donda 2014, Kasulo 2006). An Act of Parliament in 1946 established the Department of Fisheries (DoF), transferring the control and ownership of the lake resources from traditional authorities to the central government (Kasulo 2006). Before independence, the DoF experimented with different fishing gear and boats, proposed fishing regulations, and introduced licenses for foreign owned commercial fishers. However, enforcement and monitoring remained weak.

After independence, the Malawi government focused fisheries management on maximizing the sustainable yield and improving the efficiency of exploitation, processing and marketing (Kasulo 2006). Over the years, the central government has adopted a number of fisheries laws and regulations, including the Fisheries and Aquaculture Policy of 2001, the Fisheries Conservation and Management Act of 1997, and the Fisheries Strategic Plan (FAO 2005). The National Fisheries and Aquaculture Policy provides an overarching framework for fisheries management. The Policy’s objective is to manage the fish resources for sustainable utilization and conservation of aquatic biodiversity to enhance quality of life for fishing communities. It aims to maintain fish stocks at, or above, levels that can produce a maximum sustainable yield (MSY), which is the point at which the fish stocks can sustain the maximum harvest per year without collapsing. This means that the DoF is responsible for implementing measures to maintain MSY in all lakes in Malawi (Jamu et al. 2011).

Since 2000, Fisheries Conservation and Management Regulations govern Malawi’s fishery. The Malawi Fisheries Policy and Fisheries conservation and Management Act includes participatory fisheries management (PFM)—legitimizing community participation—and providing a legal framework for co-management (Weyl et al. 2010, Jamu 2011). The regulations control fishing effort and protect breeding stock and juvenile fish by allowing such measures as closed fishing seasons, closed areas, mesh size restrictions, minimum harvest size limits, fishing net maximum headline length, and fishing licenses. However, widespread non-compliance of these regulations has made them ineffective, leading to continued declines in the Chambo fishery in Lake Malawi and Malombe (Jamu 2011).

1.6.1 Decentralization and Fisheries Co-Management

Co-management of fisheries was introduced in 1993 as part of a donor-funded pilot project implemented in the Mangochi district (Hara 2008). The goals were to improve legitimacy, increase compliance of fisheries management rules, and reduce overfishing (Russel 2011). During this time, the DoF introduced elected BVCs (Hara 2008). Co-management later became part of the decentralization process, which started in 1998 with the National Decentralization Policy and the Local Government Act. The decentralization meant that fisheries management became the responsibility of the district authorities (Hara 2008). The process of decentralization has been very slow and is still a work in progress. However, at least in theory, the national, district, traditional authority, and village level bodies that are engaged in fisheries management have the following roles and responsibilities:

- **DoF:** The DoF develops and implements lake-wide fisheries management plans based on scientific information as well as social, cultural, and economic factors (Jamu et al. 2011). The DoF includes the Fisheries Research Unit (FRUs), which is tasked with providing information for decision-making. The FRU conducts stock assessments, exploratory surveys, and bio-limnology research (FAO 2005) as well as annual Frame Surveys.
- **Local Government Authorities**: Each district that has natural fish resources has a District Fisheries Office (DFO) that reports to the District Executive Director (DED) and to the district councilor. It takes policy directives from the National Department of Fisheries. These offices are responsible for monitoring, extension services, and enforcement of fisheries regulations. However, they are heavily dependent on the National Fisheries Department and the international donors for financial and material resources (Hara 2008).
- **Traditional Authorities and Village Headmen:** As mentioned above, the traditional authorities and village headmen have significant informal control over lake resources. In the past, migrant fishers needed to obtain permission from village headmen to gain temporary residence and the right to fish in a village. As part of this process, they had to give the village headman a token of appreciation, such as a bucket of fish or some other compensation. When the BVCs were created, they formally became responsible for registering migratory fishers. Although the traditional authorities do not have a formal role in fisheries anymore, migrant fishers continue to pay *mawe* (honorarium) to the village headmen in many communities. The traditional authorities are still influential and some maintain that the BVCs should report to them rather than the DoF.
- **Fisheries Associations:** These umbrella organizations look after the interests of fishers who use the four waterbodies. The Lake Malombe/Upper Shire River Fishermen’s Association organization, for example, is primarily made up of gear owners and crewmembers, and it does not represent the interests of other groups, such as traders and processors (Hara 2015). Lake Chiuta has a similar association, which was formed by the BVCs.

- **BVCs:** The Fisheries Act of 1997 established fisheries co-management, allowing fishing communities to participate in the conservation and management of fisheries (Donda 2014). BVCs were formed to act as the local representatives in fisheries co-management. According to the law, BVCs have the authority over access to and extraction of the economic benefits of fisheries exploitation (Hara 2008). This means that they should be engaged in both fisheries management and enforcement, but they are primarily engaged in enforcement (Donda 2014). There are 146 registered BVCs (Table 1.3), but few of them operate efficiently, except around Lake Chiuta.

Table 1.3: Number of BVCs registered by district and waterbody

District	Waterbody	# BVCs
Mangochi	Lake Malombe	13
	Upper Shire	13
	South East Arm of Lake Malawi	65
	South West Arm of Lake Malawi	12
Balaka	Middle Shire	2
Machinga	Lake Chilwa	11
	Lake Chiuta	12
Zomba	Lake Chilwa	18
Total for all Districts		146

Hara (2008) cites three reasons why the BVCs in Lakes Malawi, Malombe, and Chilwa have failed to function properly. First, powerful village headmen struggle to control fisheries benefits, and it has been difficult for the BVCs and the DoF to stand up to village headmen. Although the village headmen are intended to be only honorary members of the BVCs, many exert significant power. Second, there is legal ambiguity as to whether the BVC members should be elected or appointed, leading to many cases where the village headmen "stacked" the committees with friends and family. In theory, BVCs are democratically elected committees that represent fishing communities in co-management, but power struggles and vested interests have led to mismanagement and dysfunction. This leads to the third reason, which is that the BVCs' composition reflects the village headmen's interests and not the population as a whole. With only supporters on the committee, village headmen have been known to highjack the BVCs for their own gain, providing special treatment to some fishers (e.g. letting some fish during closed seasons) (Hara 2008). In addition, the local authorities focus on their own interests and do not acknowledge the voice and concerns of fishers (Donda 2014).

With decentralization, the BVCs and other sectoral management committees are not fully recognized, and their roles are somewhat uncertain. Each community has a village development committee (VDC) that should handle all affairs cutting across all sectors, including fisheries, but in reality, these entities do not manage fisheries. The rationale of the previous system, with sector-based committees, was inefficient and redundant. However, ministry and department officials maintain that the sectoral committees fill an important role in mobilizing communities around important topics (Hara 2008). The preferred solution is seemingly to call the BVCs and other sectoral committees, sub-committees under the VDCs.

1.6.2 Lake Chiuta and its Approach to Managing BVCs

Despite the fact that the Lake Chitua fishery is on the decline, the Lake often is touted as the only example of successful community based management in Malawi because the BVCs have been able to institute local fisheries management rules. According to Hara (2015), several factors set the BVCs in Lake Chiuta apart from the other lakes. First, the DoF does not have a strong presence in Lake Chiuta, which gives the local communities room to manage the fishery on their own. The BVCs were formed upon the fishers' own initiative as a response to the local authorities' failure to put a stop to the destructive fishing methods and social activities of migrant nkacha fishers from Mozambique. BVC membership was open to all local fishers; however, chiefs were excluded, with the exception of two village headmen who were also fishers. Second, all BVC members in Lake Chiuta pay semi-annual membership fees, which provide operational funds for the BVC while also providing a sense of ownership among the BVC members. The BVCs hold regular meetings as well as a general annual meeting, which is open to all members.

The BVCs in Lake Chiuta have a strong enforcement program that includes punitive sanctions that was developed independently from the DoF. Fees collected from fishers that are breaking management rules are used to run the BVCs and pay local police to assist in patrolling. This is different from the other lakes, where fees go into the general fund and little if anything comes back to the BVCs. Because of the strong local management in Lake Chiuta, the status of the fishery was thought to have improved. However, there is evidence that fish catch trends have stabilized in Lake Chiuta at a very low level of productivity compared to earlier catch data (Figure 1.2). It is possible that the status of the fishery is healthier than what the data suggest because since 2004 the DoF has not been able to collect data from landing beaches in the southern marshes of the lake. Hence, it is difficult to ascertain whether the improved co-management has led to corresponding improvement in the fishery. To establish this would require re-establishment of comprehensive catch monitoring data on the Lake and collaborating with Mozambique to harmonize the monitoring and management systems. This clearly provides an opportunity for FISH to contribute towards improved fisheries management in Lake Chiuta.

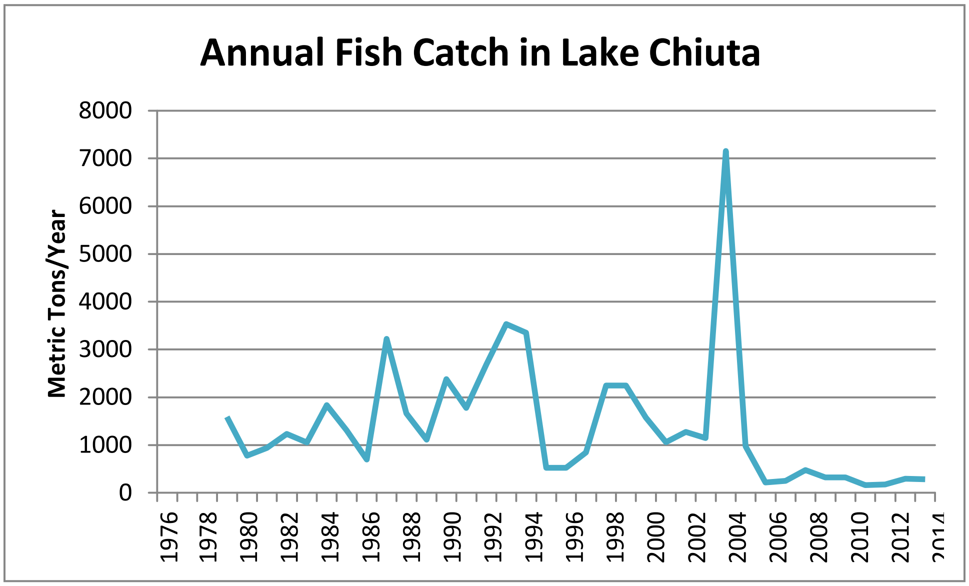

Figure 1.2: Annual fish catch in Lake Chiuta

1.7 Review of Current Fisheries Management Rules and Measures

The Fisheries Conservation and Management Act provides the legal basis for the measures needed for the development and implementation to maintain fisheries at MSY. The fisheries management tools used in Malawi fall under the following general categories: input controls, technical measures, and output controls. Input controls, such as licenses, time restrictions, and gear restrictions limit the number of fishers and the time and effort fishers put into fishing, indirectly controlling the amount of fish caught (Selig et al., in press). Technical measures include protected areas, time-area closures, and limits on fish size. Output controls, such as total allowable catches, territorial use rights, and catch shares that can directly limit the amount of fish that are harvested have not been widely used in Malawi.

1.7.1 Gear Limitations

Mesh and gear limitations regulate fisheries exploitation. The main fishing gear types all have mesh limitations to control the size of fish caught. Minimum mesh sizes are based on the size-at-maturity for the target species—protecting young fish from being caught before they are mature (FAO 2005). Mesh size regulations apply to all waterbodies (Jamu et al. 2011) and supplement closed seasons and closed areas. Some types of fishing gear are allowed only in certain areas. For example, the open water seine *Nkacha* is allowed only in Lake Malombe (Jamu et al. 2011). Destructive fishing methods, such as poisons and explosives, are prohibited in all water bodies.

1.7.2 Harvest Size Limits and Licensing

Harvest size limits, adopted to augment mesh size restrictions (Donda 2014), intend to give fish time to grow to maturity, which helps sustain maximum sustainable yield by letting the fish reproduce. Currently, the size limits cover only chambo (*Oreochromis* spp.) and potamodromous mpasa (*O. microlepis*), also known as the lake salmon. Compliance is an issue, and to date the harvest size limits have not been successfully implemented (Jamu et al. 2011).

Since the 1930s, fisheries licenses have been in place to control the number of large-scale commercial vessels operating in various fishing zones of Lake Malawi, but weak enforcement capacity limits their effectiveness. Small-scale commercial fishing vessels are licensed to fish in specific zones or strata. Because of the mobility of the fishing fleet, it has been difficult to administer a licensing system for the artisanal sector in Lake Malawi. For this reason, licensing is used only to limit access in the commercial trawling section (Donda 2014). In addition, the penalties for fishing without a license are so small that fishers can afford to pay the fines if caught. Hence, the licensing system is a source of revenue for the government, but it does not limit fishing effort. In Lake Chiuta, BVCs enforce a 2 ¾ inch minimum mesh size for gillnets. In addition, all gillnets that operate on the lake are licensed. The license fees as well as fees collected from fishers that do not comply with the minimum mesh size are used to fund continued enforcement.

1.7.3 Closed Seasons

Inshore areas of Lake Malawi are closed during the fish-breeding season (Donda 2014). The closed season runs from November 1 to December 31 of each year in Lake Malawi for all beach seines and from January 1 to March 31 of each year in Lake Malombe for all seine nets (FAO 2005). Lake Chilwa closes for fishing in December, January, and February (World Fish Center 2010). The closed seasons apply only to small-scale fisheries, because they are the only ones that target inshore areas, which are breeding grounds for chambo (Jamu et al. 2011). Commercial trawlers, which operate offshore, can fish year-round. However, some commercial trawlers reportedly have been fishing in inshore areas all year without penalty from the DoF. This has led small-scale fishers to believe that they are treated unfairly because commercial trawlers are allowed to fish and encroach in closed areas during the closed season. As a result, some small-scale fishers disregard the closed seasons and fish throughout the year.

1.7.4 Protected Areas/No-take Reserves

Lake Malawi National Park and Liwonde National Park, which covers part of Lake Malombe, are the only gazette freshwater protected areas in Malawi. Lake Chilwa, which is a designated Ramsar site, is also supposed to provide some protection for migratory birds within both the lake and its wetlands. As conservation reserves that protect biodiversity, fishing is prohibited within the Malawi and Liwonde National Parks. The Lake Malawi National Park includes the headlands and islands as well as an aquatic zone extending 100 meters from the shore. Local communities have also established smaller semi-permanent or temporary no-take zones or fish sanctuaries as part of co-management arrangements. One example is the deep-hole refugia in in Lake Chilwa's affluent rivers, which are protected and used as fish sanctuaries during periods of lake recession.

Harvest reserves are also used. These are permanent or seasonal closures connected to critical life-cycle phases. For example, small-scale fishers are prohibited from blocking river mouths with fish weirs or nets. Commercial trawlers are not allowed to fish in waters of less than 18 meters or fish closer than one nautical mile from the shoreline (Jamu et al., 2011).

1.7.5 Conflicts and Compliance Issues

As emphasized above, there is poor compliance with the established fisheries regulations in all lakes except some areas of Lake Chiuta, where the BVCs (sometimes violently) enforce the fisheries management rules and impose sanctions on those who break the rules (Hara 2015). However, aerial surveys have shown that there are severe compliance issues in the southern marshes of Lake Chiuta, which are remote, making rules difficult to enforce. Several issues contribute to the poor compliance in the other lakes. First, the local communities were not fully engaged or represented in the establishment of the rules. The regulations were formed under the direction of government, and although the co-management system had established democratic and transparent processes, the government still had the final say about which regulations were adopted (Hara 2002, Donda 2014). In addition, democracy is still a new concept in Malawi, and there has been a paucity of elected councilors for more than 10 years decision making happens largely by autocratic authority. Secondly, fishing is an important livelihood that provides daily income and subsistence in the poor lake communities. Poverty drives the local communities to think more about short-term economic benefits and subsistence, and because fishing is a particularly lucrative livelihood, it is more attractive to fish than to engage in long-term fisheries conservation (Donda 2014).

Conflicts between small and large-scale fishers also contribute to low compliance. For example, the closed season for beach seine nets is applicable only to small-scale fishers, who perceive the trawl fisheries as getting special treatment because they are allowed to fish in deeper waters during the closed season. Believing that they all target the same fish species as the trawlers, many small-scale fishers feel justified to fish during the closed season (Donda 2014). On the other hand, trawlers feel mistreated because they are the only ones denied the right to fish in area A, which is closed to trawling to protect the chambo breeding habitats.

1.8 Drivers of and Contributing Factors to Freshwater Biodiversity

Behind the direct threats to biodiversity loss and resource degradation are a number of indirect contributing factors that interact in complex ways to threaten biodiversity. These include population growth, economic, socio-political, cultural, and infrastructure-related factors that influence human behavior towards the environment. People in the SEA of Lake Malawi and Lake Malombe live with scarce livelihood options, high population growth, dependence on smallholder agriculture focusing on maize, high rates of illiteracy, poor access to savings and credit, and health related issues—all of which put fish biodiversity at risk because they drive or contribute to unsustainable resource use.

1.8.1 Population Growth and Migration

Malawi is one of the most densely populated countries in Africa. According to the 2011 household survey, approximately 13,977,000 people live in Malawi, spread over 118,484 km^2. That puts the average population density at approximately 118 persons per km^2. The most densely populated areas are in the southern region of Malawi, where the average density is 185 persons per km^2. The Chilwa basin, which is close to the most densely populated area, has an average population density of approximately 164 persons per km^2 (World Fish Center 2010). In Mangochi, the average is 128 persons per km^2, but the concentration of people is higher along the lakeshores, where fishing is an important economic activity (Mangochi District 2014). In 2006, the Mangochi district had a population growth rate of 3.04%, which was higher than the national growth rate of 2.6% (Mangochi District 2006). At 2.98%, the Zomba district's growth rate was also higher than the national average in 2006 (Zomba District 2007). The fertility rates of both Zomba and Mangochi are also higher than the national average, and approximately 60% of the population is younger than 19 years old (Mangochi District 2006). The population of the SEA of Lake Malawi increased by almost 37% over 10 years—from 295,891 in 1998 to 404,850 persons in 2008. For the Zomba District, the population grew from 398,000 persons in 1998 to 500,859 in 2006 (Zomba District 2007). This growth is due to a combination of high fertility rates and migration. The Lake areas are attractive because they are perceived to have relatively good soil for farming as well as fish resources. With increased population come greater demands on the natural resources, often leading to an increase in aquatic and terrestrial biodiversity degradation as more land is cleared for development and settlement (EAD 2010).

Many Malawian fishers migrate throughout the year depending on where the fish catches are highest. Some are part-time fishers who fish only during times when agriculture or other livelihoods are uncertain or in decline. Fisher mobility provides livelihood security and a safety net. Migrant fishers do not participate in local co-management, and they have been known to ignore fishing regulations (Russel 2011). However, pressure from migrant fishers can also prompt community leaders to strengthen the fisheries management and to address conflicts with neighboring communities (Russel 2011).

1.8.2 Poverty

Malawi is one of the poorest countries in the world. With a GDPs/capita of US $226 (World Bank 2014), Malawi faces formidable development and conservation challenges and ranked 174th out of 187 countries on the 2013 Human Development Index (UNDP Human Development Report, 2014). According to the United Nations Development Program's Human Development Report for 2014, about 62% of the population in Malawi lives on less than US $1.25 a day and 89% lives below the US $2 a day threshold. A survey conducted by Lake Malawi Basin Program in 2008 found the average household income to be approximately US $0.74 per day and that only 22% of the sampled households, which included the Mangochi district, had an income of over US $1 per day. The 2011 integrated household survey assessed the proportion of the population that was poor (those having a total consumption below MK 37,002 per year) and ultra-poor (those with a total consumption below MK 22,956. Table 1.4 below shows that all of the project districts are poorer than the national average, with Mangochi and Machinga being the most poor and Zomba being closest to the national average.

Table 1.4: Incidence of poverty and ultra poverty in the FISH Districts

District	Poor	Ultra-poor
Mangochi	73.2	44.4
Machinga	75.0	39.2
Balaka	67.7	33.2
Zomba	56.6	26.4
National average	50.7	22.3

Source: National Statistical Office, 2012

Poverty is cited frequently as a reason for natural resources exploitation and misuse. A high population density, food insecurity, poor agricultural technologies, and lack of non-natural resources-based livelihoods drive people to use ecosystem services to satisfy short-term dependence, compromising the long-term sustainable use of resources (EAD 2010). Poor farming techniques, infertile soils, expensive fishing gear, lack of credit and extension services, poor infrastructure, and diseases contribute to poverty. Only 12% of rural households have access to credit (IFAD 2012).

1.8.3 Overdependence on Smallholder Agriculture

Approximately 85% of households in Malawi are engaged in agricultural activities. The dependence on agriculture is similar throughout the entire country, with a somewhat lower rate (82%) in the Southern Region (National Statistical Office 2011). Approximately 85% of the households in Mangochi District are reportedly engaged in natural resources-based livelihoods that include fishing (Mangochi District 2006); and in Zomba, approximately 90% of the households are engaged in agriculture and/or fishing (Zomba District 2007).

Maize is the main staple of the local diet, and most households try to be self-sufficient in maize, even if the prices are so low that it would be better economically to grow other crops (Ellis 2002). Households focus on maize because they are not confident that they will be able to buy maize from the market during lean seasons. Households also lack the cash and other resources to experiment with higher value crops (Ellis 2002).

Inadequate/lack of access to markets and market information make it difficult for farmers to negotiate fair terms, and most produce is sold locally at low prices (Matiya and Donda 2014, Lake Malawi Basin Program 2008). Furthermore, the rain-fed agriculture is vulnerable to changes in the rain pattern. The growing season is only four to five months long, between November and March, and there are years when the rain fails. For example, Malawi experienced three droughts in the 1990s, when the rainy season did not produce enough water to feed the smallholder agriculture (Ellis 2002). The Mangochi and Balaka Districts both reported severe droughts in 2004/2005 and 2011/2012. The agriculture is also vulnerable to flooding, which brings about severe erosion—something that the lake communities experienced in early 2015.

Agriculture and other pressures on development contribute to the habitat loss experienced in Malawi. Agriculture stresses resilient systems because important areas, such as swamps and forests, are reclaimed. The use of irrigation reservoirs contributes to erosion and sedimentation and affects the water quality and quantity, threatening catchment areas.

1.8.4 Food Security

Chronic food insecurity is common in Malawi (Ellis 2002). The 2011 Integrated Household Survey measured food security as high, marginal, low, and very low.[1] As shown in Table 1.5, within the project Districts, the least food insecure district was , and the most food insecure district was Balaka.

Table 1.5: Population by food security status in the week prior to the survey in 2011

District	Low food security	Very low food security
Mangochi	13.4	17.7
Machinga	16.0	14.4

[1] Low food security are households that are concerned about not having access to enough food and therefore reduced the quality and the variety of the food consumed, but quantity of food intake and normal eating patterns were not disrupted. Very low food security are households that experience multiple indications of disrupted eating patterns and reduced food intake. They report reduction in food quality, variety, and frequency of food consumed.

Balaka	10.1	44.7
Zomba	12.1	36.6
National average	7.9	32.5

Source: National Statistics Office

The relatively high food security in Mangochi and Machinga could be the result of their proximity to the lakes and the availability of fish as a food source. The fishery sector has the potential to provide between 60-70% of the total animal protein in Malawi. However, both fishing and farming are seasonal, and food insecurity is common during certain times of the year. A survey conducted by the Lake Malawi Basin Program in 2008 revealed that 56% of households experience food shortages between December and March, and 23% of households were food insecure between October and March. The situation is similar in Lake Chilwa, where the households have the lowest income and food reserves in January and February (World Fish Center 2010). During lean times, households cope by offering cash for labor, engaging in food-for-work programs, and selling natural resources-based products, such as firewood and charcoal. Some also migrate to urban centers (World Fish Center 2010). Many households turn to fishing as a way to generate cash to buy food. Unfortunately, the lean agricultural season also coincides with the closed season for seine nets, which can drive many to break the fishing rules (Lake Malawi Basin Program 2008).

1.8.5 Lack of Alternative Livelihood Options

Smallholder farming is the primary livelihood for people living in the lake areas. Households in the Lake Chilwa area have on average two sources of income, but both of them are usually natural resources based—and the lean season for fisheries and farming coincide. Apart from farming, livelihoods include working as a laborer in the estate sector (tobacco, coffee, tea, and cotton),[2] fishing, small business/petty trade, hiring of semi-skilled labor, livestock sales, and other natural resources-based livelihoods, such as charcoal making. Fishing and fish marketing are among the highest income-earning livelihoods available to people living along the lakes (Malawi Lake Basin Program 2008).

Lack of access to savings and credit is a major impediment to livelihoods diversification. A survey conducted by the Malawi Lake Basin Program in 2007, found that only three percent of households had access to savings, and one percent had access to credit (Malawi Lake Basin Program 2008). Similarly, the 2011 IHS found that only 1.1% of households in Mangochi had obtained a loan sometime in the last year. The other districts had a higher percentage (Machinga 5.8%, Zomba 6.3%, and Balaka 9.6%), but only Balaka was higher than the national average of 8.3%. The World Fish Center (2010) found that there are no formal credit facilities in the rural communities of Lake Chilwa, and that those seeking a loan have to travel to the urban centers of Liwonde, Zomba, and Phalombe. There are examples of community-based savings and credit, but the proportion of beneficiaries is low. According to the 2011 IHS, people do not obtain loans because they do not know of any lender. However, a significant proportion also indicated that they do not have any need for credit.

[2] The estate sector, which produces tobacco, tea, cotton, sugar, and coffee, is the main provider of wage labor in Malawi as a whole.

1.8.6 High Rates of Illiteracy

Illiteracy is common in Malawi, and according to the 2011 IHS, 21.1% of the population aged 15 years and above has never attended school (14% for men and 28% for women). The illiteracy rates vary between districts, and as shown in Table 1.6., Zomba and Balaka have a higher rate of literacy than Mangochi and Machinga. High rates of illiteracy in the Mangochi and Machinga Districts are due to a large percentage of the population being older than 15 and never having attended school.

Table 1.6: Illiteracy and schooling levels for FISH Project Districts in 2011

District	Literacy level	Percent aged 15 and above who never attended school
Mangochi	34.1	49.8
Machinga	41.0	42.0
Balaka	65.6	14.5
Zomba	69.4	16.6

Source: National Statistics Office 2012

A Lake Malawi Basin Program survey conducted in 2008 found that lack of interest and the need for children to work on family farms were the main reasons for keeping children out of school rather than the unavailability of schools. The 2011 IHS found that the three main reasons why people did not attend school were 1) lack of money; 2) they were not allowed to attend school; and 3) they were not interested. The problem with illiteracy is that it holds people back in terms of accessing information and knowledge, for example about alternative technology and livelihoods, value chain improvements, and improved agricultural practices, and services, such as savings and loans.

1.8.7 Gender Inequalities

Women living in the lakeshore communities are disadvantaged in many ways. Women have limited access to, and control over capital, land, agricultural inputs, technologies, and leadership opportunities. Although women produce 80% of the food for household consumption, male extension officers prefer to work with male farmers—to some extent denying women access to valuable extension advice (Lake Malawi Basin Program 2008). Women-led households are more vulnerable than households led by men. For example, the Lake Malawi Basin program found that women led 85% of food insecure households. Although many communities are matrilineal, there are gender inequalities in land access and ownership, and female-headed households have less land than their male counterparts do (FAO 2011).

Women are disadvantaged from an early age. Girls are less likely than boys are to attend primary school. As shown in Table 1.6, Mangochi is the worst district when it comes to illiteracy, which had an average enrollment rate for primary school-age children of 71% in 2006. However, there is a large gender gap, with only 50% of girls enrolled and an even lower percentage in some traditional authorities (TAs) (Mangochi District 2006).

Girls often drop out of school when they get married or have children. Through initiation rites, girls are encouraged to transition to adulthood as soon as they reach puberty, and many are married as young teens (Skinner et al. 2013). The lack of education and early marriages mean that many girls never have a chance to move beyond keeping a family and engaging in subsistence farming.

Women do not go out on fishing boats, but they participate in the fishing industry as boat and gear owners. According to the 2014 Annual Frame Survey, 162 of 11,546 gear owners in Malawi are women, representing 1% of all gear owners in Malawi. Within any given gear type, women constituted at most 4% of the total gear owners. The gear owned by women included chilimiras, chikwekwesas, handlines, kambuzi seines, long lines, Usipa seines, Matemba seines, ngongongos, and nkacha seines. Although some women own fishing gear, there are no female crewmembers.

More women are involved in fish trading and processing. Fish trading is a relatively lucrative livelihood, but it sometimes puts women in a vulnerable position. Transient men are also vulnerable as many engage in risky behaviors. For example, some women are obliged to exchange sex for access to buying fish from local fishers (Hara 2015). Although certainly not all migrant fishers seek out transactional sex, those who do often place themselves and their partners at risk for HIV/AIDS (Torell 2006).

1.8.8 Health Issues

Those living around the lakeshores have insufficient access to health services. Although there are hospitals, health centers, and outreach clinics, they are insufficiently staffed and equipped. The infant and under-five mortality rates are higher in the southern region, which includes the four lakes, than the national average in Malawi. For example, the Mangochi District has an infant mortality rate of approximately 90 deaths per 1,000 live births, compared to the national average of 77 deaths per 1,000 live births (Mangochi District Profile 2014). That could in part be because Mangochi has one of the lowest proportions of child delivery attended by skilled health personnel in Malawi (70.8%). The other three FISH project districts are all above the national average of 83.3%: Machinga (86.9%), Balaka (85.4%), and Zomba (87.6%).

Malaria is the most common disease in the lake areas, followed by respiratory infections, diarrhea, anemia, and bilharzia/schistosomiasis. HIV/AIDS and other sexually transmitted infections (STIs) are also common. Research conducted by Madsen et al. between 1998 and 2007 found a high prevalence of schistosomiasis in communities living along the shores of Lake Malawi. They found that the prevalence of urinary schistosomiasis ranged from 10.2% to 26.4% in inland villages and from 21.0% to 72.7% in lakeshore villages. Infection rates were higher among school age children—ranging from 15.3% to 57.1% in inland schools and from 56.2% to 94.0% in lakeshore schools.

The HIV infection rate in Malawi as a whole was 10.3% in 2010 (UNAIDS). The HIV infection rate is higher in the southern region, and was about twice as high as the rest of the country (14.5% in 2010). The HIV infection rate for the Mangochi District was a staggering 21% in 2010, and an alarming 33% among fishers, processors and traders.

Malnutrition is another health problem, especially among children under five years old. This is a critical window in childhood development, and the lack of proper nutrition in combination with diarrhea, which compromises nutrient uptake, has long-lasting and often irreversible effects. Children are highly vulnerable to diarrhea, which is common during the rainy season. Lack of potable water is a challenge that contributes to the high rates of diarrhea (GOM 2006). The current potable water supply situation in the lake areas is poor, and the sanitation conditions are even worse. As shown in Table 1.7, between 76 and 88 percent of the people living in the FISH project districts have access to an improved water source. However, the access to improved water sources varies widely between TAs. Some TAs have up to 95% coverage, while others have coverage of around 50%.

Table 1.7: Access to improved water and sanitation by District (2011)

District	**Access to an improved water source (percent)**	**Access to improved sanitation (percent)**
Mangochi	87.9	67.1
Machinga	75.8	64.9
Balaka	83.1	60.2
Zomba	87.6	73.5
National average	78.7	72.4

Source: National Statistics Office 2012

Access to improved sanitation also varies between the four districts covered by the FISH project. Balaka is the worst off, with only about 60% of households having access to improved sanitation. At 73.5%, Zomba is the only district that is close to the national average of the households having access to pit latrines in 2006. There are few hand washing facilities with coverage of only 24% (ICIEDEA 2011). In Lake Chilwa, potable water and sanitary facilities are particularly bad in fishing communities, and beach sanitation is a major problem. Some fishers stay in floating huts on the lake marshes. Sleeping, eating, and bathing out in the marshes, they are particularly vulnerable to cholera and diarrhea (World Fish Center 2010).

Households without sanitary toilets and access to safe water rely on the lakes for drinking and bathing. During the rainy season, excrement washes into rivers, streams, and directly into the lakes. Exposure to waterborne diseases, such as cholera, bilharzia, typhoid, and dysentery is worst during this time of the year. According to the Integrated Household Survey (GoM, 2011), Mangochi reported the highest percentage (14%) incidence of diarrhea cases, and this was higher than the national average of 10.9%. Poor health is a contributing factor to biodiversity conservation, because households that are struggling with health issues are more likely to put pressure on natural resources. For example, studies from Tanzania found that AIDS-affected households were more likely to engage in destructive livelihood practices—especially woodcutting and charcoal making to raise income (Torell et al. 2006). This occurs because households that have sick and dying family members lose manpower and need additional income to pay for expenses related to health care and funerals. As described under the food insecurity section above, when people have little or no options, they turn to natural resources extraction as a coping strategy needed for extra income.

1.8.9 Weak Enabling Environment Limits Effective Management

The District authorities are responsible for implementing national policies and regulations related to fisheries, forestry, and other topics related to natural resource management and biodiversity conservation. The District Executive Committee (DEC), the technocrats who are answerable to the District Assembly (i.e., the politically elected body Council), provides extension services to local communities who participate in resource co-management through village natural resources management committees (VNRMC) and BVCs. Although the system seems clear in theory, as described in more detail in section 1.6, conflicting or non-functioning government management systems and overlapping jurisdictions hamper effective governance. Furthermore, lack of infrastructure, personnel, and funding results in poor enforcement.

1.8.10 Climate Change

Climate change is expected to increase air temperatures, alter patterns in precipitation and runoff, and increase extreme weather events in Malawi (Ngochera 2014). Based on these general trends, the FISH team conducted a rapid climate change vulnerability mapping exercise for the entire project area to seek greater insights into the variability across the region to guide our interventions. The Intergovernmental Panel on Climate Change (IPCC) conceptual framework, which separates vulnerability into three components: exposure, sensitivity, and adaptive capacity to climate stressors, was used. Emphasis also was given to the general vulnerability of the communities within 10km of the project lake areas with a minor focus on the fisheries sector, since most communities are engaged in multiple livelihoods. Existing national data sets were combined with data collected during the PRA visits with the BVCs. Combining the results provided a more detailed analysis across the project region that had not been achieved through other national assessments. Because this was a rapid assessment, current hazards were used for the exposure analysis. While these maps provide some insight into the variability of vulnerability across the area, one should be extremely cautious in making general conclusions without ground-truthing the analysis. National data sets are often outdated and can lack localized input. The PRA data collected was hyper-localized, which made it difficult to expand those findings to larger areas.

The mapping exercise included 15 indicators collectively teased out the exposure, sensitivity, and adaptive capacity of the communities, which could potentially predict likely vulnerability to climate change. The final set of indicators was included based on the cost and feasibility of the data collection as well as the assumed link to a mental model of vulnerability for lakeshore communities in Malawi. Multiple assumptions were made based on what compels sensitivity and adaptive capacity, though the indicators are similar to those conducted in other studies of this nature. Below is the list of indictors used to conduct the climate change vulnerability rapid mapping exercise:

Exposure Indicators

- •Drought severity
- Flooding areas
- Rainfall amounts (precipitation)
- Lake drying areas

Sensitivity Indicators

- Dambos
- Drought tolerant crops
- Productivity of farmland per hectare
- Condition of transportation infrastructure
- Poverty Levels
- Distance to Trading Centers

Adaptive Capacity Indicators

- Soil health (community wide) use maize map
- Distance to boreholes
- Ability of BVC to deliver services
- Mother education level
- Remittance levels
- Level of illegal gear use
- Number of livelihoods per household
- Level of savings

Results from the mapping exercise (Figure 1.3) show some pockets of high vulnerability compared to other areas within the surrounding lake areas. These included Cape Maclear area of Lake Malawi, the southwest section of Lake Chiuta, the central western section of Lake Chilwa and the central eastern section of Lake Malombe. The primary factors for their high vulnerability varied for each place; however, flood and drought zones were a major factor for Chilwa and Chiuta Lake areas.

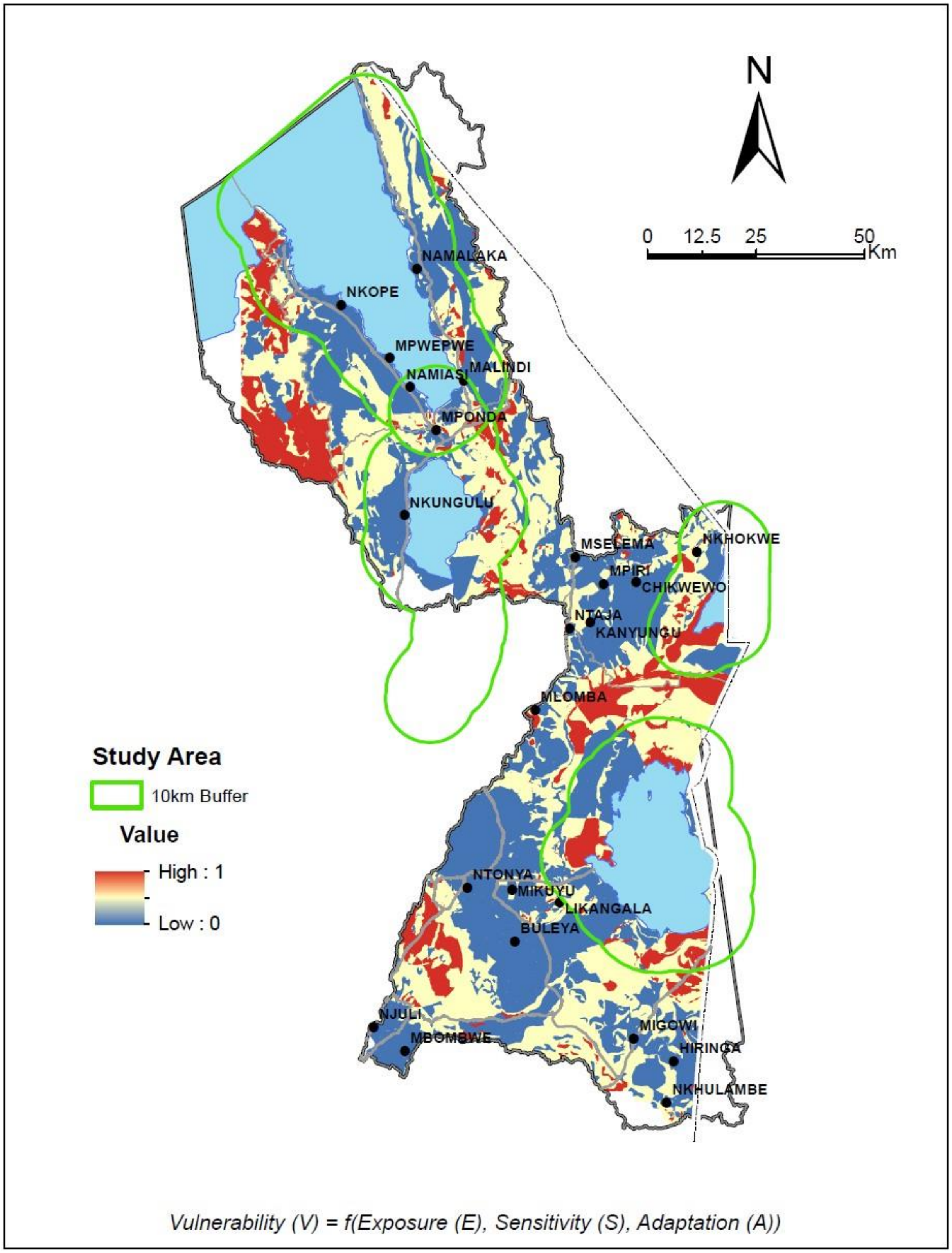

Figure 1.3: Climate change vulnerability map

The literature provided additional insight into Malawi's vulnerability to climate change. An increase in air temperature will mean a rise in water temperature. This, coupled with changing rainfall patterns, which will affect lake levels, will directly affect fish reproduction, growth, and migration patterns and indirectly impact fish biodiversity through changes in habitats, stocks, and species distribution. Deeper waters have already become warmer due to a reduction in cold-water intrusion and warmer winters (Ngochera 2014). The warming may suppress upwelling in Lake Malawi, reducing pelagic productivity. Elevated water temperatures in shallow areas may force fish to migrate to deeper, cooler water, making fish less accessible to the artisanal fishers using canoes and small, planked boats (Ngochera 2014). Migrant seine fishers (nkacha), who are at conflict with the traditional gill net fishers (Njaya 2009), target the deeper water stocks.

Climate change will also increase the vulnerability of the rain-fed smallholder agriculture. Droughts are predicted to become more common—leading to increased food insecurity. Flooding, such as the 2015 events, contribute to increased sedimentation and siltation from the erosion of soils left bare by agriculture and deforestation. The increased rate of sedimentation may have direct impacts on Chambo and other fish that breed in rocky habitats. Many breeding areas already have been covered by mud, and the situation is predicted to get worse (Maitya 2014).

Rural households have few safety nets and are highly susceptible to climate-related shocks, such as droughts and flooding events (Ellis 2002). The adaptive capacity is low, and all of the factors described above—including small and declining farm sizes, lack of livelihood options, poor governance, lack of capital, and food insecurity—contribute to household vulnerability.

1.8.11 Deforestation and Farming on Fragile Lands

Forest reserves scattered around the four lakes are under increasing pressure by wood collectors who make a livelihood from the sale of firewood and charcoal. Population growth and increasing pressure on arable land have also led farmers to expand their fields to the vulnerable hillsides for agriculture. Bare hillsides are vulnerable to erosion and soil loss during the rainy season—potentially causing increased siltation and eutrophication of the lakes. This is a double-edged sword, because on one hand, the nutrient loading drives production, but on the other, the higher sedimentation levels disrupt the rocky breeding habitats. Farmers also cultivate along the riverbanks, and their crops are prone to being washed away during flood events. The adjacent riverine and downstream areas are susceptible to the negative impacts of increased erosion. The fisheries sector also contributes to deforestation. For example, fish smoking activities in Lake Chilwa consume about 6500 tons of firewood annually (Jamu et al. 2003). Recently introduced parboiling and deep-frying potentially double, if not triple, this wood demand (Luhanga 2012). Protecting wetlands, their function, and the ecosystem's integrity has large implications on the sustainability of fisheries and the resilience of the people in the Lake plains (Sarch & Allison 2000).

2 THE SOUTHEASTERN ARM OF LAKE MALAWI

The Southeast Arm of Lake Malawi (SEA) is located between 35° 50’ to 35° 10’ east and 13° 44’ to 14° 25’ south and has a total surface area of approximately 2,000 km^2. It is 80 km long and 30 km wide with an average depth of 65 meters and maximum depth of 130 meters. The estimated volume of the SEA is 113 km^3, or about 2% of the total volume of the lake. Due to the shallow nature of the SEA, it experiences seasonal mixing and the upwelling of nutrient rich water promoting the highest levels of primary, zooplankton, and fisheries production per unit area in the entire lake (Ngochera 2014).

The SEA is located within two drainage basins: the Southeast Lakeshore River sub-basin (total area: 1,540 km^2) and the Lisangadzi River sub-basin (total area: 1,259 km^2). The Lusalumwe, Lungwena, Lugola, and Lilole rivers all drain into the SEA, and the Shire River is the sole outlet, and whereas 10-12% of the annual lake level loss flows out the Shire, the bulk is lost to evaporation. The lake receives the majority of its nutrients from rivers and atmospheric deposition.

2.1 High Biodiversity Areas

2.1.1 Fish Diversity and Endemism

Lake Malawi has the highest levels of freshwater fish biodiversity in the world. It is the habitat for more than 1,000 species belonging to 11 families, with many of them endemic. (Table 2.1).

Table 2.1: The riverine and lacustrine fish inhabiting Lake Malawi

Family	Genera	Species	% endemism
Anguillidae	1	1	0
Aplocheilidae	1	2	100
Bagridae	2	4	50
Characide	2	2	0
Cichlidae	41	Circa 750	99.5
Claridae	2	17	71
Cyprinidae	5	26	35
Mastacembelida	1	2	100
Mochokoidae	2	3	33
Mormyridae	4	7	0
Protopteridae	1	1	0

Source: Bell et al. 2012, p. 724

A 2005 survey of artisanal and industrial fisheries of the Southern Lake Malawi recorded more than 200 species of fish from single fishing localities (Weyl et al. 2005). However, the species richness has declined over the last 20 years due to overharvesting, habitat degradation, and land use change and development within the upstream catchments (Duponchelle and Ribbink 2000, Maguza-Tembo 2004, Ngochera 2014). Comparing the species richness and abundance between 1993 and 2005, the general trend is a reduction in species. The area exhibiting the greatest loss during that time was Nkhata Bay, where researchers estimated that 40 local species have become extinct (Kanyumba, 2009).

2.1.2 Habitat Types

There are a variety of different habitat types within the SEA of Lake Malawi (Figure 2.1). Each is important for various fish species as explained in Table 2.2 below.

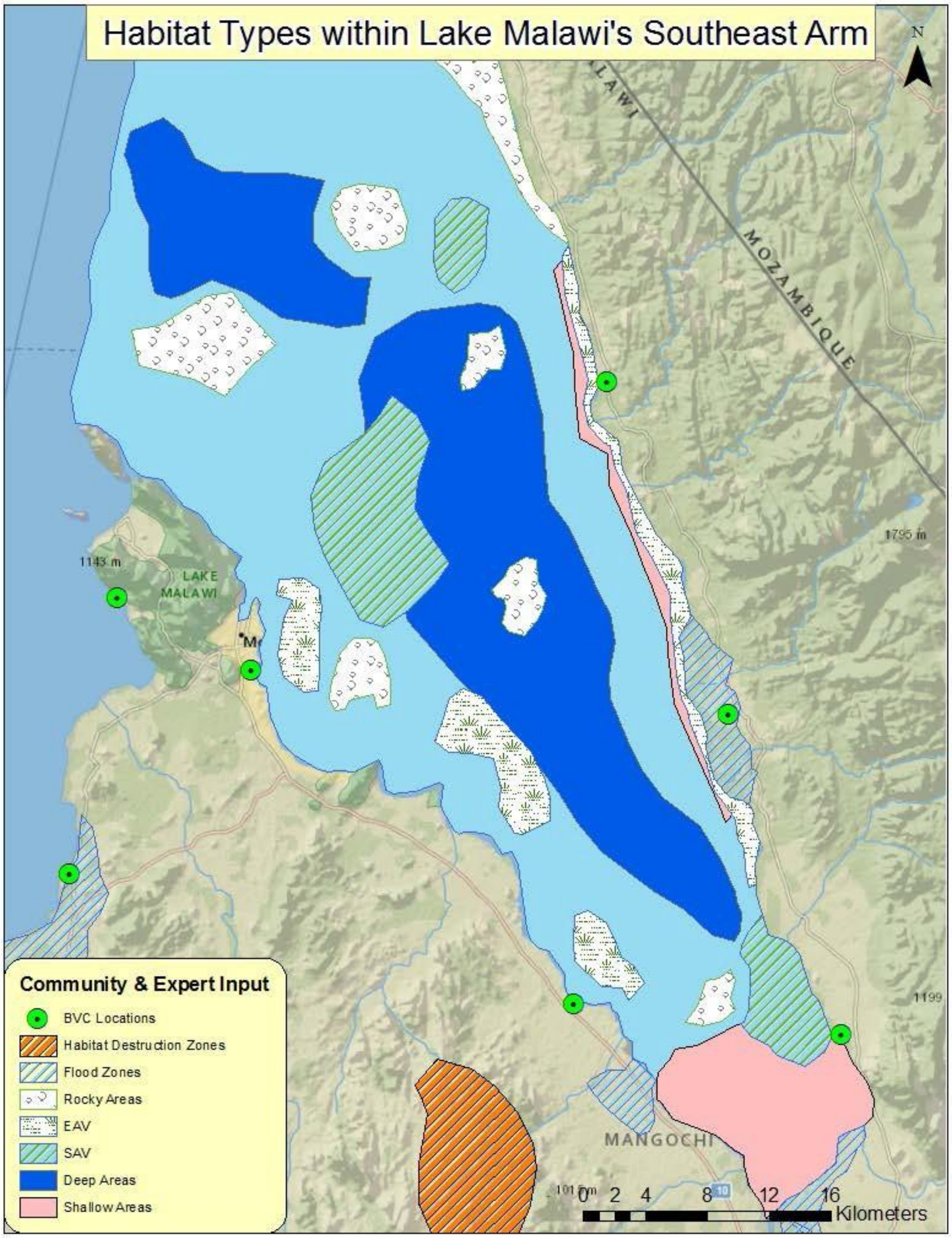

Figure 2.1: Distribution of habitats within the SEA of Lake Malawi based upon local ecological knowledge gathered from community PRA assessments and local expert workshop.

Rocky. These habitats are located along the northeastern shore of the SEA, around the periphery of the islands as well as within Lake Malawi national park and the Nkhudzi spit (Figures 2.1 and 2.2). Rocky areas are dominated by brightly colored cichlids locally referred to as "mbuna." The algal mats that grow on the rocks are primarily responsible for supporting the rich diversity of these cichlids, and the location of specific mbuna-rich locations are highlighted in Figure 2.2.

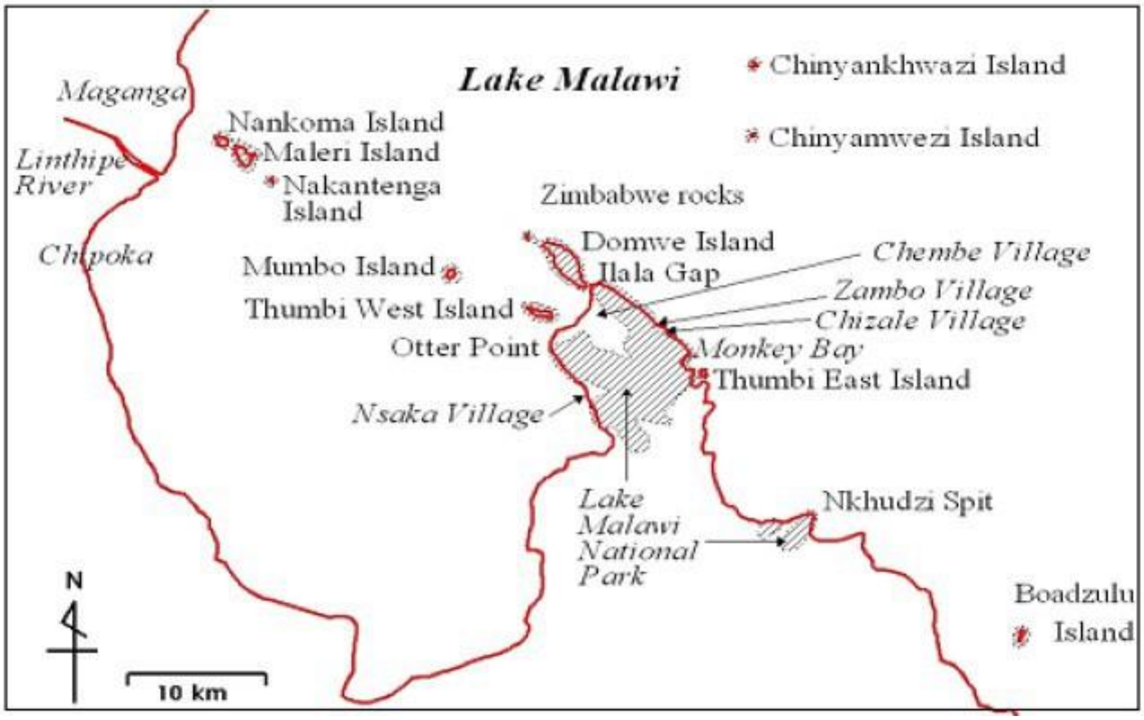

Figure 2.2: Mbuna-rich areas around Lake Malawi National Park
Source: Kanyumba et al. 2012, p. 544.

Aquatic vegetation. A long band of emergent aquatic vegetation (EAV) is located along the eastern boundary of the SEA, and the results of the community PRA mapping activities and expert validation indicate that there are a few large patches present approximately two kilometers offshore of the southwest shoreline. The SAV is distributed primarily along the south and southwestern shorelines as well as offshore near the deeper areas (Figure 2.1). As discussed in detail below, the emergent and SAV serves as critical breeding, nursery, and juvenile habitat for a number of fish species.

Shallow areas. The shallowest areas, located in the southern most section and along the eastern shoreline, provide important habitat for shallow water demersal species including bombe (*Bathyclarias spp.*), kampango (*Bagrus spp.*), utaka (*Copadichromis spp.*), kambuzi (small *Lethrinops spp.* and *Otopharynx spp.*), and chambo (*Oreochromis spp.*).

Deep areas: The deeper sections, which extend along the long axis of the SEA, serve as important habitat for a number of deep water demersal species including ndunduma (*Diplotaxodon spp.*), chisawasawa (*Lethrinops* spp.), *Bagrus spp.*, and *Bathyclarias spp.* (Ngochera 2014, Donda & Hara 2014). The depth preference of *Lethrinops* spp. and two other related species are shown in Figure 2.3.

Species in the water column (pelagic community). The pelagic community is dominated (in abundance) by usipa (*Engraulicypris sardella*) and includes utaka (*Haplochromis spp.*) and ncheni (*Rhamphochromis spp.*) (Ngochera 2014, Banda and T'omasson 1997). The abundance of usipa exhibits high levels of inter-annual variation, attributed to differences in upwelling strength (Tweddle & Lewis 1990 and Allison et al. 1995 as cited in van Zwieten et al. 2011).

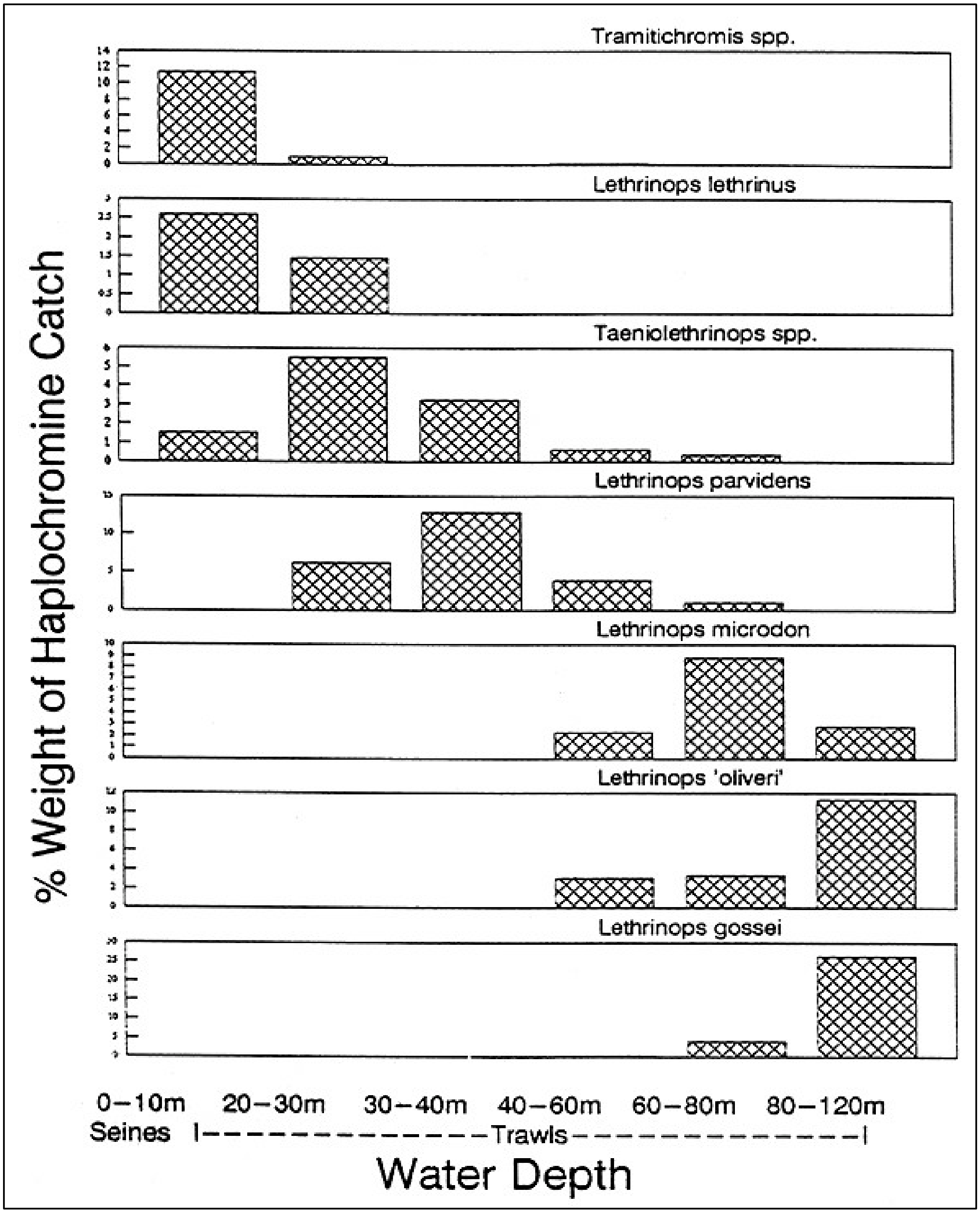

Figure 2.3: The depth preferences of *Lethrinops spp.* and related species
Source: FAO 1993, p. 30.

2.1.3 Breeding Habitats

The rivers and tributaries flowing into Lake Malawi as well as the nearshore sandy and muddy substrates serve as important fish breeding habitats (Pereyra et al. 2004, Turner 2004). During the spawning season, which commences with the onset of the rainy season, Cyprinids (e.g., mpasa, kadyakolo, sanjika), and Clarias catfish species migrate upstream into Lake Malawi's tributaries (Weyl et al. 2010).

The usipa, *Engraulicypris sardella*, tend to breed in 1-2 m deep water along the beach shore of the southwestern shorelines of Lake Malawi (Morioka & Kaunda 2005). Similarly, the chambo (*Oreochromis spp.*) use the nearshore environment for spawning, and the males construct their nests on sandy or muddy bottoms (Bell et al. 2012). *Oreochromis baronage* typically nest at depths ranging from 0.5 to 30 m while *O. lidole* nest in depths greater than 17 m and *O. squamipinnis* nest at a wide range of depths (Turner et al. 1991). Specific breeding areas identified for *O. karongae* and *O. lidole* lie within the SEA include Boadzulu Island and the northern part of the SEA, respectively (FAO 1993). Following mating, the female chambo brood their eggs and larvae in their mouths for approximately two weeks until the fry yolk sacs have been absorbed (FAO 1993).

2.1.4 Nursery Habitats

Once the fry yolk sacs are absorbed, female chambo migrates into shallow water, where they release their fry in vegetated areas. Utaka also release their fry in shallow water (van Zwieten et al. 2011). Chambo continue to provide protection for their offspring by allowing them to swim back into their mouths if threatened (the fry-guarding stage). The fry continue to return to the female's mouths for several weeks until they have reached a certain size (15 mm for *O. squamipinnis*, 24 mm for *O. karongae*, and 58 mm for *O. lidole* (Lowe 1952 as cited in FAO 1993).

2.1.5 Juvenile and Adult Feeding Habitats

The juvenile chambo continue to develop in shallow water concentrated around macrophytes and rocky outcroppings and then move to progressively deeper water as they grow. Some species, such as mlamba, transition from being planktivorous to piscivorous/zooplanktivorous once they reach a certain length and migrate from the nearshore area into the deeper pelagic zone to feed (Kaunda and Hetch 2002). Other species, such as ncheni, occupy a wide range of habitats during their juvenile and adult stages, including rocky habitats, shallow inshore waters, the surface layers of open water, and deeper areas (Allison et al. 1996, Thompson & Allison 1997, Turner 2004).

As shown in Table 2.2, findings from the PRA correspond with the literature review regarding the major breeding habitats, nursery grounds, juvenile habitats, and adult feeding grounds for the major fish species caught in the SEA of Lake Malawi. Local communities elaborated on more species, reinforcing the importance of submerged and emerging aquatic vegetation, river inlets/outlets, shallow and rocky areas (Figure 2.4). The local communities confirm that some species stay within a certain area whereas others move between habitats, depending on the life cycle.

Table 2.2: Summary of key habitats for critical life stages of the main fish species groups within the SEA of Lake Malawi

Species	Breeding Habitat	Nursery Grounds	Juvenile Habitat	Adult Feeding Ground
Chambo/kasawala *Oreochromis lidole, O. squamipinnis, O. karongae*	EAV, SAV, river inlets/outlets, shallow areas	EAV, SAV, river inlets/outlets, middle of the lake	SAV, river inlets/outlets, shallow areas, middle of the lake	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas
Gongo/Chisawasawa/ Sawasawa/Gong'ola *Lenthrinops mylodon*	EAV, deep areas	EAV, rocky areas, middle of the lake	Rocky areas, middle of the lake, shallow areas	SAV, shallow areas
Jamison/Jamisoni wamkazi /Anyana *Diplotaxodon ecclesi*	Rocky areas, shallow areas, deep areas	SAV, rocky areas, shallow areas, middle of the lake, deep areas	EAV, SAV, shallow areas, middle of the lake, deep areas	Shallow areas, middle of the lake, deep areas
Kambuzi *Lethrinops spp. Otopharynx spp.*	SAV, rocky areas, river inlets/outlets, middle of the lake, shallow areas	SAV, rocky areas, river inlets/outlets, shallow areas, middle of the lake, deep areas	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas	EAV, SAV, rocky areas, river inlets/outlets, shallow areas, middle of the lake, deep areas
Kampango/Mbuvu *Bagrus meridionalis*	Rocky areas, shallow areas, deep areas	EAV, rocky areas	EAV, rocky areas	EAV, rocky areas, middle of the lake, deep areas
Matemba *Barbus paludinosus*	Shallow areas	River inlets/outlets	EAV, river inlets, deep areas of the lake	Rocky areas, EAVs, SAVs, shallow areas
Mbaba *Lethrinops spp. Protomelas spp.*	EAV, SAV	EAV, deep areas, rocky areas, middle areas of the lake	Middle area of the lake	SAV
Mbuna/Kadyakoro/ Tsungwa	SAV, Rocky areas	SAV, Rocky areas	SAV, EAV, rocky areas, river inlets/outlets,	SAV, EAV, rocky areas, shallow areas

Species	Breeding Habitat	Nursery Grounds	Juvenile Habitat	Adult Feeding Ground
Pseudotropheus spp.			shallow areas	
Mlamba/bombe *Clarias gariepinus* and *Bathyclarias spp.*	EAV, SAV, rocky areas, river inlets/outlets, shallow areas, deep areas	EAV, SAV, rocky areas, river inlets/outlets, shallow areas, middle of the lake, deep areas	EAV, SAV, rocky areas, river inlets/outlets, shallow areas, middle of the lake, deep areas	EAV, SAV, rocky areas, river inlets/outlets, shallow areas, middle of the lake, deep areas
Mpasa/Nyengeri *Opsaridium microlepis*	SAV, river inlets/outlets, shallow areas	EAV, River inlets/outlets, shallow areas	River inlets/outlets, deep areas, shallow areas	River inlets/outlets, deep areas
Nchila *Labeo mesops*	River inlets/outlets	River inlets/outlets	EAVs, rivers	Shallow areas, EAVs, SAVs
Sanjika *Opsaridium microcephalum* and *O. tweddleroum*	River inlets/outlets	River inlets/outlets, shallow areas	River inlets/outlets, Shallow areas, deep areas	River inlets/outlets
Usipa *Engraulicypris sardella*	EAV, shallow areas, middle of the lake, deep areas	EAV, rocky areas, shallow areas, middle of the lake, deep areas	EAV, rocky areas, shallow areas, middle of the lake, deep areas	EAV, SAV, rocky areas, shallow areas, middle of the lake, deep areas
Utaka/ Chiyendammwamba	SAV, EAV, rocky areas, shallow areas, middle of the lake, deep areas	SAV, EAV, rocky areas, shallow areas, middle of the lake, deep areas	EAV, SAV, river inlets/outlets, rocky areas, shallow areas, middle of the lake, deep areas	Rocky areas, river inlets/outlets, shallow areas, middle of the lake, deep areas

HIGH BIODIVERSITY AREAS WITHIN LAKE MALAWI'S SEA

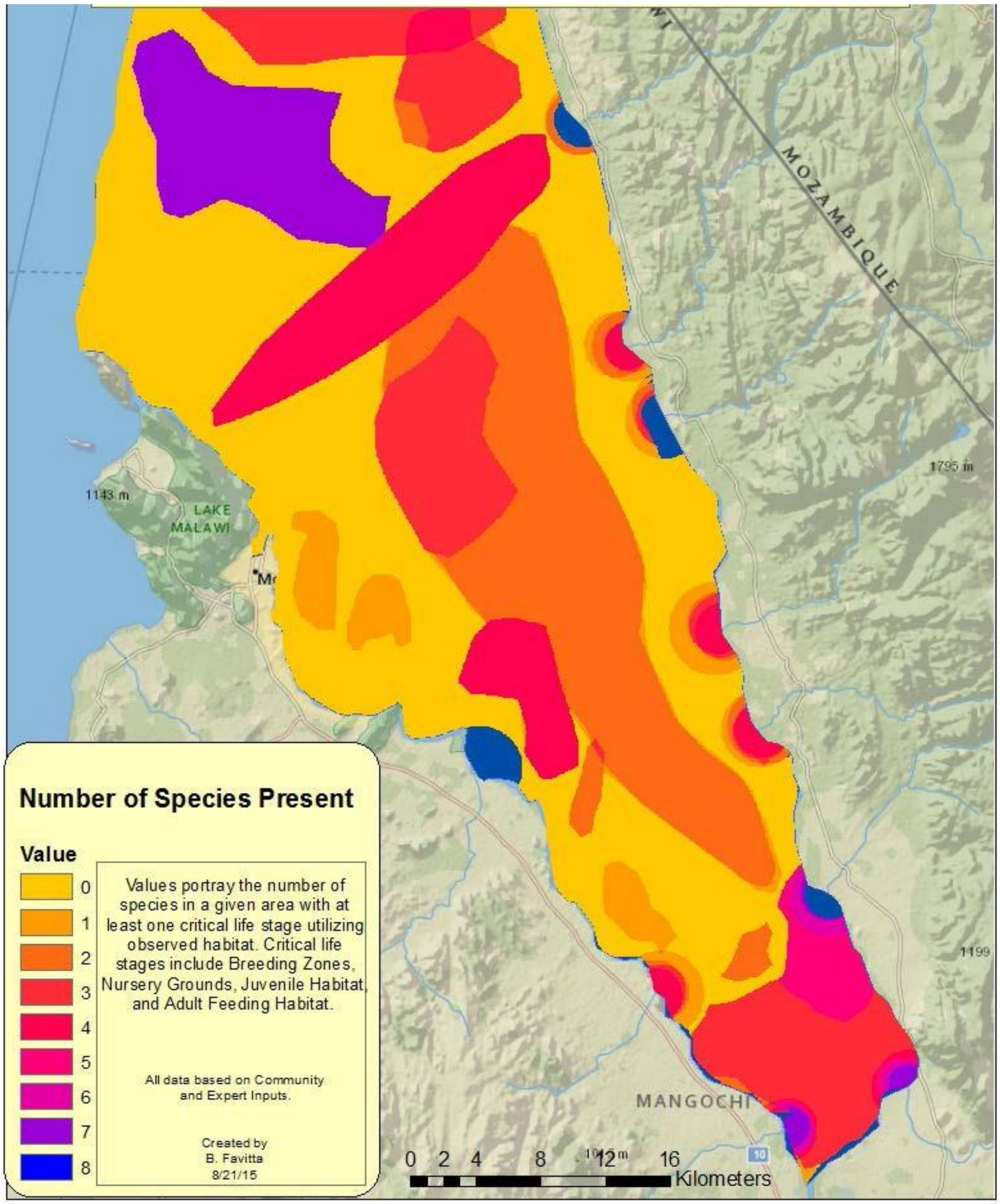

Figure 2.4: Community perceived high biodiversity areas within the SEA of Lake Malawi

The above map highlights species-rich zones within the SEA of Lake Malawi. The different colors on the map represent the cumulative score for the main fish species harvested by the local communities with at least one critical life stage occupying the given habitat area. Life stages are all given a value of one and are not weighted (i.e., the multiple life stages of a single species coexisting within a habitat area were not double counted). The highest species richness areas for the species targeted by the local communities are adjacent to the river mouths in the southeast corner of the SEA. The shallow areas are also home to a number of different species. Adults typically utilize the deep areas as feeding grounds, while species congregate in river mouth areas and within the submerged and emergent aquatic vegetation during the breeding season and juvenile life stages.

2.1.6 Fish Sanctuary-Lake Malawi National Park

Lake Malawi National Park, established in 1980 and declared a UNESCO World Heritage Site in 1984, is at the tip of the Nankumba peninsula between the Southeast and Southwest arms of Lake Malawi. In addition to the peninsula, the park includes the Nkhudzi Spit and 12 islands within Lake Malawi. All aquatic habitat that lies within 100 meters of the park's terrestrial components is included within the park's boundaries, totaling ~7km^2 (UNESCO 2014). Given that the endemic cichlids are stenotopic and often restricted to small outcrops of rocks adjacent to the lakeshore and along the periphery of the islands, the aquatic area encompassed within the park's boundaries provides long-term protection to a very rich assemblage of species.

2.1.7 Other Aquatic Biodiversity

The biomass and composition of phytoplankton and zooplankton fluctuate throughout the year (Ngochera 2014, p. 48). More than 60% of the total phytoplankton biomass is composed of "picoplankton" (Ngochera 2006, Guildford & Taylor 2011). *Planktolyngbya nyassensis*, which was once very common in the lake, has been replaced by *P. tallingi*, a species that is more prevalent in settings with lower light and greater nutrient concentrations (Higgins et al. 2001). Additionally, there have also been recent reports of the potentially toxic *Cylindrospermopsis raciborski* within the lake (Kling, personal communication as cited in Ngochera 2014). The implications of these changes in phytoplankton composition on zooplankton and fish production are unknown.

The zooplankton community within Lake Malawi comprises seven species (i.e., *Bosmina longirostris*, *Chaoborus edulis*, *Diaphanosoma excisum*, *Mesocyclops aequatorialis*, *Thermocyclops neglectus*, *Thermodiaptomus mixtus*, and *Tropodiaptomus cunningtoni*). The total biomass, which fluctuates between 16 to 46 mg/m^3 throughout the year in the SEA, is composed predominantly of copepods (>70%) (Ngochera 2014).

The diversity, abundance and distribution of aquatic plants (macrophytes) around Lake Malawi are poorly understood and have been identified as a priority for research (WWF 2005, Ngochera 2014). The most common emergent and floating macrophytes along the lakeshore and within the shallow fringe areas, rivers and swamps include *Phragmites mauritianus, P. australis* (reeds), *Typha domingensis* (bulrush), *Cyperus papyrus* (papyrus) and *Vossia cuspidata* (hippo-grass).

Free-floating macrophytes (*Pista stratiotes*, hyacinth, *Salvinia spp*), rooted macrophytes with leaves floating on the surface of the lake (*Nymphaea peterslane*), and rooted submerged macrophytes (*Potamogeton spp., Vallisnera spp.*) are the predominant species in the sublittoral zone.

Other noteworthy aquatic fauna associated with the freshwater habitats within and around the SEA include crocodiles, hippos, monitor lizards, terrapins, turtles and water birds such as fish eagles, gray-headed gulls, open-billed stork, pelicans, pied kingfishers, and white-fronted cormorants.

2.2 Trends in Fisheries

The SEA supports both an artisanal and larger-scale mechanized commercial fishing sector. The artisanal fisheries are multi-species and multi-gear utilizing a number of different harvesting techniques including gill nets, hooks and lines, traps, open water purse seines (i.e., nkacha, chilimira, kauni), beach seines (i.e., kambuzi and chambo), and scoop nets/dip nets (Donda & Hara 2014). The main species targeted by the artisanal fishers include *Oreochromis* species (chambo), *Haplochromis* species (kambuzi), *Engraulicypris sardella* (usipa), *Copadichromis* species (utaka), *Bargrus meridionalis* (kampango), and *Clarias gariepinus* (mlamba).

Trawling on Lake Malawi began in 1968, but really expanded in scope in the 1980s. The species initially targeted by the trawlers included *Lethrinops mylodon*, *L. macracanthus*, *Taeniolethrinops furcicauda*, *T. praeorbitalis*, *Ctenopharynx spp.* and then *Oreochromis spp.* as the aforementioned fish species either became locally overfished or were significantly reduced in number from the trawling activities (Donda & Hara 2014). Currently, small haplochromines (Mangochi District SOER, 2014) dominate the catch. The semi-industrial fishery employs mainly pair trawls in depths ranging from 18-50 meters, while the industrial fishery uses mid-water trawls and bottom-trawls with the latter typically employed in deeper waters ranging from 50-100 meters. The combined catch of the 11 pair trawlers and 10 stern trawlers rose from 3,940.74 T in 2005 to 4,877.39 T in 2010, due to increases in overall effort (Mangochi District SOER, 2014)(see Figure 2.2).

Historically, the main fishery within the whole of Lake Malawi was *L. mesops*, but heavy fishing pressure lead to the collapse of this species in the early 1970s. The *Oreochromis spp.* (chambo) fishery then dominated the catches reaching peak harvest levels of 15,000 MT/year (i.e., 70% of the total fisheries production) in the late 1980s (FAO 1993, Banda et al. 2005). Yet, by the late 1990s, the annual harvest declined by 80% to only 3,000 MT/year, and by the early 2000s, the chambo comprised only 5% to the total fisheries production (Banda et al. 2005 and GoM 2000, JICA 2005 as cited in Ngochera 2014). The declining trend in chambo throughout the lake was also observed in the SEA (Figure 2.5).

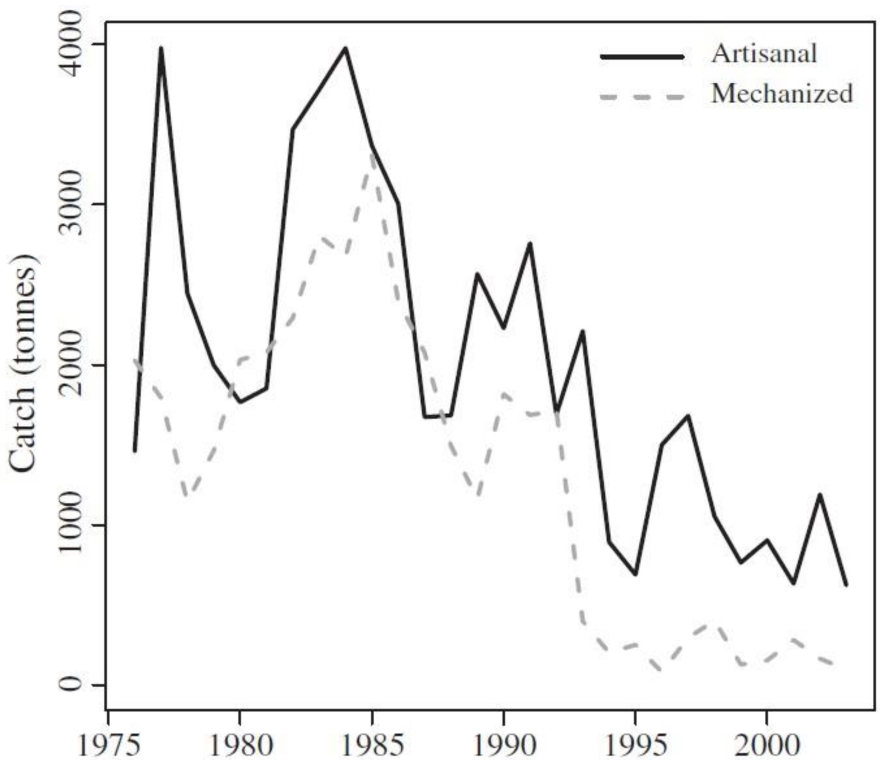

Figure 2.5: Total chambo yield (in tons) of the artisanal and commercial fisheries in the SEA
Source of Figure: Bell et al., 2012, p. 724

Following the collapse of the chambo, which like *L. mesops* was also due to overexploitation, haplochromine and the small zooplanktivorous usipa and utaka species began to dominate the catch. However, following the trend of fishing down the food web, the larger haplochromine species, such as *Lethrinops stridei* and *L. macracanthus,* have been replaced by small cichlids such as *L. auritus* and *Otopharynx argyrsoma*. The increasing abundance of usipa, utaka, and mcheni contributes to the rise in total fish production observed since 2003 (Figures 2.6 and 2.7).

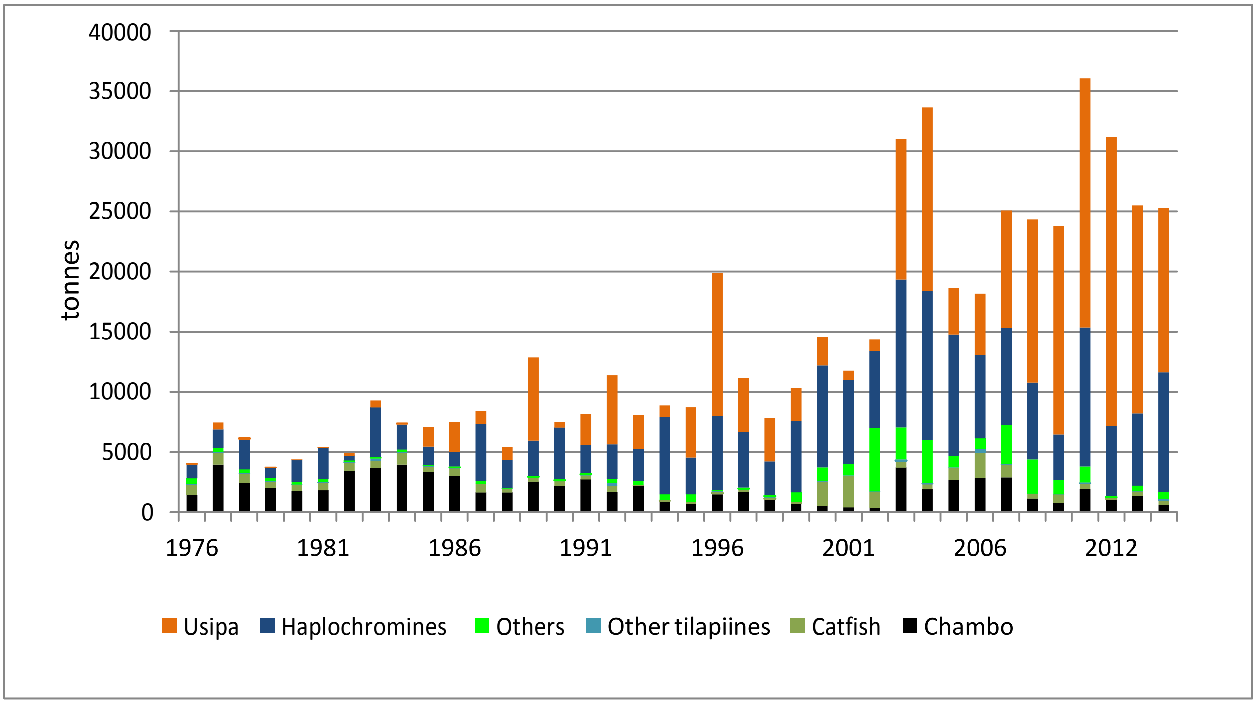

Figure 2.6: Total catch by species group in Lake Malawi (1976-2014)
Source: Jamu et al. 2011, p.3 and Department of Fisheries (2015).

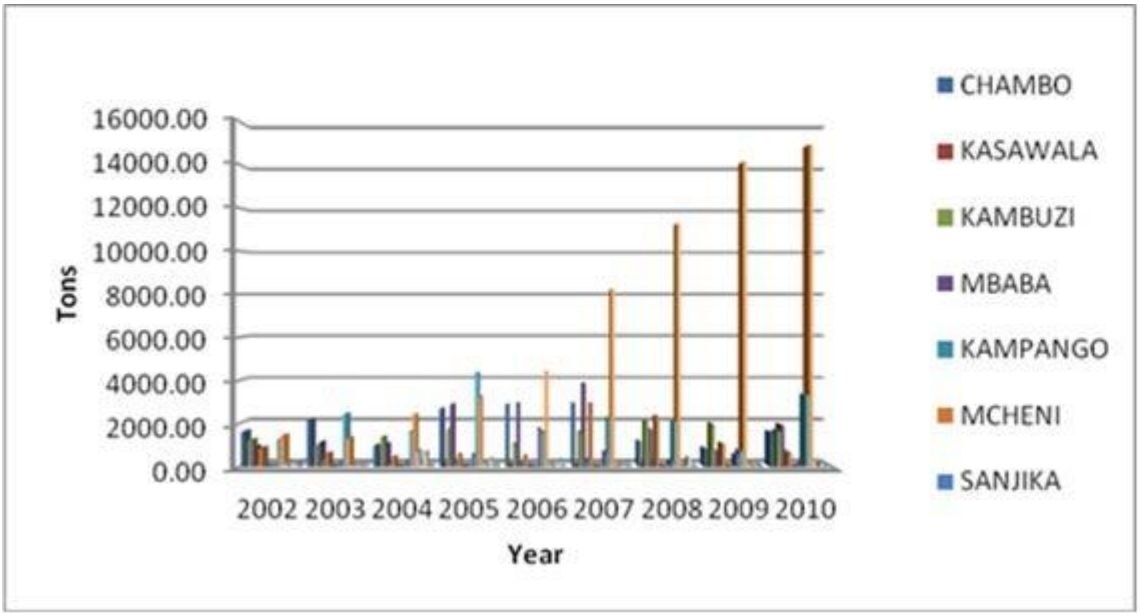

Figure 2.7: Total fish catch by species in the SEA of Lake Malawi (2002-2010)
Source: Mangochi District Profile, 2014, p. 72

Comparing the catch data for various species for Mangochi District (including Lake Malombe) from 1976 to 2014, shows that usipa has grown to dominate the fishery in metric tons. The haplochromines, including utaka and kambuzi, are also important, while chambo and other tilapia fish have seen a downward trend. The contribution of small fish species (usipa and haplochromines) has increased from 34% in 1976 to 93% of total catch in 2014. Other fish species, such as mcheni, mlamba, and nkholokolo saw an upward trend in the late 1990s and early 2000s, but have exhibited a downward trend in the last five years (Figure 2.8).

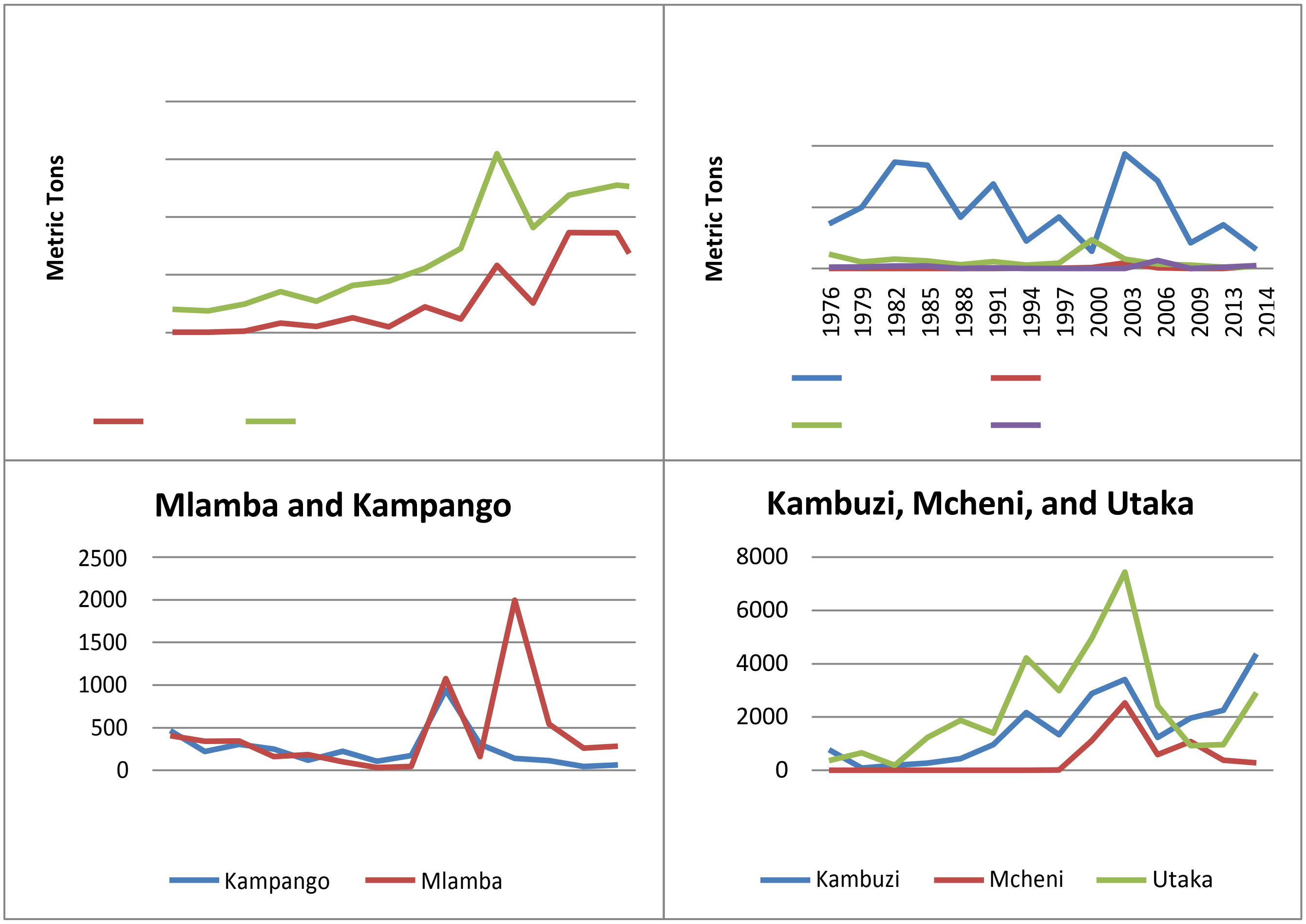

Figure 2.8: Catch statistics for Mangochi District (1976-2014)
Source of data: Fisheries Research Unit

2.2.1 Summary of Frame Survey Results

The annual frame surveys, which collect information on the dominant fishing gear, types of boats, and number of gear owners and crewmembers have been carried out every August and September since 1976. In the SEA, the number of fishers increased three-fold from ~4000 individuals in 1981 to ~12,500 individuals in 2003. Within that same timeframe, the number of boats increased from 1000 to 2500, and the number of crewmembers per boat rose from an average of 3.6 to 5 (Van Swieten et al. 2011). Over that time, the numbers of chambo and kambuzi nets declined in abundance in response to the lower chambo stocks. Use of other fishing gear—such as the chilimira nets, nkacha seines (derived from kambuzi seines), gillnets, longlines, traps, and mosquito nets—has risen as fishers have moved further offshore to target pelagic species (Figure 2.9) (Van Swieten et al. 2011).

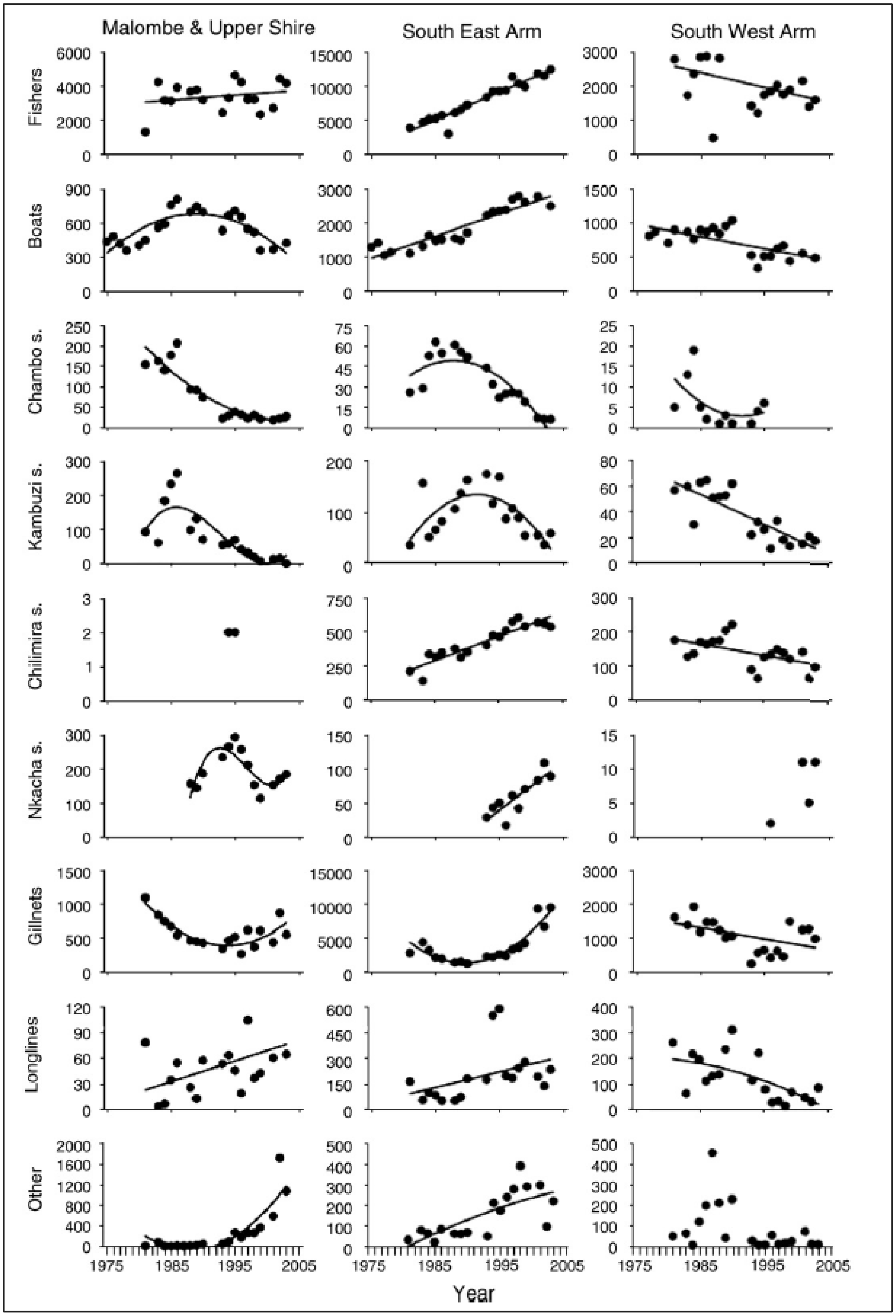

Figure 2.9: Trends in the number of fishers and types of boats/fishing gear (1976-2005)
Source of Figure: van Zwieten et al., 2011, p. 36.

The chilimira nets capture the pelagic *Rhamphochromis spp.*; longlines catch predominantly *Bagrus spp.* and *Bathyclarias spp.* and to a lesser extent *Rhamphochromis spp.,* while the handlines and mosquito nets target predatory cichlids, juvenile tilapia, usipa, and utaka, respectively.

FRAME survey data collected between 2005 and 2014 show mixed trends in the number of gear owners, crewmembers, and boat types and most fishing gear (Table 2.3). The data show that the number of boats with engines has gone up while those without engines have gone down. The number of gear owners has gone down since 2008, while the number of crew members has gone up—indicating that the crew members may be working on larger boats and nets and are also fishing offshore and targeting pelagic and deep water stocks. The change in targeting pelagic and deep-water stocks has also been documented through the ETOA PRA exercise.

Table 2.3: Estimated numbers of gear owners, crew members and fishing craft in the Mangochi District portion of Lake Malawi from 2005 to 2014

Indicator	2005	2008	2014
Gear Owners	1,664	2148	1,712
Crew Members	10,285	11,719	11,945
Plank boats with engines	267	417	527
Plank boats w/o engines	903	1,060	839
Dugout canoes	1,681	2,303	2,401

Source of data 2005, 2008, and 2014 Department of Fisheries FRAME surveys

As shown in Table 2.4, there is also a mixed trend when it comes to gear types in the Mangochi District portion of Lake Malawi between 2005 and 2014. Some gear types, such as fish traps and handlines, have reduced over time, whereas others, such as Kandwindwi nets, have gone up. Gillnets, longlines, and Chilimira nets are the most common nets.

Popular gear that is effective at collecting vast quantities of fish are the nkacha and kambuzi nets. The nkacha net is an open-water seine net with a footrope that is weighted to the bottom when in operation. Two boats and seven crew members operate the net, which is cast in a circular manner with a crew member diving down to tie the foot rope together, effectively forming a bag in which the fish are trapped. They are long nets—90-200 meters depending on the location, with the longest in the SEA of Lake Malawi. Closed seasons for use of nkacha nets are in place but are not well enforced (November to December in the SEA of Lake Malawi and October to December in Lake Malombe). These closed seasons were established to protect Chambo during the spawning period.

The kambuzi is a seine net that cast from the beach in a semi-circle using a single boat. Both sides are pulled to the beach simultaneously by two sets of people, normally requiring 6 to 20 assistants depending on the length (lengths range 50-700 meters). Maximum legal length for the SEA of Lake Malawi is 150 m.

Table 2.4: Estimated numbers of fishing gear types in the Mangochi District portion of Lake Malawi from 2005 to 2014

Indicator	2005	2008	2014
Gillnets	3,747	10,904	906
Chilimira nets	584	621	659
Chambo seines	9	196	59
Kambuzi seines	31	23	15
Nkacha nets	93	77	38
Kandwindwi nets	29	43	51
Longlines	1,030	1,437	725
Handlines	700	585	100
Fish Traps	70	58	12
Mosquito nets/Usipa Seine	181	133	167

Source of data 2005, 2008, and 2014 Department of Fisheries FRAME Surveys

2.2.2 Local Fisheries Management Practices

A number of local fisheries management practices are implemented in the SEA of Lake Malawi:

- Closure of Area A to trawling in the mid-1990s and late 2000s. It remains closed as a conservation measure. However, illegal fishing by pair trawlers was rampant until 2014 when Fisheries Association of Malawi (FISAM) started to monitor its members and sanction those who were fishing in Area A illegally. The trawlers must secure a license to fish in other sections of the SEA.
- Minimum mesh sizes for each gear type as well as maximum headline length to limit the size of the fishing nets.
- Minimum allowable catch sizes for fish species to ensure reproduction prior to harvest.
- Closed season prohibiting use of all beach seines between November 1 and December 31 to protect chambo during spawning. The ETOA stakeholder workshop proposed that the closed season should be reviewed so that it is not based solely on chambo management, but reflects the multispecies nature of the fishery. Proposals include closing Area A to all active gear (e.g. chilimira nets, etc.), and declaring this area as a sanctuary.

2.3 Primary Threats, Stressors, and Drivers to Freshwater Biodiversity

A review of the existing literature around freshwater biodiversity in Lake Malawi found that the greatest threats within the SEA of Lake Malawi include the following: overfishing, illegal fishing, declining water quality due to land use changes within the upstream catchment, degradation and loss of aquatic vegetation, the introduction of exotic species such as hyacinth, and climate change. The sporadic nature of existing biophysical data in concert with numerous factors acting together to create cumulative impacts make it difficult to assess the relative severity of these threats to the fish biodiversity within Lake Malawi (Ngochera 2014). However, as shown in Table 2.5 below, the PRA field studies and the expert feedback meeting largely identified the same threats as the literature review—reinforcing that they are very real to local communities.

Table 2.5: Primary threats, stressors, drivers, and contributing factors to Lake Malawi's freshwater biodiversity

Threats	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Overfishing	X	X	X
Illegal/improper use of gear	X	X	X
Trawlers		X	
Deforestation	X	X	
Sedimentation and soil erosion	X	X	
Invasive species (water hyacinths)	X	X	
Aquarium fishery	X		
Stressors	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Climate change	X	X	X
Climate variability	X	X	X
Drivers	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Poor education and low literacy	X	X	X
Poor governance: lack of capacity, resources, leadership, bylaws and other rules that restrict access and manages how much fish is taken out	X	X	X
Lack of power and knowledge to enforce	X	X	X
Contributing Factors	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Poverty and food insecurity	X	X	X
High population growth rates	X	X	X
Lack of livelihood opportunities	X	X	X
High postharvest losses	X	X	X

2.3.1 Overfishing

Overfishing is regarded as the major cause of low catches in Lake Malawi. It has resulted in the fishing down the food chain process described in detail in the fisheries trend section above. Fishing down the food chain means that as larger fish are overharvested and disappear, fishers resort to catching smaller fish that are lower on the food chain. However, it is difficult to pinpoint the exact extent of overfishing, because the relative fish downward catch levels coincide with a reduced water level in the lake (FAO 2005). Catch per unit effort (CPUE) rates also coincide with water level and physical chemical properties of the water (Macuiane 2006)—hence, the relative fish abundance at any given time depends on how much fish has been taken out as well as on the water level and chemical properties of the water.

According to local experts and communities, the open-access regime, which allows migrant fishers unrestricted access to local waters, and a quickly growing local population propel overfishing. Migrant fishers come into the SEA of Lake Malawi without authorization—or with the blessing of the local chiefs who look after their own interests. Almost all Lake Malawi communities mention population growth as the most important driver for overfishing—and lack of education and resistance to family planning are cited as reasons for the high population growth. Poor governance capacity contributes to the overfishing problem. Fisheries officers and BVC members lack the capacity and resources to restrict access and implement fishing regulations to manage how much fish is harvested. Bylaws have the potential to restrict access and empower the BVCs with enforcement authority. However, there are no working bylaws in place. Bylaws require District Council approval but without elected councilors, the District Councils have been dormant for a decade. With new councilors in place, it is now possible to once again develop and adopt bylaws to implement local fisheries co-management rules.

2.3.2 Illegal/improper Use of Gear

All Lake Malawi communities state that illegal and improper use of gear (illegal season of use; illegal location of use) and illegal trawler operations (time of day, location, and gear) are among the largest (if not the largest) threat to fish biodiversity and abundance. There are commercial 10 trawlers operating on the SEA of Lake Malawi. A trawler can make revenue of 1 million Kwacha in one day, yet pay no taxes, because it is not registered as a company. The license fees are minimal, and the penalties for fishing infractions are small and rarely enforced—encouraging the trawlers to fish illegally to maximize their harvest.

The continued use of illegal gear, such as the nkacha nets that were introduced by fishers migrating from Lake Malombe in 1989, have indiscriminately targeted juvenile fish seeking refuge in the nearshore shallower waters. In addition, fishers are increasingly targeting mbunas, which are sold for consumption outside the lake catchment area. In the past, mbunas were not targeted, because it was widely believed that they were inedible. However, this emerging practice could adversely affect the overall levels of biodiversity within the SEA.

The expert feedback meeting identified several issues that contribute to illegal and improper use of fishing gear:

- Lack of co-management and self-enforcement
- Inadequate financial resources of the DoF Fisheries Enforcement Unit to conduct surveillance and enforcement activities (staff, boats, fuel)

- Lack of understanding among fishing stakeholders on what represents illegal gear (and for what areas and when).

According to the local communities, poverty, population growth, and lack of education drive illegal and improper use of fishing gear. Through the PRA, local communities state that both local and migratory fishers use illegal gear. Illegal fishing is rampant because there are very few fisheries extension officers, and they do not have the capacity to enforce. In the past, some communities took it upon themselves to chase away illegal gear owners and trawlers fishing in shallow water. However, lack of compliance, acceptance of illegal fishers by some chiefs, and weak BVCs prevent enforcement. The Districts' fisheries enforcement unit is also understaffed and lacks the capacity and resources to conduct surveillance and enforce fisheries rules.

2.3.3 Sedimentation

Local communities pointed out sedimentation as a priority threat to fisheries. Focus group respondents maintain that sedimentation puts stress on multiple fish species, including mbuna, chambo, ningwi, sanjika, fwili, and mpasa. Expanding agriculture and shoreline development for tourism infrastructure have caused high levels of deforestation in the catchment surrounding the SEA and have resulted in increased rates of soil erosion, nutrient loading, and the siltation of the lake bottom (Kingdon et al. 1999 as cited in Ngochera 2014, Hecky et al. 2003, Weyl et al. 2010). In 2011, there were ~40 tourism accommodation units on the beaches adjacent to the SEA with the greatest concentration occurring along the western side (Hara et al. 2014). Many of the tourism developers have removed the aquatic macrophytes located along the fringes of the lakeshore to create beaches for their guests (WWF 2005). These losses are further compounded by the nearshore and offshore SAV and EAV removed by the seine netting. Local communities state that population growth is the largest driver of increased sediment loading, and that population pressure leads to deforestation for agriculture as well as cutting wood for sale. The resultant bare earth is exposed to the elements and erosion, leading to silt and sand entering into river systems, clogging the rivers and river mouths.

Increases in the sediment loading have the following adverse impacts on the lake ecosystem:

1. Higher water turbidity and lower light penetration, which in turn reduces the photosynthetic rates of primary producers
2. Loss of benthic habitat complexity and the smothering of important spawning grounds and feeding habitats
3. Negative impacts on the reproductive behavior of haplochromine cichlids that rely highly on visual cues for mate selection (Lévêque 1995, Munthali 1997, Bootsma and Hecky 1999, Weyl et al. 2010).

As discussed previously, the stenotopic nature of the rock-dwelling mbuna and their reliance on the algae species growing on the rocks render these species particularly vulnerable to increased levels of sedimentation. The mbuna respond to losses in habitat and declining food availability by migrating upwards into shallower waters, which leaves them much more susceptible to predation (Higgins et al. 2001 as cited in Ngochera 2014).

The increased loadings of nitrogen, phosphorus, and other nutrients via the inflowing rivers and atmospheric deposition from biomass burning within the catchment can increase the rates of primary production for the small pelagics. However, excessive amounts can lead to eutrophication and changes in phytoplankton species composition, which in turn can adversely impact the higher trophic levels, by for example disrupting breeding habitats.

2.3.4 Invasive Species

Multiple local communities state that water hyacinth, *Eichhornia crassipes*, pose a threat to freshwater biodiversity, because it has the ability to out-compete native vegetation and grow profusely in shallow waters and bays. It was introduced accidentally into Malawi in the 1960s and has become more prevalent over time in the tributaries flowing into the SEA (Phiri et al. 2001, Ngochera 2014). Within the lake itself, water hyacinth is not very abundant, which is likely due to the lower nutrient concentrations within the open waters of the lake (Bootsma and Harvey 1999). However, it does have the potential to become problematic in the future, especially within the SEA because of the relatively higher nutrient concentrations found there versus other sections of the lake. Local communities dislike the water hyacinths because they harbor crocodiles, which make physical removal difficult, and because fishing nets get tangled up in the vegetation. The expansion of water hyacinth could have serious implications for biodiversity as the lake's richest fish communities are found in the nearshore zone of the Southeast Arm.

2.3.5 Climate Change

Next to overfishing and illegal/improper use of fishing gear, climate change is the most important threat mentioned by Lake Malawi communities. The ETOA research finds that climate change contributes to varying and uncertain rainfall patterns, heat waves, flooding, and drought and more storms. Community members state that rains are less predictable, with both droughts and flooding being more common. They also mention that the winds have changed, and that the strong Mwera winds are more common and unpredictable throughout the year—making fishing more difficult and hazardous on the lake. The literature review finds that climate warming might have important consequences on Lake Malawi's pelagic ecosystem. Reduced mixing has been reported for Lake Malawi, where deep water renewal rates measured in 1997 were less than half of what they were in 1976 (Vollmer et al. 2005 as cited in van Zwieten et al. 2011). Although climate change impacts on biodiversity are difficult to isolate (Ngochera 2014), changes in both air and water temperature have influenced the productivity of the lake in the past (Msiska 1998, Bootsma 2006). Records indicate that the deep waters of Lake Malawi have warmed 0.29 °C since 1953 (Beauchamp 1953, Patterson and Kachinjika 1995) and that the water levels have dropped from 477 m above sea level in the 1980s to ~474.8 m in the last three decades (Kumambala et. al., 2010). Local communities maintain that the lake level drop has negative consequences as it shrinks the shallow breeding and nursery grounds. Scientific evidence supports this, showing high lake levels increase areas available for fish spawning and nursing (Bell et al., 2012). Other records show that between 1939-1999 average water temperatures warmed from 22.02 °C to 22.74 °C; these small changes influence the nutrient cycle (Vollmer et al. 2002), due to the increased stratification of the water column. Hence, small changes become significant during cold and windy times of the year, affecting the phytoplankton and fish productivity (Bootsma 2006).

Over the next century, the air temperature is predicted to increase approximately 4° C in this part of Africa (Bootsma 2006). Parallel to changes in temperatures, rain patterns are changing. Historical records show that small increments on the rate of precipitation can cause severe flooding, as seen in 1979-80. On the other hand, decreases in the ratio of precipitation have closed the outflow of the lake, as seen in 1915 and 1937 (Kidd 1983) and a near close in 1997 (Boostma 2006). Additionally, increased rainfall increases run-off, triggers sediment and silt loading that changes turbidity, alters the photosynthetic rate in the lake, and can directly smother habitats and interfere with some of the fish reproduction and their behavioral cues (Lévêque 1995, Bootsma and Hecky 1999, Weyl et al. 2010). At the same time, it adds to a nutrient re-charge that boosts production. According to local communities, increased intensity of rains in combination with unsustainable cutting of trees and poor catchment agriculture practices have led to increased sedimentation, which communities perceive as having negative consequences for the fish ecosystems, by, for example destroying fish breeding and nursery grounds and reducing aquatic productivity. Poverty, population growth, and lack of alternative livelihoods make local communities more vulnerable to climate change—and contribute to both overfishing and clear cutting as fisheries and forestry are two of the more lucrative livelihoods available to the resource-dependent communities.

2.3.6 High Rates of Post-Harvest Loss

Extensive post-harvest losses reduce the quantity and quality of fish available to consumers and the income of fishers and actors in the fish value chain. The loss in nutritional value also has consequences for human health and well-being. It is estimated that as much as 40% of the fish caught in Malawi is lost due to improper handling along the fish value chain and poor fish processing techniques. The post-harvest loss problem increased as the target species composition shifted from large cichlids, catfish, and cyprinids to smaller fish species, such as Usipa and Haplochromines.This has implications for fish post-harvest losses since almost all the small pelagic fish are sold sun-dried, parboiled/fried, or smoked. In contrast, Chambo is mostly sold fresh (and iced) because it is a high-value species that meets local demand for fresh fish and can fetch a premium.

Experts maintain that post-harvest losses of usipa and other small pelagic fish are due in part to the crushing of fish at the bottom of boats and decomposition due to the long time on the water before landing. Losses occur when it is windy because boats cannot make it back to the landing site. As a result, they must land and sell at a low price somewhere else. However, the largest post-harvest losses occur after the fish are landed. Fish are most abundant during the three months of rainy season, and this is when fish loss is very high. Usipa are highly perishable, and in the rainy season, a high percentage rots during cloudy days before it is processed and marketed.

2.3.7 Aquarium Fish Collection

A threat to fish biodiversity that came out only through the literature review is aquarium fish collection. Five companies target the rock-dwelling cichlids, the mbuna along the rocky shores of the lake and around the islands for the export market. The statistics from the Malawi sector indicate that ~50,000 individuals are exported annually (WWF 2005). The fish collection sometimes results in the relocation of ornamental fish from their natural habitats (Ngochera 2014).

2.4 Opportunities for Action/Management Suggestions

2.4.1 Improving Fisheries Governance

To reduce overfishing and illegal and inappropriate use of fishing gear, it is essential to improve fisheries co-management and either limit fisheries access (e.g. closed areas, closed seasons, limited issue of fish licensing/user fees, etc.) or restrict how much fish is taken out (e.g. by limiting size, instituting quotas, and implementing monitoring, surveillance, and enforcement). Although legislation supports co-management, it has been very difficult to implement effectively in the SEA of Lake Malawi. Fisheries governance would greatly improve if BVCs managed to adopt the six policy steps that are considered essential for effective fisheries co-management at the village level:

1. Work with BVCs to register as CBOs
2. Define the boundaries for the BVCs area of authority
3. Implement community based monitoring, including stock assessments to establish baselines
4. Develop a management plan that outlines that goals and objectives of fisheries management
5. Develop bylaws to implement the management plan
6. Develop an agreement between the BVC and the DoF signed by the Director.

The election of new District Councilors eliminates one hurdle, and it is once again possible to pass fisheries bylaws. Following the advice of Hara (2015), a solution could be to limit access and implement a system of individual quotas or fishing rights managed by the BVCs in collaboration with the DoF. Restricting access would be controversial and would require shifting the current attitude towards limiting open access fishing. It would also require centralizing the fish landing to a few centralized sites for better ease of monitoring and control.

Strengthening the BVCs to manage the fishery more effectively would be less controversial. Local communities maintain that the BVCs would become more effective if they had identity cards, uniforms, and boats with engines for patrols. The communities believe that closed seasons and gear restrictions (to prevent the use of illegal gear) are the best ways to manage the fishery, and they would like assistance in strengthening the BVCs to allow them to work effectively. One community suggests that illegal gear should be confiscated and destroyed rather than allowing the culprits to have the gear returned for further use after paying a small fee. Actions, such as establishing fish sanctuaries and brush parks, might also help by protecting fish habitats. The BVCs need capacity development in fisheries co-management, learning how decentralization works and what the roles and responsibilities of various stakeholders are in the management process, i.e. mainstreaming fisheries co-management in the LGA structure from VDC, to ADC to DDP process. As part of strengthening their leadership, the BVCs must receive the tools to help them manage corruption. Any training should include the Chiefs, to ensure that they understand the importance of limiting access and working with the BVCs to prevent migrants to fish freely with illegal gear in community waters.

Local communities also suggest that the government should ensure that commercial trawlers respect existing fisheries regulations. Following this, local experts propose that trawler company registration should be a condition of fish licensing. The Fisheries Association Constitution should be reviewed and revised. It may help if the BVCs are empowered to inspect and help enforce the rules that apply to trawlers. Local communities went as far as to state that the BVCs should be empowered to revoke fishing licenses when trawlers encroach in shallow areas. Since trawlers are managed at a higher level, this might not be possible. However, the Government could create a forum that brings the commercial and artisanal fishers together to bridge the gap between the two entities and make the regulations for each type of fishery clear to both groups. That may make it clear when trawlers actually break rules and when they are actually within their legal rights (e.g. to fish in deeper waters during times when shallow areas are closed to fishing). It could also help create a dialogue between the artisanal and commercial fishing interests to advance co-management—and obtain more-transparent information about catch volume and composition.

2.4.2 Addressing Habitat Destruction and Climate Change Threats

Local communities make a link between climate change and increased erosion/sediment and silt loading. Experts agree that although the increase in sedimentation is primarily linked to deforestation, it is certainly exacerbated by the more intense rains and floods experienced in the area. To protect fisheries-ecosystem habitats, it is important to address sediment loading. Local communities suggest such action as tree planting on deforested areas—especially on mountain slopes and along river banks (including the provision of tools and equipment and establishing tree nurseries); planting elephant grass on farmlands and along rivers; implementing bylaws that prevent deforestation along the riverbanks; educating communities on forest management; forming/strengthening village natural resources conservation committees VNRMC; and providing loans to start small-scale businesses to reduce pressure on forestry. Several communities already are planting trees along riverbanks and on mountain slopes, but it is not clear what the success rates have been of these initiatives.

Past practices used to manage water hyacinths include physical removal of the plants that are closer to the beach. Local communities suggest reviving a moribund water hyacinth control program.

Local communities also suggest training and education on climate change effects and adaptation options that include school education programs, awareness-raising campaigns, and workshops that bring knowledgeable scientists to user groups and management committees. Beyond village level, there is a need for a mapping and GIS database development for climate change adaptation planning with maps and products suitable for use at local, sectoral and national levels. These tools may be helpful in the development of more integrated risk assessments to better account for risk factors, such as environmental degradation. For example, direct measures of the effects of habitat degradation on erosion and on the connection with fisheries and food security are needed. For example, better understand is needed on (i) the linkages between sedimentation and the destruction of spawning and nursery areas; (ii) requirements for successful spawning and growth of fish and (iii) the linkages between more nutrient rich waters and the growth of forage fish.

2.4.3 Addressing Socio-economic Drivers (Population Growth, Poverty, and Lack of Livelihood Options)

Local communities and experts cite hunger, poverty, population growth, lack of livelihoods, and illiteracy as root causes to resource degradation. The SEA of Lake Malawi struggles with high population density and growth rate, declining agricultural production, and low resilience to climate change, all of which exacerbate food insecurity, environmental degradation and poverty. Households are highly dependent on farming, fisheries, local wood sources, and other natural resources for their food and livelihoods. Priorities of local communities include addressing population growth by requiring the government to increase access to family planning commodities, supporting adult literacy, introducing school feeding programs, and developing bylaws to address child labor issues. Government should connect with partner projects, such as FISH, FP/SRH, ASPIRE, and those that have a mandate to promote the adoption of positive sexual and reproductive health behaviors and encourage girls' empowerment and education.

It is the poorest and most marginalized who are least able to adapt and are most vulnerable to climate hazards and impacts. To create resilient communities, it is essential to address poverty. One approach to minimize coastal ecosystem threats is to promote enterprise development that is compatible with natural resources management efforts. These are enterprises that depend on intact biodiversity, natural resources and the environment, and that therefore motivate small enterprise operators to protect these resources from internal and external threats. It is important to note that an enterprise on its own will generally not achieve conservation goals in a region. It is the overall plan for conservation, of which the conservation enterprise is a component, which will determine its success. Examples of conservation enterprises include:

- Climate smart agriculture, which integrates soil and water conservation, watershed management and ecosystem management
- Beekeeping
- Community-based ecotourism
- Sustainable aquaculture
- Agroforestry
- Adding value to existing managed small-scale fisheries (e.g. reducing post-harvest loss by promoting the use of improved energy efficient fish smokers and solar fish dryers).

Among these livelihoods that local communities indicate interest in are improved agriculture, aquaculture, agroforestry, and value chain improvements.

Value can be added to existing livelihoods in fisheries in three different ways:

1. Reduce spoilage and improve product quality (provide ice/cooling facilities on boats; reduce time from catch to market; improve hygiene and sanitation on boats and at market)
2. Improve processing (improved smoking, fuel-efficient cooking stoves and solar drying techniques; refined products: fish sausage, canning, etc.)
3. Increase price by niche labeling and marketing "better" products (create a local brand name that links product to a fisheries management/sustainability program, fair trade, certification).

To add value to the current fishery, the local communities would need the following types of support:

- **Tools and structures:** ice, freezers, water, latrines, structures to handle fish so that they are not crushed onboard the vessels and when landed, smokers, solar dryers, etc.
- **Training:** technical trainings, financial literacy, business management
- **Social organization:** producer and marketing organizations and cooperatives
- **Access to capital:** grants, loans, conditional cash transfers.

Recognizing these needs, the local communities maintain that they need tools and technologies to keep fish cold, better warehouses, and dryers and smokers to improve fish preservation.

Additionally, they have request training in how to preserve and add value to their fish products—as well as access to capital.

In terms of agriculture, local communities are interested in scaling up current irrigation schemes that use water pumps. They are also interested in adopting drought-tolerant crops and seedlings.

When planning a conservation enterprise strategy, it is critical to explore potentially feasible enterprises and the causal theory that links those enterprises with the resolution of biodiversity threats, conservation, and quality-of-life goals. It is also critical to conduct feasibility studies to ensure the proposed enterprise is viable. A common mistake when selecting conservation enterprise is failing to determine whether there are markets for the goods and services that will be produce —or failing to properly train the entrepreneurs in marketing and sales.

Local communities state the need for microfinance to enable investments in microenterprises. Microfinance has the potential to increase resilience by providing financial literacy, providing access to savings and loans, and encouraging long-term behaviors. Three types of microfinance that the project could support are:

- **Village Savings and Loans Associations (VSLAs)** require group participants to contribute a regular amount of funds each week or month. The group members take turns collecting the full contribution of all members.
- **Community savings and credit cooperatives** are cooperative financial institutions that provide savings and credit services to individual members. As cooperatives, the members own the institution; with each member have the right to one vote in the organization. These entities are legally constituted and fall under national cooperative legislation.
- **Village banks** are community-managed credit and savings associations that often target female participants. Sponsoring agencies, such as FINCA, provide seed capital to the bank, which in turn lends money to its members. All members sign the loan agreement to offer a collective guarantee. The sponsoring agencies usually provide loans for income-generating activities as well as incentives to save money, as well as a mutual support group of 30 to 50 people. Members' savings stay in the village bank and finance new loans.

Although only about 1% of the population in the Mangochi District has accessed savings and credit products, several projects and community initiatives support a multitude of microfinance institutions and schemes, including those implemented by current FISH project partners.

3 LAKE MALOMBE

Lake Malombe, a natural impoundment of the Upper Shire River, is located approximately 16 km downstream of the outlet of Lake Malawi between 14° 30'S and 14° 45'S and between 35° 12'E and 34° 20'E, and has a total surface area of ~390 km^2. It is 30 km long and 15 km wide with an average depth of 5 to 7 meters (Jamu et al. 2011). The lake is polymictic (fully mixed) as the shallow depths permit complete mixing by the wind and frequent recycling of nutrients from the sediments. This, in combination with the input of nutrient rich waters from the SEA via the Shire River, results in high fisheries productivity. The lake's fish yield in 2009 was 77 kg/ha/yr (Guildford et al. 2009 as cited in Jamu et al. 2011).

The total catchment area surrounding Lake Malombe is 3,387 km^2 (WWF 2005). Liwonde National Park, which is located in the southeast portion of the catchment, comprises approximately one-third of the catchment area. The vegetation along the lakeshore is composed of swamps (e.g., *Phragmites australis* (reeds), *Typha domingensis* (bulrush), *Cyperus papyrus* (papyrus), *Vossia cuspidate* (Hippo grass), *Pennisetum purpureum*), interspersed with hyacinth, scrubs and woodlands. The predominant vegetation types along the northeastern and western sides of the lake are woodland, scrub, and thicket, while the southeastern side of the lake has scattered patches of mopane woodland (WWF 2005). The surrounding plains are cultivated with crops such as maize, cassava, groundnuts, and cotton.

3.1 Biodiversity Hotspots

3.1.1 Fish Diversity, Abundance and Distribution

A total of 47 species has been documented within Lake Malombe belonging to the Anguillidae, Bagridae, Characidae, Cichlidae, Claridae, Cyprinidae, Mastacembelidae, Mochokidae, and Mormyridae families (WWF 2005). Historically, the highest abundance of kasawala, juvenile chambo, was observed within the Upper Shire River prior to the chambo collapse in the late 1980s as the water receded from the adjacent floodplains during the dry season. Most of the kasawala migrated towards Lake Malombe, but it is unclear whether these migration patterns still exist given the large reduction in the chambo stocks in the Upper Shire River between the early 1970s to early 1990s (FAO 1993). All three species of chambo (*Oreochromis karongae*, *O. lidole* and *O. squamipinnis*) are found within the lake's clear water located near the Shire River inlet. Numerous species including mlamba, mpasa, mphuta, nkholokolo, ntchira, sanjika, and silibanga are present in the inflowing and outflowing rivers. Usipa is concentrated within the Upper Shire River and northern section of Lake Malombe while sapuwa and matemba are found predominantly within the middle and southern sections of the lake, respectively. Utaka is particularly abundant within the eastern portion of the lake while ncheni have been documented within the SAV as well as the Upper Shire River and Chia Lagoon (Turner et al. 2001). Other species such as kambuzi and kampango are distributed throughout the entire lake.

3.1.2 Habitat Types

The bottom substrate of Lake Malombe is muddy, and with the exception of the area closest to the Shire River inlet, the water is quite turbid (personal communication, G. Kanyerere). The deepest section of the lake coincides with the geological formation of the historic Shire riverbed, while the shallowest areas are located along the western and southeastern shoreline (Figure 3.1). The lake was historically covered in dense beds of oxygen weeds (Tarbit 1972), but only small, thin bands of continuous EAV remain along the northeastern, eastern, and southwestern shoreline. Similarly, the SAV has been reduced to a small number of patches coinciding with the shallower areas of the lake (Figure 3.1).

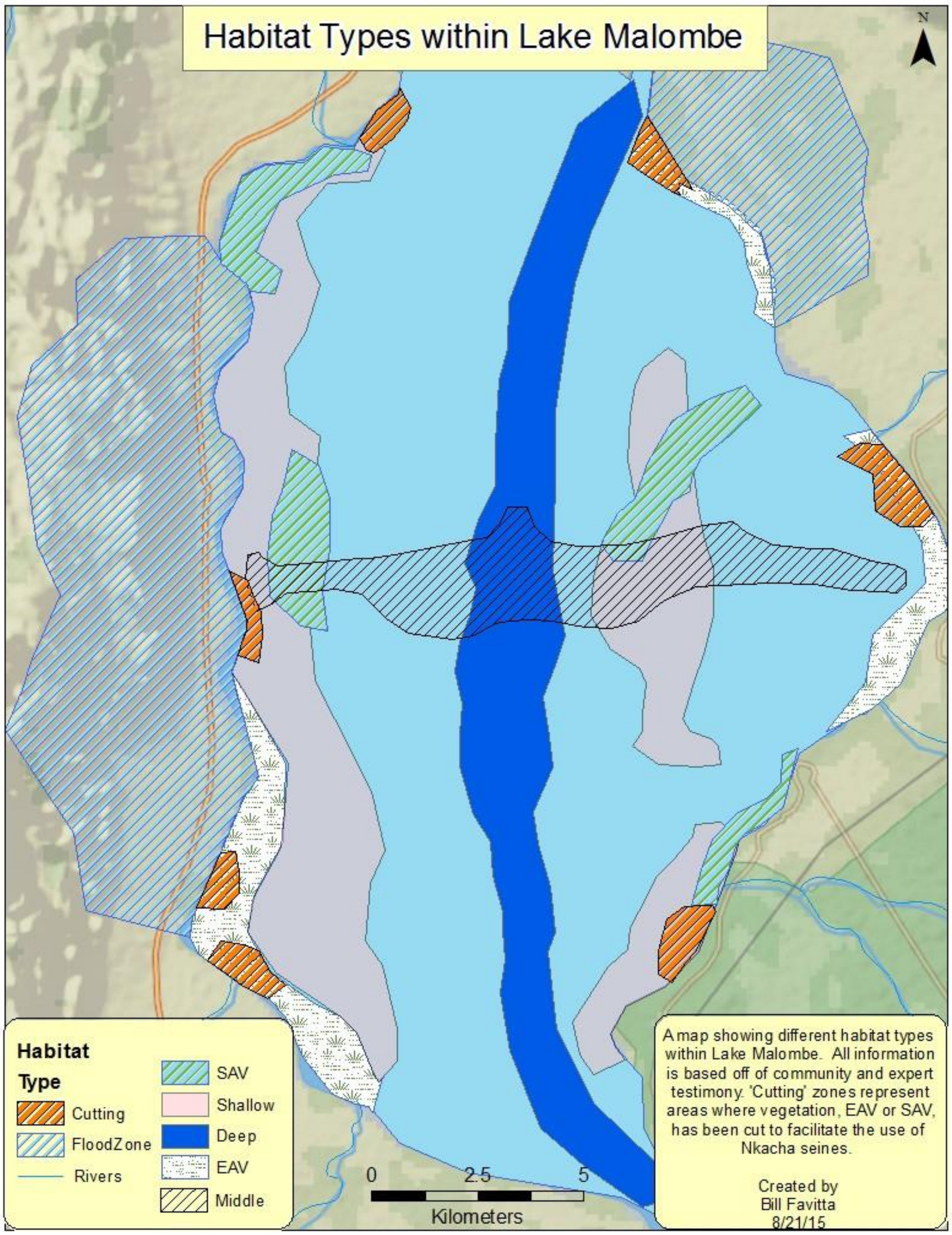

Figure 3.1: Distribution of habitats within Lake Malombe based upon local ecological knowledge gathered from community PRA assessments and local expert workshop

3.1.3 Breeding Habitats

The emergent and SAV within Lake Malombe as well as the inflowing rivers all serve as very important breeding habitats for a wide array of species including chambo, kambuzi, mbaba, mlamba, nkhalara and silibanga. High levels of chambo breeding activity, especially *Oreochromis karongae*, were historically observed from July to December in Lake Malombe (FAO 1993). However, the removal and degradation of the aquatic vegetation over time due to cutting and damage from fishing equipment has adversely affected the chambo stocks by reducing the total area of available breeding habitat. Many *Lethrinops spp.* (kambuzi) have been observed breeding over sandy shores (FAO 1993), and a study conducted by Jambo and Hecht (2001) found high abundances of breeding female kambuzi in areas with muddy substratum and aquatic macrophytes. Species such as makumba, matemba, nkholokolo, phuta, and sanjika were reported during the PRA with communities to breed in the emergent vegetation and inflowing rivers while the mpasa and samwamowa (*Mormyrus longirostis*) were reported to breed in SAV and inflowing rivers (Table 3.1).

3.1.4 Nursery Grounds

The female chambo release and protect their fry in nearshore shallow water macrophyte habitats. Observations made during a 1993 FAO study found chambo fry up to 7 cm (kasawala) in length gathered in large shoals at depths less than one meter, and fry 7-15 cm in length most abundant in water depths of a few meters concentrated around SAV. EAV was widely reported during the PRA activities and confirmed by the local experts to serve as essential refugia to an assortment of species including kambuzi, kampango, matemba, mbaba, mlamba, mpasa, nkhalara, sanjika, silibanga, and usipa. River inlets/outlets and shallower sections of the lake also provide important nursery habitat to a number different species (Table 3.1 and Figure 3.2).

3.1.5 Juvenile and adult feeding habitat

Similar to the patterns described above, many of the fish inhabiting Lake Malombe continue to use the EAV, SAV, river inlets/outlets and shallow areas during their juvenile and adult stages (Table 3.1). Certain species such as chambo, kambuzi, kampango, mbaba, mlamba, samwamowa and usipa are reported to utilize a range of habitat types during their juvenile and adult stages while others such as bluefish, dondolo, mpasa, mphuta, ncheni, ningwi are restricted to only one or two specific types of habitat (Table 3.1).

Table 3.1: Summary of key habitats for critical life stages of the main fish species groups within Lake Malombe

Species	Breeding Habitat	Nursery Grounds	Juvenile Habitat	Adult Feeding Ground
Bluefish *Copadichromis chrysonotus*	Middle of the lake	Shallow areas, SAV	Middle of the lake, deep areas	Middle of the lake
Chambo/kasawala *Oreochromis lidole,* *O. squamipinnis,* *O. karongae*	EAV, SAV, river inlets/outlets, shallow areas	EAV, SAV, shallow areas	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas
Chimbenje *Fossorochromis rostratus*	Shallow areas, SAV	Shallow areas	River inlets/outlets, shallow areas	SAV, river inlets/outlets
Dondolo *Docimodus spp.*	EAV, SAV, shallow areas	Shallow areas	Shallow areas	Shallow areas
Kadyakoro	River inlets, rivers	Rivers/inlets, shallow areas	River inlets/outlets, shallow areas	River inlets/outlets, shallow areas
Kambuzi *Lethrinops spp.* *Otopharynx spp.*	EAV, SAV, shallow areas, middle of the lake	EAV, SAV, shallow areas, middle of the lake, deep areas	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas
Kampango *Bagrus meridionalis*	Shallow areas, middle of the lake	EAV, shallow areas, middle of the lake, deep areas	EAV, middle of the lake, deep areas	EAV, SAV, middle of the lake, deep areas

Species	Breeding Habitat	Nursery Grounds	Juvenile Habitat	Adult Feeding Ground
Makumba *Oreochromis shiranus*	EAV, river inlets/outlets, shallow areas	Shallow areas	EAV, shallow areas, rocky areas	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake
Matemba *Barbus paludinosus*	EAV, river inlets/outlets, shallow areas	EAV, SAV, river inlets/outlets	SAV, river inlets/outlets, shallow areas	SAV, river inlets/outlets, shallow areas
Mbaba *Lethrinops spp.* *Protomelas spp.*	EAV, SAV, river inlets/outlets, middle of the lake	EAV, SAV, shallow areas, middle of the lake	Shallow areas, deep areas	River inlets/outlets, shallow areas, middle of the lake, deep areas
Mlamba/bombe *Clarias gariepinus and Bathyclarias spp*.	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas
Mpasa *Opsaridium microlepis*	SAV, river inlets/outlets	EAV, shallow areas	River inlets/outlets, shallow areas	Shallow areas
Mphuta *Marcusenius macrolepidotus*	River inlets/outlets	River inlets/outlets	River inlets/outlets, middle of the lake	EAV
Ncheni *Rhamphocromis spp.*	Middle of the lake	Middle of the lake, deep areas	Middle of the lake, deep areas	Middle of the lake

Species	**Breeding Habitat**	**Nursery Grounds**	**Juvenile Habitat**	**Adult Feeding Ground**
Ningwi *Labeo cylindricus*	SAV, river inlets	SAV, Middle of the lake	SAV	SAV
Nkhalara *Brycinus imberi*	EAV, SAV, river inlets/outlets	EAV, SAV, river inlets/outlets, shallow areas	EAV, river inlets/outlets, shallow areas	EAV, SAV, shallow areas
Nkholokolo *Synodontis njassae*	EAV, river inlets/outlets, shallow areas	SAV, shallow areas; deep areas	SAV, river inlets/outlets	EAV, SAV, river inlets/outlets
Nchila *Labeo mesops*	River inlets/outlets, deep areas	Shallow areas, SAV	SAV, river inlets/outlets, shallow areas	SAV, river inlets/outlets
Phuta	EAV, river inlets/outlets	Shallow areas	SAV	River inlets/outlets, shallow areas
Sanjika *Opsaridium microcephalum*	EAV, river inlets/outlets	EAV, SAV, shallow areas	River inlets/outlets, shallow areas, middle of the lake, deep areas	River inlets/outlets, shallow areas
Sapuwa *Bathyclarias nyasensis*	Middle of the lake	Middle of the lake	Middle of the lake	Middle of the lake
Silibanga	EAV, SAV, river inlets/outlets, shallow areas	EAV	EAV, shallow areas	EAV, SAV, river inlets/outlets
Solomon fish (samwamowa)	SAV, river inlets/outlets	SAV	River inlets/outlets, shallow areas, middle of the lake, deep areas	SAV, deep areas

Species	Breeding Habitat	Nursery Grounds	Juvenile Habitat	Adult Feeding Ground
Usiliwa	EAV	Middle of the lake, shallow areas, deep areas	Shallow areas	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas
Usipa *Engraulicypris sardella*	EAV, shallow areas, middle of the lake, deep areas	SAV, shallow areas	SAV, shallow areas, middle of the lake, deep areas	EAV, SAV, middle of the lake, deep areas

Note: The sources of the tabulated data include peer-reviewed literature, the community PRA exercises and expert validation

HIGH BIODIVERSITY AREAS WITHIN LAKE MALOMBE

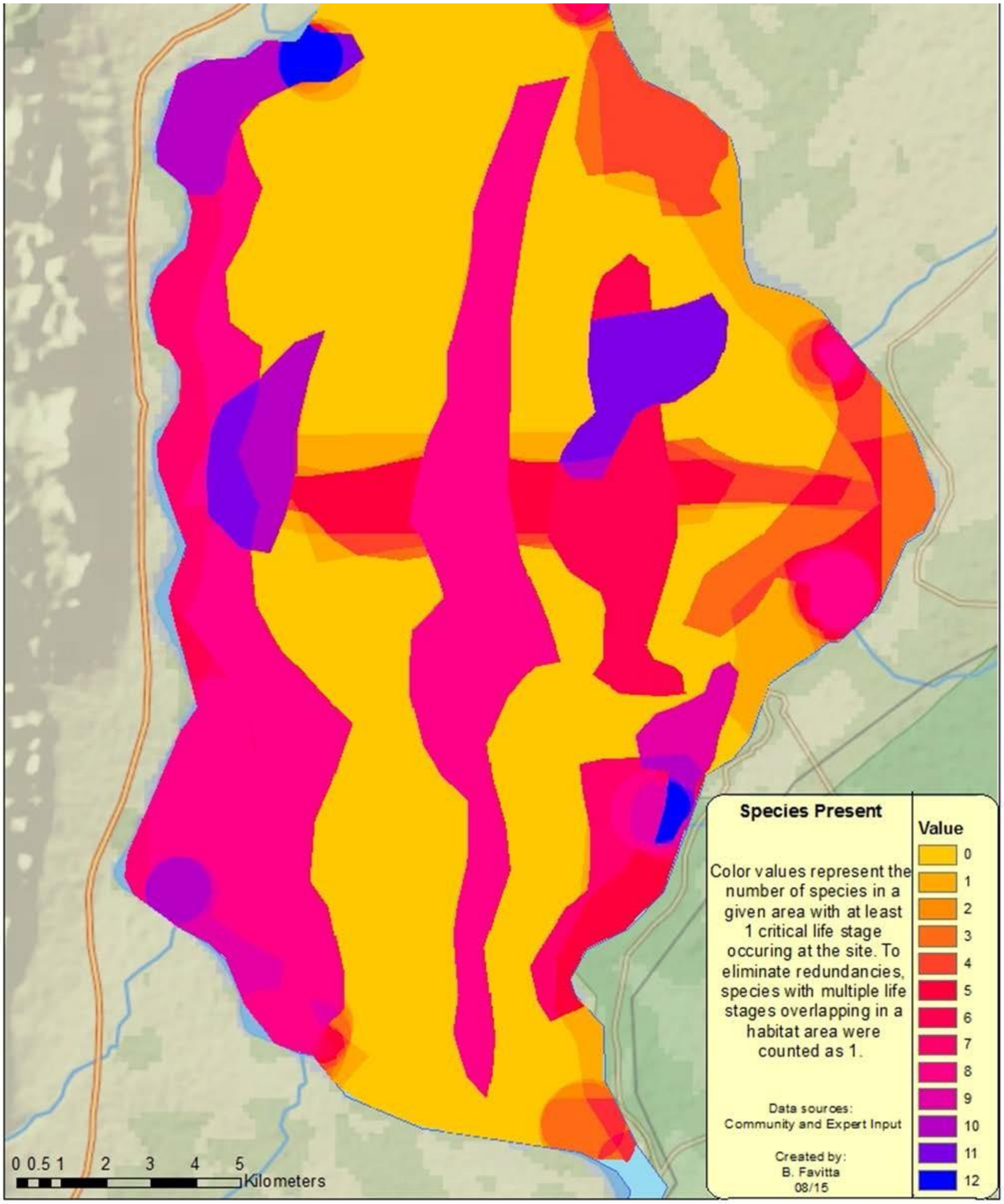

Figure 3.2: High biodiversity areas map based on community perceptions and validated by local experts. The different colored areas represent the different habitat types where the important fish species are found within Lake Malombe.

The above map highlights species rich zones within Lake Malombe. The different colors on the map represent the cumulative score of fish species harvested by the local communities with at least one critical life stage occupying the given habitat area. Life stages are all given a value of one and are not weighted (i.e., the multiple life stages of a single species coexisting within a habitat area are not double counted). The highest species richness areas are found in the vicinity of the river inlets followed by the shallow areas with submerged and EAV (Figure 3.2).

3.1.6 Fish Sanctuary – Liwonde National Park

Liwonde National Park, which was established as a game reserve in 1969 and upgraded to national park status in 1973, contains 584 km^2 of protected forest, savannah, and riverine habitat. According to the National Parks and Wildlife Act of 1992 and the National Parks and Wildlife Regulations of 1994, section 6-j, "all fishing, hunting, and harvesting of any resources, alive or dead, within the national parks is prohibited. It is also illegal for individuals, with or without vehicles, to occupy park waters without explicit permission from a Park Wildlife Officer or utilizing an entrance/exit site designated by said park officers." The penalty for not abiding by the park regulations is a 200-500 Kwacha fine and three months of imprisonment for a first offense and 500-1,000 Kwacha fine and six months of imprisonment for subsequent offenses.

3.1.7 Other Aquatic Biodiversity

The dominant phytoplankton within Lake Malombe are *Surirella* and *Aulacoseira* while *Bosmina* and *Mesocyclops* dominant the zooplankton community. The vegetation along the lakeshore is comprised of *Phragmites australis* (reeds), *Typha domingensis* (bulrush), *Cyperus papyrus* (papyrus), and *Vossia cuspidate* (Hippo grass). Other noteworthy aquatic fauna associated with the freshwater habitats within and around Lake Malombe include amphibians, crocodiles, monitor lizards, snakes, turtles, hippos, otters, and water birds. According to the local communities, the highest concentrations of crocodiles, monitor lizards, turtles, hippos and otters are found in and around the river inlets and outlets. The hippos also congregate in the shallow areas of the lake and river while the crocodiles re reported to prefer the deeper areas of the lake. The turtles are being harvested and exported to China, but a ban is now in place and is being followed (personal communication, G. Kanyerere).

3.2 Trends in Small Scale Fisheries

Artisanal fishing commenced in Lake Malombe in the 1960s after the large crocodile population was eradicated (Tweddle et al. 1994). In the 1980s, the Lake Malombe fishery comprised approximately 15% of the country's total fish landings with *Oreochromis squamipinnis* and *O. karongae* constituting the majority of the catch (FAO 1993). However, the total catch levels fell from ~13,000 MT/yr in the early-1980s to ~2000 MT/yr by 2007. Within the past five years, the total catch levels have fluctuated between 3,530 MT/yr to 4,575 MT/yr (Figure 3.3).

This declining trend was due in large part to the significant reductions in the chambo population (i.e., a 98% reduction from a peak catch of 8,000 MT/yr in 1982 to less than 200 MT/yr in 2003 (Jamu et al. 2011). Over 90% of the reduction occurred between 1981 and 1991, a time period corresponding to a 320% increase in the number of kambuzi and nkacha seines (FAO 1993). Both of these nets have small mesh, and the collapse of the chambo has been attributed to the high exploitation rates of juveniles and spawners as well as the removal of important inshore and offshore weed beds by the beach seines lowering the total area of available critical life stage habitats (FAO 1993, Mangochi District Profile 2014). Other factors that may have contributed to the decline include decreasing water levels due to reduced rainfall and increasing silt load (van

Zwieten et al. 2003 as cited in Jamu et al. 2011, and Banda et al. 2002; Zwieten et al. 2003, as cited in van Zwieten et al. 2011).

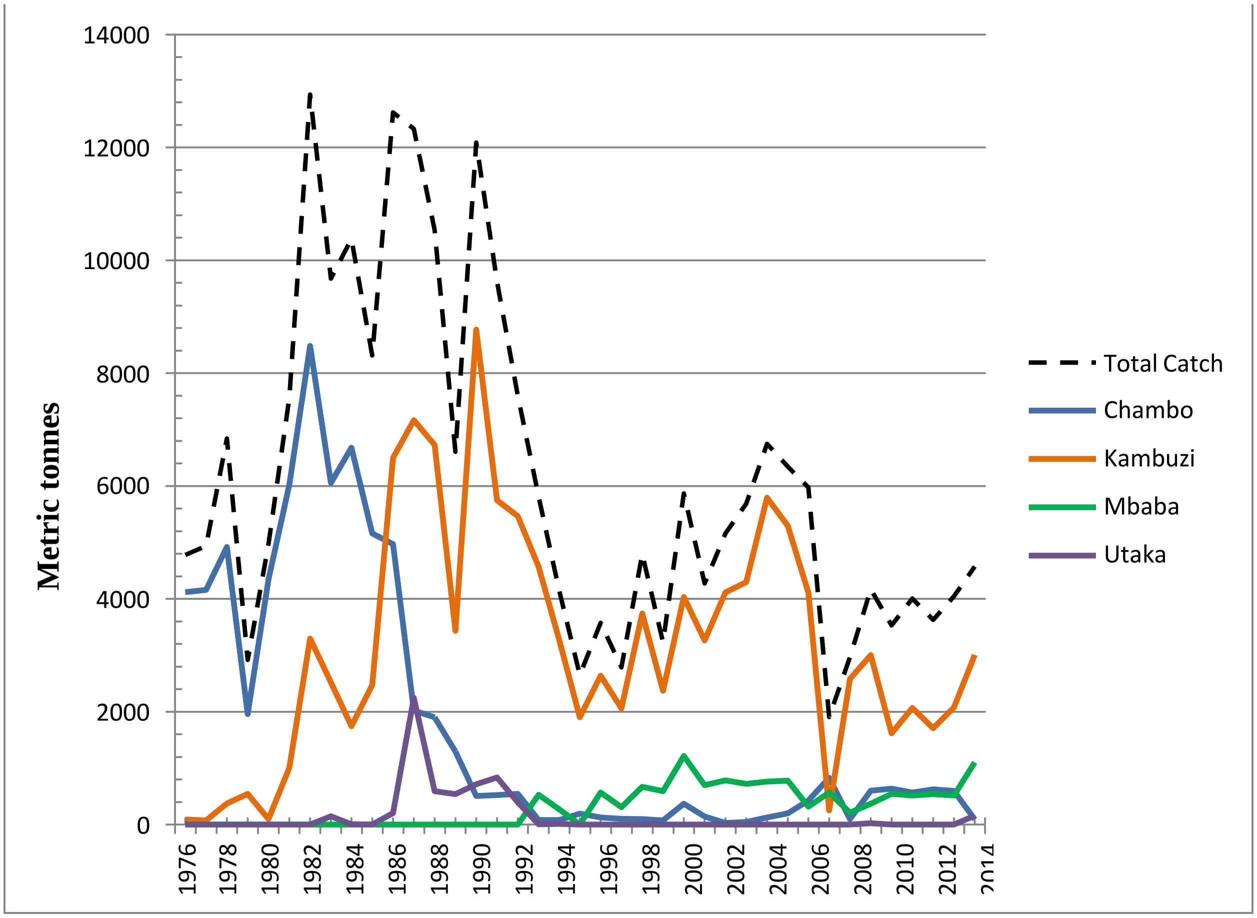

Figure 3.3: Overall total catch and total catch of chambo, kambuzi, mbaba and utaka in Lake Malombe (1976-2014)
Source of data: Fisheries Research Unit

As the chambo population declined, the kambuzi (small haplochromine cichlids) population swelled from 4% of the total catch in 1976 to almost 90% of the total catch by 1991 (FAO 1993). The trend of kambuzi dominating the catch has continued, especially in the eastern part of Lake Malombe. The utaka, which peaked at ~2200 MT in 1987, has declined considerably while the mbaba has fluctuated between 200 MT/yr to 1,200 MT/yr since the mid-1990s (Figure 3.4).

Other species harvested from Lake Malombe include kampango, mlamba, nchila, and usipa. The annual catch levels of usipa have exhibited cyclical fluctuations since 1990 while the total amounts of kampango, mlamba and nchila harvested have all declined over the past 25 years (Figure 3.5).

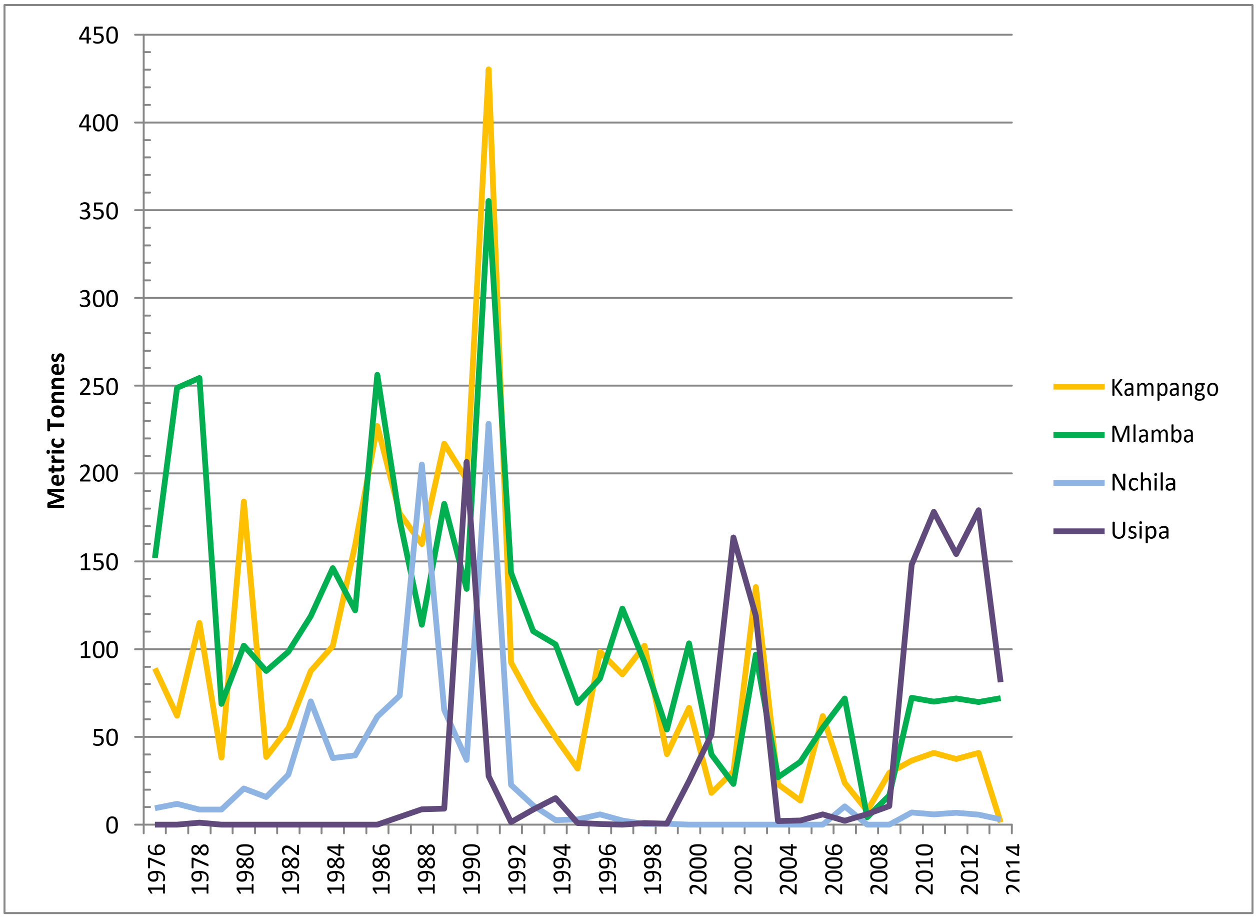

Figure 3.4: Total catch of kampango, mlamba, nchila and usipa in Lake Malombe (1976-2014)
Source of data: Fisheries Research Unit

3.2.1 Summary of Frame Survey Results

The frame surveys, which collect information on the dominant fishing gear, types of boats, and number of gear owners and crewmembers, have been carried out annually every August and September since 1976. Within Lake Malombe and the Upper Shire River, the number of fishers remained relatively constant between 1976 and 2005, but the numbers of boats and quantities of chambo and kambuzi seines have declined since the mid-1990s in response to the dwindling chambo stocks (Figure 3.5). The number of nkacha seines peaked in the early 1990s and then declined, but this trend reversed in the early 2000s as their usage increased again. Other less expensive gear types such as gillnets, longlines, and mosquito nets became more profuse from the mid-1990s to 2005 (Figure 3.5).

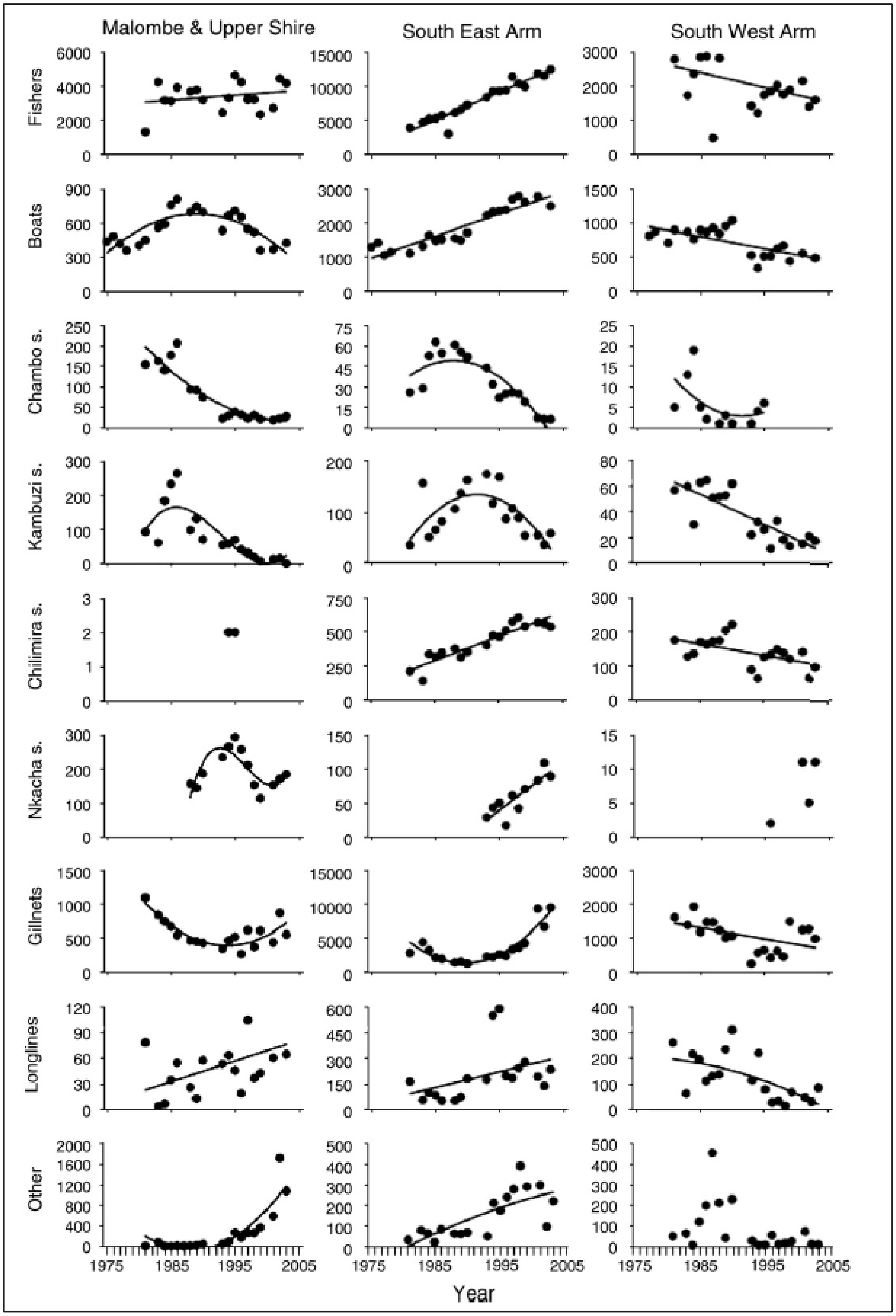

Figure 3.5: Trends in the number of fishers and types of boats/fishing gear (1976-2005)
Source: van Zwieten et al., 2011, p. 36.

More recent frame survey data collected between 2005 and 2014 show an overall decreasing trend in the number of gear owners and crewmembers despite the increases observed between 2005 and 2008 (Table 3.2).

Table 3.2: Estimated numbers of gear owners, crewmembers and fishing craft in Lake Malombe in 2005, 2008 and 2014

Indicator	2005	2008	2014
Gear Owners	438	497	319
Crew Members	3583	3618	1906
Plank boats with engines	0	0	0
Plank boats without engines	369	446	367
Dugout canoes	125	82	no data

Source of the original data: 2005, 2008 and 2014 Department of Fisheries Annual Frame Survey Reports

The number of chambo seines has continued to decline since 2005, while the number of nkacha seines has continued to rise. In contrast to the pattern observed between 1975 to 2005, the number of gill nets and mosquito nets has fallen considerably and longlines decreased by 75% from 2008 to 2014. The use of inexpensive small meshed illegal gillnets, which are locally referred to as 'ngongongo,' have risen markedly since 2005 (Table 3.3). The increase in ngongongo reflects the decreasing size and quantity of fish caught in the Lake.

Table 3.3: Estimated numbers and percentage changes of fishing gear in Lake Malombe in 2005, 2008 and 2014

Indicator	2005	2008	2014
Chambo seines/wogo	42	14	4
Chilimira nets	0	10	no data
Fish traps	424	643	no data
Gill nets	768	616.5	137
Handlines	76	2	no data
Kambuzi seines	0	5	no data
Kandwindwi nets	1	26	12
Longlines	72	168.6	41
Mosquito nets	103	74	37
Nkacha seine nets	145	139	186

Indicator	2005	2008	2014
Ngongongo	43	145	522

Source of the original data: 2005, 2008 and 2014 Department of Fisheries Annual Frame Survey Reports

3.2.2 Local Fisheries Management Practices

All of the fish and other aquatic flora and fauna that falls within the boundaries of Liwonde National Park are protected from harvesting. However, enforcement of these no-take regulations within the National Park is weak due to a lack of resources and poaching is a common occurrence. In addition, the entire lake is closed to active fishing gear equipment by the DoF every October to December to allow the fish, mostly Chambo to breed (SMEC 2013). Passive gear such as fish traps and the 3.5-inch mesh size gill nets are permitted, but illegal fishing with the active gear still frequently occurs. All seine nets are prohibited by the Department of Fisheries under the Fisheries Conservation and Management Act in the lake from January 1 to March 31 of each year, and the net requirements that must be abided by during the other months of the year are summarized in Table 3.4. The usipa beach seine is prohibited by the DoF under the Fisheries Conservation and Management Act between the hours of 6 a.m. to 6 p.m., while it is illegal to use mosquito nets anywhere within the lake.

Table 3.4: Fishing gear regulations for beach seine nets in Lake Malombe

Beach Seine nets	Minimum cod end mesh size	Maximum head line length	Maximum net depth
Nkacha	19 mm (0.75”)	100 m (328 ft)	10 m (32.8 ft)
Kambuzi seine	19 mm (0.75”)	500 m (1640 ft)	N/A
Chambo seine	90 mm (3.5”)	1000 m (3280 ft)	N/A

Source of information: http://www.malawilii.org/files/mw/legislation/consolidated-act/66:05/fisheries_conservation_management_act_pdf_70735.pdf

3.3 Primary Threats, Stressors, and Drivers to Freshwater Biodiversity

The greatest threats and stressors to the freshwater biodiversity within Lake Malombe discussed in the literature and identified by the local communities, scientists, and managers include the following: aquatic vegetation fragmentation and loss, the continued use of destructive and illegal fishing gear, overfishing, deforestation within the upstream catchment leading to high levels of sedimentation, climate change, climate variability, and lowering lake levels (Table 3.5). The primary drivers and contributing factors underlying these threats and stressors include high population growth rates and migration, the open access nature of the fisheries, food insecurity, limited income generating alternatives, and poor governance (Table 3.5).

Table 3.5: Primary threats, stressors, drivers, and contributing factors to Lake Malombe’s freshwater biodiversity

Threats	Literature Review	Local Communities	Scientists/ Managers
Loss/defragmentation of SAV and EAV	X	X	X
Deforestation	X	X	X

Threats	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Destructive/illegal gear	X	X	X
Overfishing	X	X	X
Sedimentation (river inlets/lake bottom)	X	X	X
Stressors	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Climate change	X	X	X
Climate variability	X	X	X
Lowering lake levels	X	X	X
Drivers	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Poor education and low literacy		X	
Poor governance: lack of capacity, resources, leadership, bylaws	X	X	X
Open access nature of the fisheries	X	X	X
Non-compliance closed areas/seasons	X		X
Lack of knowledge about enforcement		X	
Lack of political will			X
Contributing Factors	**Literature Review**	**Local Communities**	**Scientists/ Managers**
High population growth rates	X	X	X
Migrant fishers	X	X	
Limited income generating alternatives	X	X	X
Food insecurity	X	X	

3.3.1 Aquatic Vegetation Fragmentation and Loss

Historically, dense areas of aquatic vegetation covered Lake Malombe, but large areas of SAV (SAV) were removed since the 1970s to enable beach seining (van Zwieten et al., 2003). The use of nkacha nets, in particular, has been responsible for the high rates of SAV loss. The spatial extent of EAV has also declined considerably due to the creation of beach landing sites, clearing for additional fishing grounds, and cutting to construct roof thatching, fencing, and mats.

The areas highlighted in orange in Figure 3.1 denote the local community members' perceptions of the remaining sections of SAV and EAV within the lake currently facing the greatest threat of further cutting. During the PRA visits, the community members of Chisumbi and Nalikolo villages discussed how the reductions in aquatic vegetation have adversely impacted the kambuzi, makumba, mbaba, mlamba, mputa, nkhalala, silibanga, and usipa stocks due to the loss of critical breeding grounds and important refuge areas that provide protection from fishing pressure.

3.3.2 Destructive/Illegal Gear

The aquatic vegetation not completely removed to facilitate fishing remains vulnerable to further damage by destructive fishing gear dragged through the water column. In addition to damaging important breeding/brooding areas and refuge habitat for small fry, under-mesh sized nets (such as nkacha (mesh size < 19 mm (0.75”), kambuzi seines (mesh size < 19 mm (0.75”), chambo seines (mesh size < 90 mm (3.5”), kandwindwi, and mosquito nets as well as under-mesh sized bunts) indiscriminately capture large quantities of small juvenile fish, placing the long-term availability of many stocks at risk.

All four of the communities visited around Lake Malombe identify the use of illegal gear by migratory and local fishers as the greatest threat to fish abundance and overall biodiversity levels. They attribute the wide-scale use of these types of gear as lack of alternatives due to high levels of poverty and population growth rates, weak enforcement, and a lack of education/awareness of the fisheries regulations and the biological consequences, and the fact that much of this gear is cheaper and more efficient than the legal alternatives. The community of Mwalija reports success in chasing away all of the kandwindwi gear owners targeting juvenile fish while the village of Chisumbi acknowledges that its efforts to chase out migratory fishers and confiscate the illegal gear used at night by members of their community have been hampered by a lack of wide scale collaboration among the fishers. The community of Likulungwa has put license fees in place, but reports a lack of adherence to mesh size restrictions, while the Nalikolo BVC has been trying to confiscate the illegal fishing gear and sensitize their community on the dangers and long-term implications of using illegal gear.

3.3.3 Overfishing and Non-compliance with Closed Seasons and Areas

The open-access nature of the fisheries, overcapitalization, and uncontrolled levels of fishing effort have all contributed to the overexploitation of the fish stocks within Lake Malombe. The local communities and experts identify high levels of poverty and population growth rates, food insecurity, limited land for farming, and the paucity of alternative income generating activities as the main factors driving overfishing. The management measures put into place to control harvesting at certain times of the year (i.e., the closed season from October through December) or in certain locations (i.e., protected areas like the aquatic components of Liwonde National Park) are often subjected to high levels of poaching due to lack of enforcement and corruption.

3.3.4 Deforestation and Sedimentation

Concurrent with the changes in the onshore and offshore aquatic vegetation, the surrounding catchment area experienced high levels of deforestation due mainly to the expansion of agriculture and high demands for firewood and charcoal production. In particular, the land located on the western side of Lake Malombe has changed from forest cover to annual cropland (Figures 3.6 and 3.7).

This deforestation has resulted in higher incidences of flash flooding, greater amounts of runoff during the rainy season, cessation of inflow from the tributaries entering the western side of the lake during the dry season as well as increased loadings of sediments. The additional sediments reduce the spatial extent of breeding habitat available to many fish species because sediments are smothering the areas. During the PRA visits, the community members from Chisumbi specifically mentioned on a few separate occasions how sedimentation is severely damaging the SAV habitat. The enhanced turbidity levels caused by sediment loading also limit how far the sunlight can penetrate the water column impeding the visual cues used for mating. Moreover, the catch rates of the fish are greater during times of high turbidity because it is difficult for the fish to actively avoid the fishing gear since they cannot see it (personal communication, G. Kanyerere). This further exacerbates the losses already experienced due to overfishing and illegal gear.

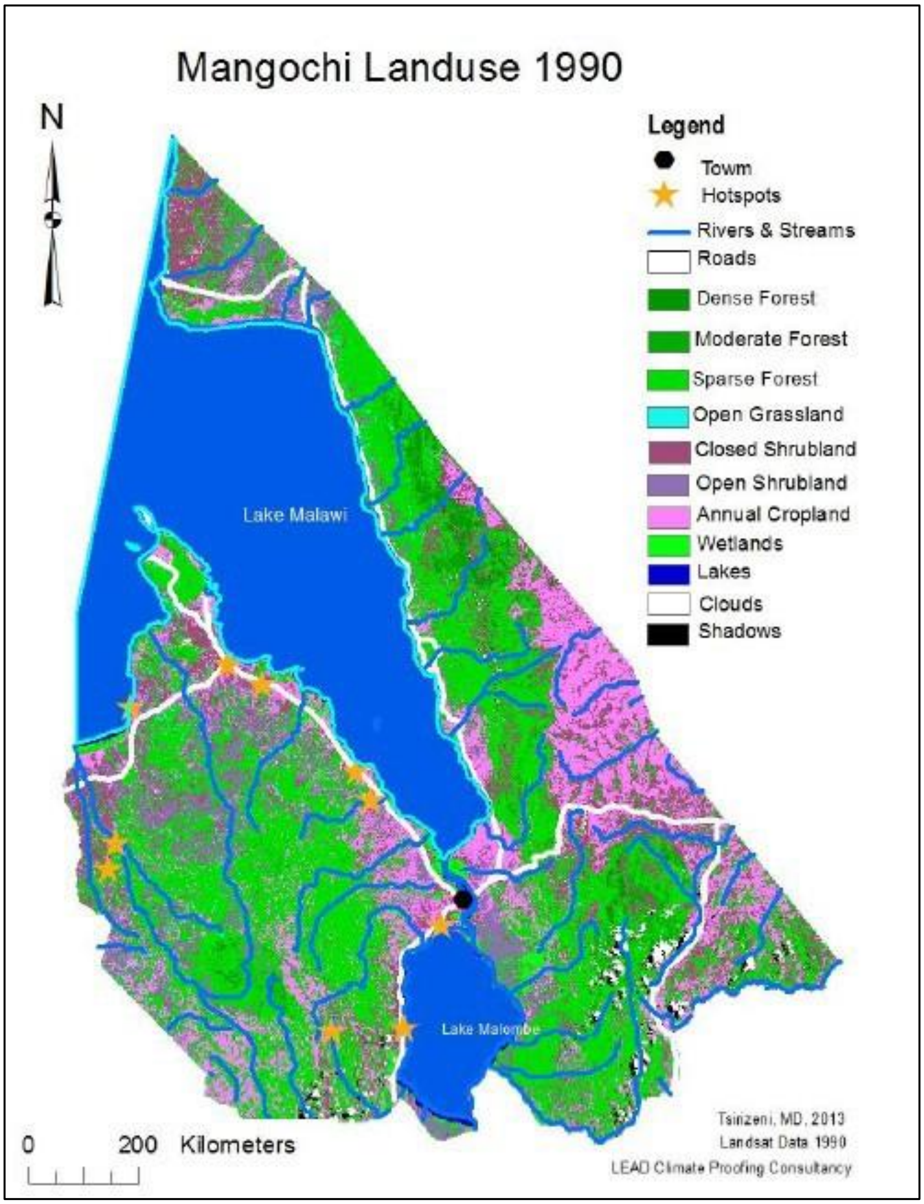

Figure 3.6: Land Use in Mangochi District in 1990
Source: Phalira et al. 2013, p. 18

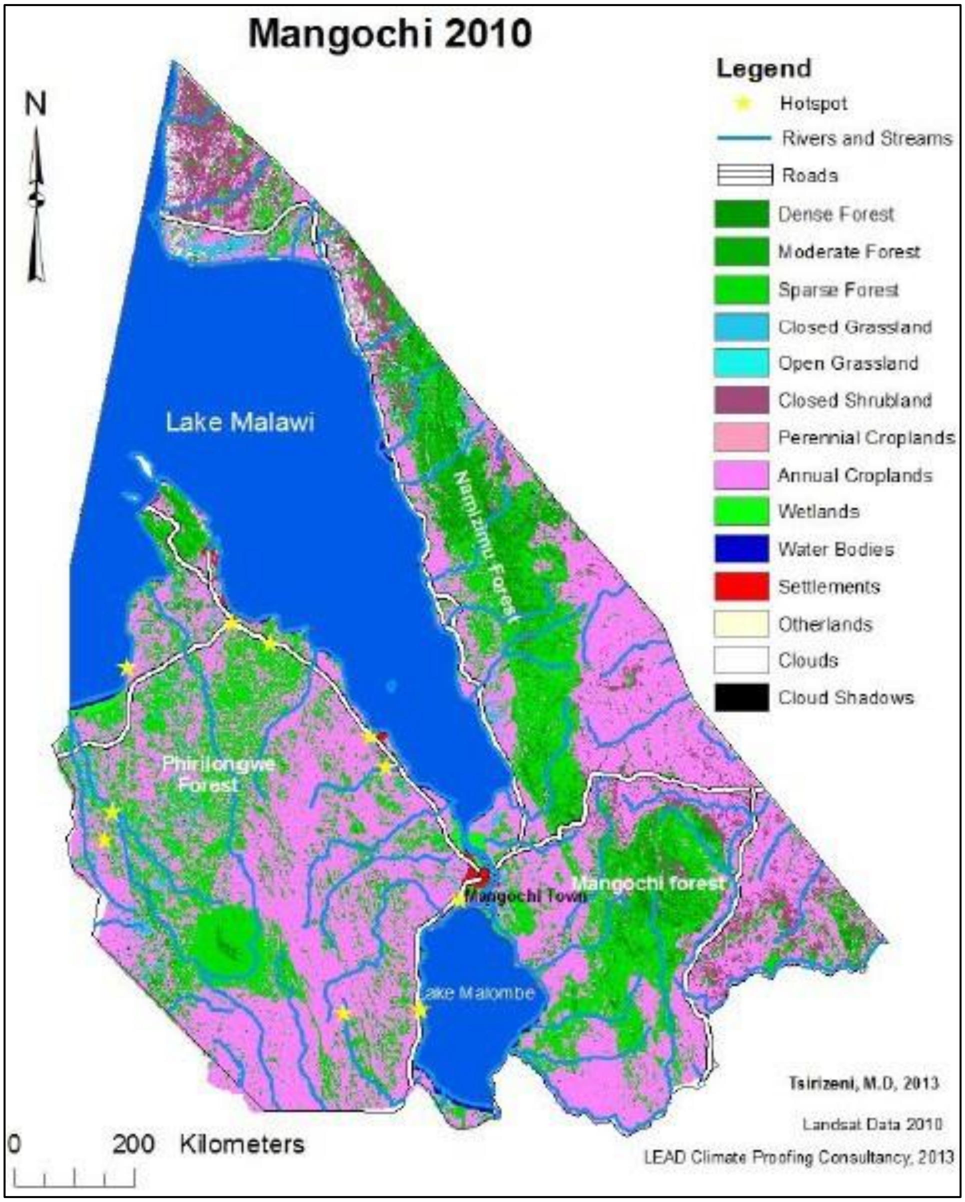

Figure 3.7: Land Use in Mangochi District in 2010
Source: Phalira et al. 2013, p. 17

3.3.5 Lowering Lake Levels

The shallow depth of Lake Malombe makes it vulnerable to changes in climate as variability in seasonal and annual precipitation can affect the lake's water levels. The lake dried up completely between 1915 and 1935, and recent research conducted by Dulanya et al. (2013) documented 13.9 to 19% reductions in the lake's overall area between 1973 and 2008 (Table 3.6). Local experts, as well as three of the four PRA communities, identify lowering lake levels as a threat to the abundance and diversity of fish within the lake, which they attribute to erratic rainfall from climate change and increased sedimentation. The deforestation along the western side of the lake has resulted in higher rates of sedimentation loading. As these sediments accumulate on the lake's bottom, the displaced water is released via the Shire River outlet in turn lowering the overall level of the lake (personal communication, M. Tsirizeni). According to the communities of Chisumbi, Likulungwa, and Mwalija, the lower water levels increase the amount of EAV and SAV that is exposed, which leads to less suitable habitat and overall reductions in fish abundance.

Table 3.6: Variations of lake surface area between 1973 and 2008

Year	km^2	% *
1973	317.5	81.4
1975	316.0	81.0
1979	320.0	82.1
1984	328.0	84.1
1989	335.6	86.1
1994	321.0	82.3
2002	316.7	81.2
2008	323.0	82.8

Source: Dulanya et al. 2013, p. 117

* *Percentages calculated using published lake surface area of 390* km^2

3.4 Opportunities for Action/Management Suggestions

3.4.1 Reductions in the use of Destructive and Illegal Fishing Gear

The pervasiveness of destructive and illegal fishing gear used within Lake Malombe can be diminished by strengthening co-management and enabling better dialogue and cooperation among the local, district, and national levels of government, providing adequate resources for enforcement, constructing brush parks to act as "silent police," and creating other opportunities for income generation.

One potential opportunity is to build a stronger partnership between the DoF and BVCs and incorporate local community members as beach scouts and data recorders. It is often very difficult for the BVC members to arrest family members and neighbors using illegal gear. However, the BVC could work hand in hand with DoF officials to have the latter visit the village on a regular basis, confiscate the gear, and use a vehicle to take it away from the village so that it is not simply reused again a few days later. In recent years, it has been reported that many of the DoF enforcement officials and staff are not staying in their stationed communities because they do not like being so isolated. The solution devised in the past was to recruit a junior assistant and data recorder from within the local communities. Currently, there are fewer than 10 data recorders in the entire country because those previously holding the posts either retired or passed away. A potential opportunity is to recruit members of the communities to serve as data recorders and fish scouts. The Lakeshore Community Project could potentially serve as a guide given that they have demonstrated success in linking community members trained in collecting water quality data with the Water Department.

Another opportunity to improve fisheries co-management is putting in place measures to enable more-effective dialogue and cooperation between the Chiefs, police, magistrates, DoF personnel, District Councilors, and the local communities (e.g., ADC, VDC and BVC). Representatives from the DoF believe that the capacity of the judiciary, prosecutors, and police must be strengthened. The latter often take those charged with possessing illegal gear to a lower level magistrate because the fines are lower, but all the fishers' cases should be dealt with at the highest levels of the magistrate.

The provision of adequate funding and resources for the DoF and BVC members to carry out the enforcement responsibilities mandated to them serves as another opportunity for reducing the prevalence of illegal fishing gear and behavior. While district level staff is employed for certain activities such as the enforcement of the closed season, there are only four staff members currently serving in this capacity for the entire area within Mangochi District. There have been instances when the entire closed season passed by without anyone from the District going out into the field due to either a lack of funding and/or other duties taking precedence. Thus, there is a great need to recruit additional technical assistants. Currently, Lake Malombe only has two technical assistants (i.e., one for the eastern side of the lake and one for the western side of the lake). Positioning additional technical assistants in the strata around Lake Malombe would allow them to enforce the fisheries regulations on a more consistent basis as well as revitalize and work with the BVCs interested in strengthening co-management. During the PRA field activities, many of the BVC members said that their ability to enforce would markedly improve with gazetted bylaws as well as the provision of equipment for patrolling (i.e., uniforms, identification cards, whistles, rain boots, dustcoats, and boat and engine). The bylaws recently passed for Mangochi District could serve as a window of opportunity for revitalizing and strengthening the relationship between the DoF and local communities.

In addition to bylaws and the provision of enforcement equipment, some of the PRA communities express the desire for a more active role and greater amount of power in fisheries management. For example, the focus group participants from Mwalija state that they have been able to stop the use of illegal gear within their own village, but complain that they cannot do anything about the illegal gear used in neighboring communities. One suggestion put forth by the Mwalija BVC members to influence the behavior of all migrant fishers entering Lake Malombe is the requirement for them to get transfer letters from their respective BVC committees. The letter would verify that the individual seeking to fish within Lake Malombe has been using sustainable and legal gear in their own waters, and all gear would be checked by the BVC prior to granting the fishing rights. In addition to this lake wide measure, some of the other communities have expressed interest in exchange visits among the BVC committee members around Lake Malombe (as well as with other lakes). These exchange visits could provide an opportunity for the BVC members to share information with one another on the problems they have been encountering, discuss what has worked and not worked, and devise additional management strategies.

Finally, the communities and local experts have identified other opportunities for reducing the prevalence of destructive gear and fishing pressure. These include ecological measures such as the construction of brush parks, establishment of closed areas, and the extension of the closed season as well as socioeconomic measures, such as the creation of income-generating alternatives and provision of small loans. In the past, old cars were sunk in the southeastern section of Lake Malombe to act as "silent police" to deter illegal fishing activities. Given the potential adverse water quality implications of using old cars, a better approach is to construct brush parks from natural materials that would inhibit the use of destructive fishing gear as well as enhance production as has been shown in West Africa. The community of Mwalija suggests that the current closed season, which extends from October to December, should be extended through the end of January since the lower water levels are exposing important EAV and SAV which are key fish breeding habitat. The alternative income generating activities proposed by the communities and local experts includes aquaculture, raising poultry, and vocational training in painting, carpentry, and bricklaying.

3.4.2 Habitat Protection Measures Within and Adjacent to the Lake

Certain areas within Lake Malombe could be declared as sanctuaries to protect important EAV and SAV serving as critical breeding and nursery grounds. Some of the specific areas suggested by Mwalija village include Mwalija, Mtenje, Mphwanya, Likala, and Changamire. In addition to establishing sanctuaries, other opportunities include the creation of bylaws to clearly define the rules and regulations regarding the cutting of EAV in areas that fall outside of the sanctuaries' boundaries. During the PRA visits, it became apparent that there is a lot of ambiguity among the communities as to which entity is primarily responsible for creating these regulations. Mwalija feels powerless and awaits formulation of the rules by DoF. In contrast, Chisumbi strongly believes that their BVC should be empowered and trained to protect the EAV and SAV. Nalikolo has been conducting civic education on the importance of conserving aquatic vegetation and requested assistance from the FISH Project in preparing bylaws.

3.4.3 Improved Land Management within the Upstream Catchment

The current levels of sedimentation adversely impacting Lake Malombe and its inflowing tributaries can be reduced by preventing further EAV removal, maintaining buffer zones around the lakeshore and riverine corridors, promoting natural regeneration and reforestation of upland species, improving fire management, and encouraging the adoption of climate smart agriculture.

One potential opportunity is to ban the further cutting of EAV for creating additional fishing areas and beach landing sites. Many of the community members understand and value the breeding, nursery, and juvenile refugia functions provided by EAV, but may need additional information on the other important ecosystem services provided by these habitats. The regulations banning EAV removal could be enforced at the VDC level by actively incorporating community members in a partnership with the Department of Forestry employing measures similar to the ones described in greater detail above in the illegal fishing section.

Another potential opportunity to reduce sedimentation loading is the maintenance of buffer zones. Although regulations stipulate a 10-meter buffer zone around the lakeshore and riverine corridors, conflicting policies between different governmental departments as well as weak enforcement have contributed to the encroachment of agriculture activities and the construction of buildings within these ecologically sensitive areas. The harmonization of policies among government departments (e.g., providing treadle pumps with pipes longer than 10 meters in length), promotion of well construction, recruitment of additional forest guards, and enhancement of co-management efforts with the Village Natural Resource Management (VNRMC) committees are all specific avenues that can be pursued to provide greater protection to the remaining undeveloped buffer zones.

The promotion of natural regeneration, reforestation, and better fire management (i.e., controlled burning and construction of firebreaks) all serve as opportunities to increase upland vegetation cover and decrease soil erosion. Stronger enforcement by Department of Forestry and empowerment of the village NRM committees are needed to ensure that the community members abide by the current rules outlining which trees can be cut in which locations and that selectively harvested areas are replanted. While there have been numerous reforestation efforts throughout Malawi, there is often no follow-up management resulting in high seedling mortality. Consequently, there is a need for systematic follow-up to determine which particular species are best suited for which environmental settings. According to the local experts, many of the plantings conducted in the past were not aligned with the actual forestry season and best times for planting. Thus, there is a great need to consider the ecology of the proposed tree species to ensure that they will survive and grow in the replanted areas and that they complement the community's needs. Considering species that afford benefits to community members (e.g., fruit trees, trees with important medicinal benefits, fast growing species to serve as a source of firewood, etc.) would provide incentives for proper care and long-term management.

One potential opportunity identified by the experts include working with Liwonde National Park and Mangochi Forest Reserve to see if blocks for sustainable community use can be set aside adjacent to these protected areas following the model used in the Zomba forest management reserve. The latter commenced initiatives with nearby communities to allow firewood harvesting in selected blocks adjacent to the reserve with the requirement that the communities replant trees to compensate for the ones harvested.

The adoption of climate smart agriculture, which integrates soil and water conservation, watershed management and ecosystem management, is another opportunity for reducing the amount of sediment entering Lake Malombe. Within the catchment area, there are small components of climate smart agricultural such as conservation agriculture currently in place, but to be more effective all of the components listed above should be integrated. Near-term climate smart agricultural opportunities identified by the scientist and management working group include intercropping to maximize the efficient use of land as well as integrated agriculture and aquaculture activities (IAA). They believe that the knowledge required to implement climate smart agricultural activities is already present at the District Level, but that the Agricultural Extension Development Officers (AEDO) and small-scale farmers would greatly benefit from training and the provision of education materials on climate smart agriculture. This sentiment was shared among the focus group participants in the villages of Chisumbi and Likulungwa as they requested training on good farming practices and the provision of climate smart agricultural inputs such as early maturity hybrid seeds.

Finally, the collaboration and the harmonization of efforts among the various projects being carried out within the four lakes and their respective upstream catchments are key elements for long-term success as the components cannot be effectively implemented in isolation of one another. Many of the scientists and managers involved in past and current projects discussed how communication, cooperation, and integration among the various projects could be improved.

One promising idea put forth was for the creation of a collaborative forum for researchers and practitioners involved in different projects within the watersheds to help weave and integrate the various projects together. In this forum, project staff could come together and share their methodologies, good practices, and adaptive management measures with one another to ensure that the target communities are receiving similar information and potential upstream/downstream synergies are identified and acted upon. Additionally, there could be dissemination workshops showcasing what has been done that has yielded promising results and invitations could be extended to international experts to help bolster the knowledge and technical skills of the forum participants.

4 LAKE CHILWA

Lake Chilwa is located in the Southern Malawi districts of Machinga, Phalombe, and Zomba, between 15° 15'S and 35° 45'E (Figure 4.1) and shares its eastern shore with Mozambique. It is 624 m above sea level and has a total surface area of ~2248 Km,^{2} within an area of ~40 km long and 30 km wide, and an average maximum depth of less than 6 m.

(Njaya 2001). The lake is an enclosed system, an endorheic and therefore slightly saline lake, with several inflowing rivers, surrounded by swamps and marshes. Numerous islands are also present, two of which are permanently inhabited (Ramsar 2014). The inflowing rivers are Domasi, Likangala, Namadzi, Naisi, Phalombe, Thondwe, and Sombani. These rivers perennially and seasonally influence the open water area, contributing to lake level fluctuations, nutrients and suspended silt and sediment load during seasonal rain (Ramsar 2014). During high water level periods, the open water covers about 1,500 km;^{2} during low water level the respective areas can have a cover of 648 km,^{2} 699 km,^{2} 300 km,^{2} and 430 km^2 (UNESCO 2015). The lake has dried up on eight occasions over the past century (Kabwazi & Wilson 1998); in Kachulu the lake level changes can be seen from 1962-1999, Figure 4.2.). Most recently, the lake dried up in 2012.

At 20 m above sea level, a sandbar separates Lake Chilwa's wetlands from those of Lake Chiuta. These two lakes were connected 15,000 years ago (Dawson 1970, Njaya et al. 1999, Njaya 2008).

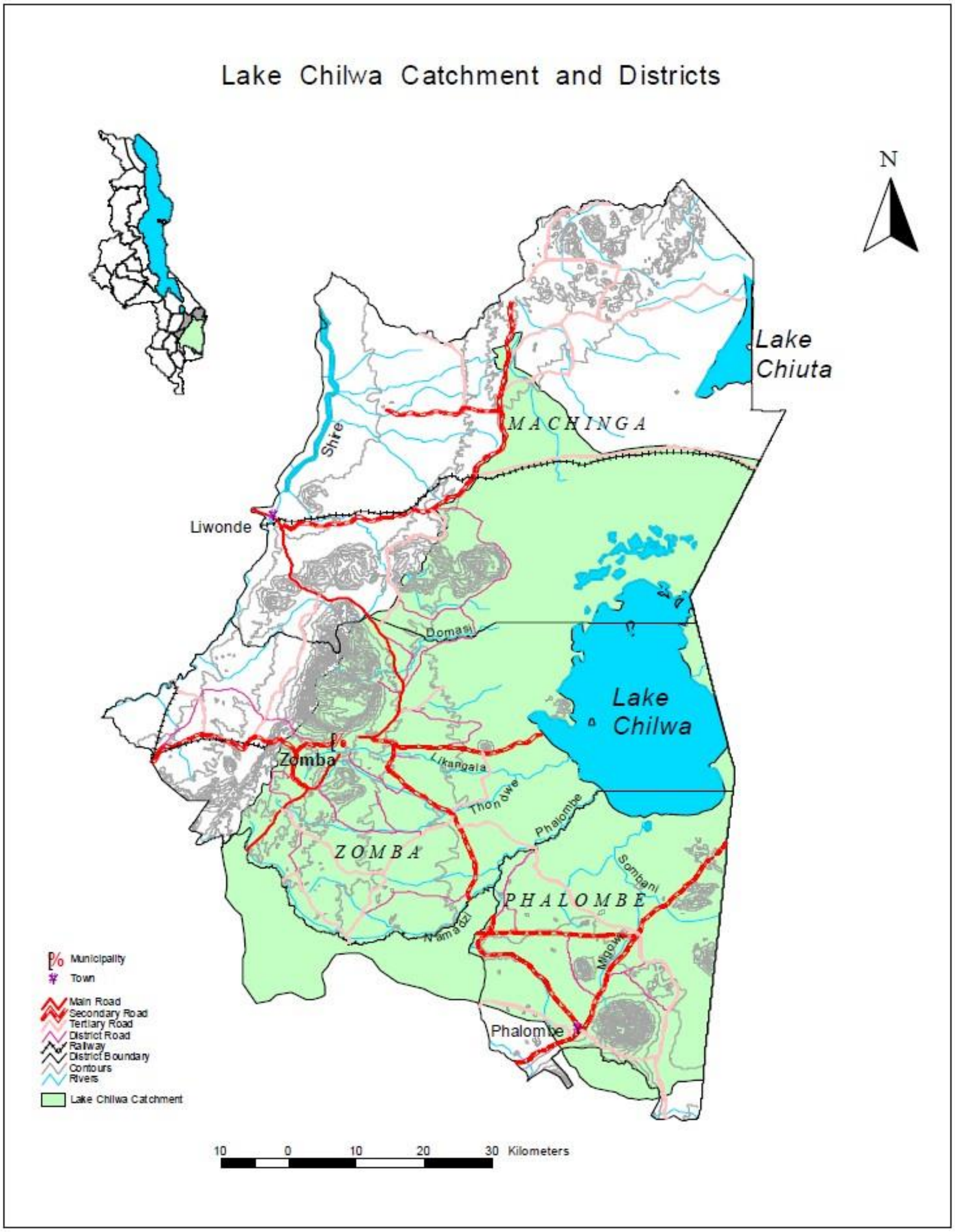

Figure 4.1: Lake Chilwa districts, catchment area and tributaries (LCBCCAP)

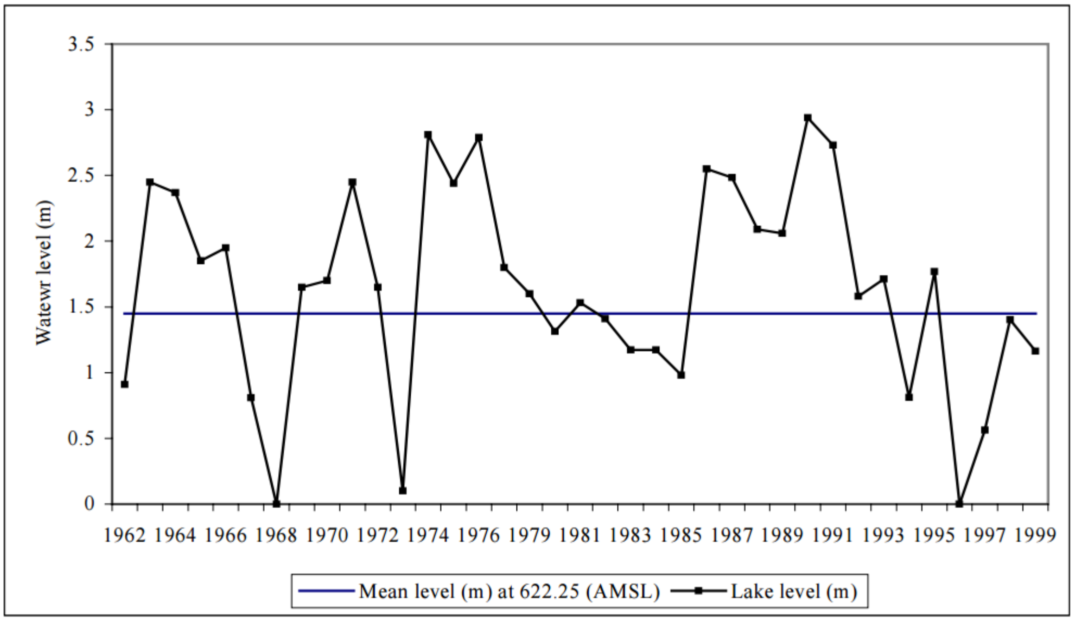

Figure 4.2: Lake level changes at Kachulu. Major recessions in 1968, 1995; minor recession in 1973 and high water levels seen between 1974-1976, 1986-87 and 1990-91.
Source: Njaya 2001.

4.1 High Biodiversity Areas

4.1.1 Fish Diversity, Abundance and Distribution

The species distribution in 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 fishes found here are matemba (*Barbus paludinosus*), makumba (*Oreochromis shiranus chilwae*), and mlamba (*Clarias gariepinus*) (Ambali & Kabwazi 1999, EAD 2000, Chandilanga et al. 2013, p 35). Species that can tolerate normal changes in salinity and lower oxygen levels are found in the swamps, these are: *Haplochromis callipterus*, *Tilapia rendalli*, *Pseudocrenila-brus philander*, *Barbus trimaculatus*, *Labeo cylindricus*, *Brynus imberi*, *Hemigrammopetersius barnardi*, *Petrocephalus catastoma*, *Marcusiensis (Gnathanemus) macrolepidus*, *Paretropius longifilis* (Furse et al. 1979). With 27 fish species (Njaya 2001), Lake Chilwa has lower fish diversity than nearby Lake Chiuta, but it is considered one of the most productive freshwater lakes in Africa (Chiotha 1996). It supplies ~25-30% of the total fish production for Malawi (Macuiane et al 2009, Kalindekafe 2014). Its fishery production is approximately 344 kg/ha/yr (Macuiane et al. 2009). The high productivity is attributed to the high nutrient level in the soils and inflowing waters that benefit the high primary and secondary productivity (MacLachlan et al. 1972, Msiska 2001). Two thirds of the lake is covered in aquatic vegetation that thrives on this nutrient loading and adds to the organic matter of the lake ecosystem (Figure 4.3).

Fluctuating states of rain and drought can change the water chemistry influencing the abundance and productivity of the fish (Cantrell 1988, Msiska 2001); species in Lake Chilwa are adapted to high fluctuations presenting high fecundity, reproduction at an earlier age and high variability in their spawning habits (Moss 1979). Low oxygen has been a cause of concern in shallow areas during dry out when fish die due to anaerobic conditions (Kalk et al. 1979); the transparency of the water seasonally fluctuates (0.04 and 0.11), and the salinity oscillates between 1-2 to 12 parts per thousand. Because of this, the most dominant species (matemba, makumba and mlamba) found in the open water are known to tolerate poor water quality in the lake (Msiska 2001). The fish abundance in Lake Chilwa recovers rapidly after a time of recession, generally bouncing back in two years due to the residual and re-colonizing fish breeding population that takes shelter in rivers, deep pool refugia, and the watershed (Figure 4.3) (Jamu & Brummett 1999). Species from the open water will move to the swamps, breed, and grow in areas near the river mouths and lagoons, and return to the lake after the drought (Ambali & Kabwazi 1999) (See Figure 4.2 & 4.3).

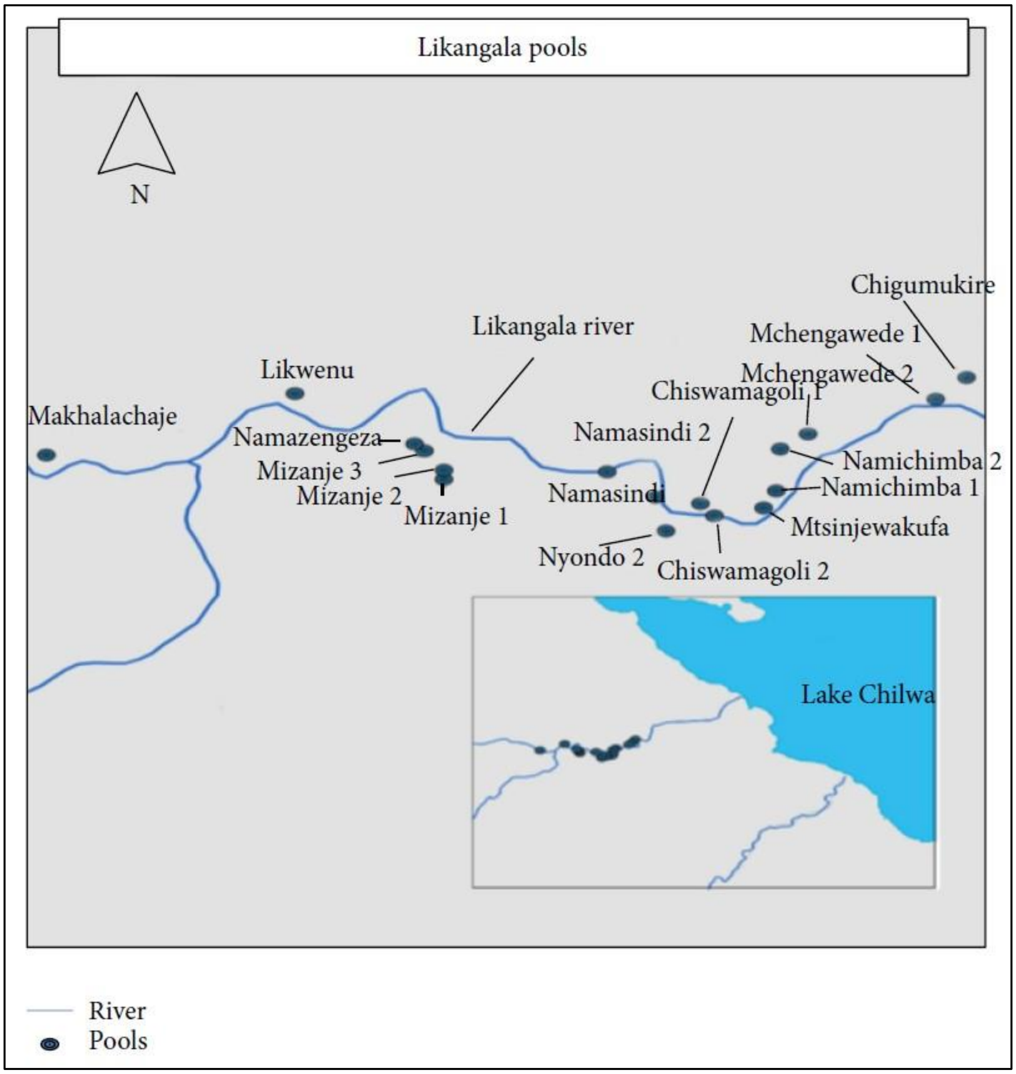

Figure 4.3: Deep hole refugia for Likangala River feeding into Lake Chilwa
Source: Makwinja et al. 2014

4.1.2 Habitat Types

Lake Chilwa is unique in its vegetative cover. It has an abundance of emergent vegetation covering 2/3 of the lake, some of which has been found to float as makeshift islands. The map below depicts habitat areas within Lake Chilwa as perceived by local communities (the data were later validated by a team of experts). The shoreline areas of Lake Chilwa are covered in thick emergent vegetation that provides refuge for many different species endemic to the lake. The northern sector of the lake exhibits the densest vegetation, which sometimes encroaches significantly into the lake's waters. Submerged vegetation grows primarily adjacent to river mouths where there is a flow of fresh water into the lake. It would seem that the most brackish waters, ranging from 1.2 – 12 parts per thousand (Njaya 2001), of the lake at large are less habitable for certain SAV species. Aside from the known islands, the only significantly rocky area lies near the eastern shoreline towards the middle section of the lake. The center of the lake is the deepest at less than 6 m, however this is relative, as the lake is shallow to begin with. Generally, all the vegetated areas are relatively shallow in less than 1m of water.

A series of wetland areas, called dambos, extends from the western shoreline of Lake Chilwa and contributes to the water circulation and fish habitat. Many of these rivers are home to “deep pools” that provide refugia for fish species during droughts. The southeast corner of the lake sees the most flooding, and the floodplain extends between two rivers expanding outwards from the lake. Overall, Lake Chilwa is an interesting system due to the species that are able to survive its more turbid, saline waters.

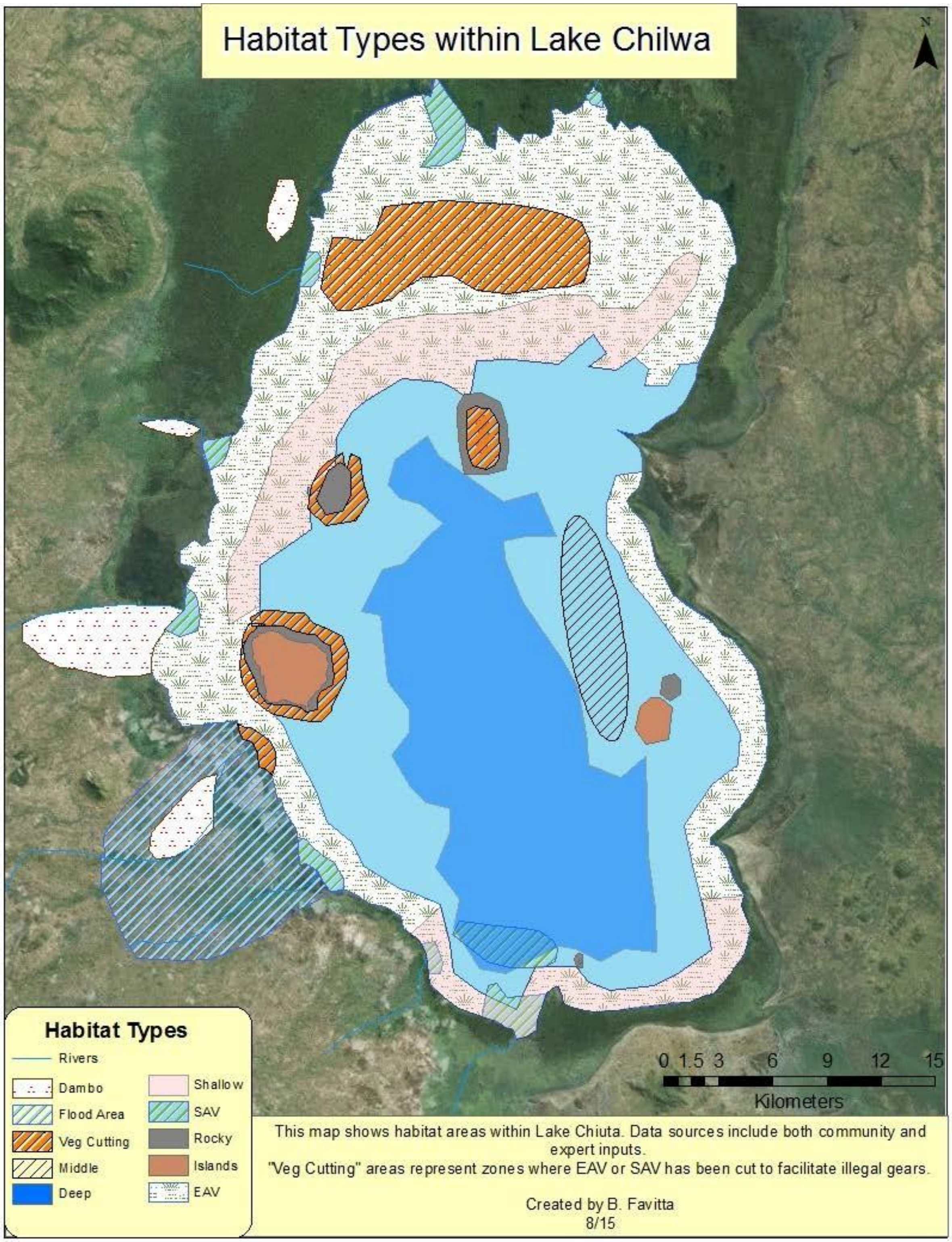

Figure 4.4: Distribution of habitat within Lake Chilwa based upon local ecological knowledge gathered from community PRA assessments and local expert workshop.

The different types of habitats serve as breeding, nursery and feeding habitats for multiple fish species (See also Figure 4.5 and Table 4.1). The two larger islands represented are permanently inhabited.

The map below highlights species rich zones within Lake Chilwa. The different colors on the map represent the cumulative score of fish species harvested by the local communities with at least one critical life stage occupying the given habitat area. Life stages are given a value of one and are not weighted (i.e., the multiple life stages of a single species coexisting within a habitat area are not double counted). The highest species-richness areas are found near the river inlets with the adjacent submerged and EAV, followed by the deep waters in the middle of the lake (Figure 4.3). Many of the species endemic to Lake Chilwa have adapted life strategies to tolerate the variability in habitat changes that synergize with either submerged or emergent vegetation. For instance, *Oreochromis shiranus* (makumba) and *Clarias spp*. (mlamba) have an early maturity with two spawning periods that respond to seasonal changes (Moss 1979). It stands to reason that the outskirts, being the most thickly vegetated areas, would have high species richness. Many species travel to river mouths for breeding and utilize those shallow, productive areas to nurse their young before moving into the lake at large.

Recent surveys with community and local experts confirm the harvesting of eleven different species in the lake in last 12 months. Of these, the most abundant are mlamba (1^{st}), matemba (2^{nd}) and nkalala (3^{rd}) (See Table 4.2 and Figure 4.7 on catch rates). Local experts indicate that when the lake levels are normal, matemba can represent up to 60% of the catch. For the last five years, mlamba, makumba (tilapia species similar to chambo) and makwale have been fished in most of the habitat types, whereas the matemba, mphuta, and matemba (occur in the middle of the lake only). Locals report the constant level of catch of makumba, matemba, mlamba, and makwale in the last 10 years as well as mphuta and nkala. The habitat type preferences during the different life cycles are noted below (Table 4.2, Figure 4.5).

HIGH BIODIVERSITY AREAS WITHIN LAKE CHILWA

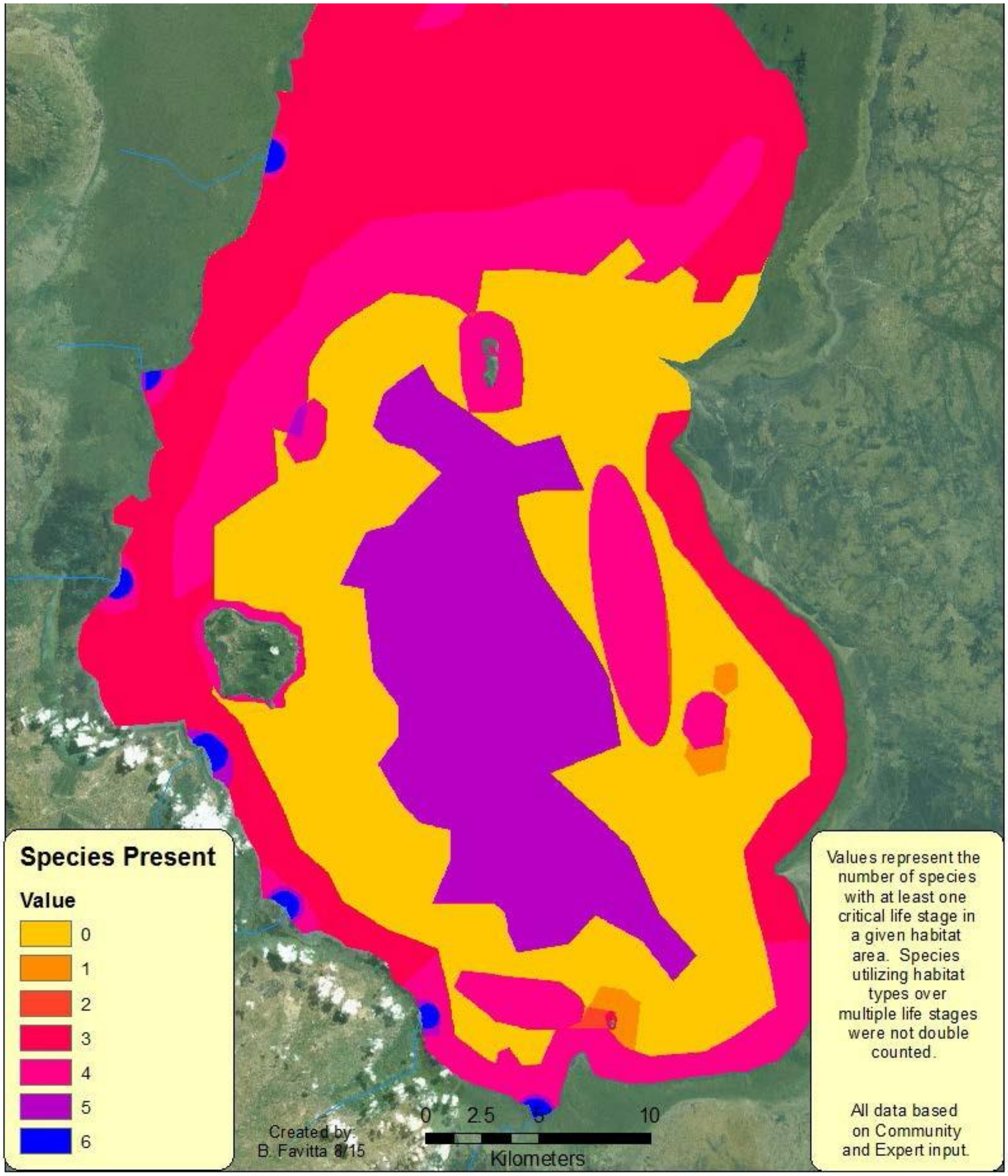

Figure 4.5: High biodiversity areas map based on community perceptions during PRA and validated by local experts. The different-colored areas represent the different habitat types where the important fish species are found within Lake Chilwa.

4.1.3 Breeding Habitats

The rich floodplains and the marshes represent essential breeding areas for the fish in Lake Chilwa. When seasonal inundation fails, the productivity of fish is greatly reduced (Furse et al.

1979). Of the three main species, *Barbus* and *Clarias* species are suited to the fluctuating environments. Under extreme circumstance *Clarias spp.* can survive after being buried in the mud when the lake dries up (Agnew 1971). From the survey data, locals outlined the presence of species in the different habitats; *Barbus* (matemba) was described as breeding in all habitats, without being observed in EAV areas where *Clarias* (mlamba) is present. Where SAV is found one also finds *Oreochromis* (chambo). The endemic cichlid, *Oreochromis shiranus chilwae* (makumba), prefers to breed in the shallows: pools, springs and lagoons breeding in the warm months from September to May (Furse et al. 1979*)* with peak spawning during October to early February (Palsson et al. 1995). In general, the three dominant fish have high fecundity levels and reproduce at relative early age.

Local participants describe the presence of the catfish *Clarias gariepinus* (mlamba) in the river and the lake. This species spawns from September continuing into the rainy season in the flooded deltas and run-up rivers (Moss 1979). After the spawning event, these fish return to the river (Furse et al. 1979) (see Table 4.2). During this time, the catches are reduced in September to February as spawning occurs in the rivers (Macuiane 2006, Macuiane et al. 2009).

Barbus paludinosus (matemba) breeds throughout the year, reaching a peak activity during November to January, near the river mouths in vegetated areas (Furse et. al. 1979, Macuiane 2006, Macuiane et al. 2009) as well as in open water (Macuiane 2006, Macuiane et al. 2009) and locals agree. The migration appears to coincide with periods of heavy rain (Shelton, 1993; Jamu & Brummett 1999, Macuiane 2006), when fish move into rivers and surrounding wetlands areas where marginal vegetation is located (Shelton 1993). Furthermore, aside from the common species described across most habitats, locals mention *Marcusenious spp* (mphuta) being in the deep (Figure 4.4).

The refugia levels in the marshes are key to the high survival rate of *Barbus spp*. A high survival rate, especially during low lake levels, allows for the stocks to be replenished when the fishing pressure has been really high (Macuiane 2006). The *Oreochromis spp*. is also more suited for the open lake water, having lower resistance to low lake levels and lower ability to recover after a recession (Njaya 2014).

Table 4.1: PRA summary of key habitats for critical life stages of the main fish species groups within Lake Chilwa

Species	Breeding Habitat	Nursery Grounds	Juvenile Habitat	Adult Feeding Ground
Chambo/kasawala *Oreochromis shiranus*	SAV, rocky, river inlets and outlets, shallow areas, middle of the lake	SAV, EAV, rocky, river inlets and outlets, deep areas, shallow areas, middle of the lake	SAV, EAV, rocky, river inlets and outlets, deep areas, shallow areas, middle of the lake	SAV, EAV, rocky, river inlets and outlets, deep areas, shallow areas, middle of the lake
Mlamba *Clarias spp.*	SAV, EAV, rocky, river inlets and outlets, deep areas, shallow areas	SAV, EAV, rocky, river inlets and outlets, shallow areas	Rocky, deep areas, shallow areas	SAV, EAV, rocky, river inlets and outlets, deep areas, shallow areas, middle of the lake
Matemba *Barbus paludinosus* *Barbus trimaculatus*	SAV, rocky, river inlets/outlets, deep areas, shallow areas, middle of the lake	Rocky, river inlets and outlets, deep areas, shallow areas, middle of the lake	SAV, EAV, rocky, river inlets and outlets, deep areas, shallow areas, middle of the lake	EAV, rocky, river inlets and outlets, shallow areas, middle of the lake
Mphuta *Marcusenious spp*	River inlets, shallow areas	Deep areas, middle of the lake	River inlets and outlets	Rocky, river inlets and outlets, deep areas, middle of the lake
Makwale/Chitondolo *Haplochromis callipterus,*	Shallow areas, rocky areas, EAV	Rocky, deep areas, middle of the lake	Rocky areas, Shallow areas	Rocky areas, shallow areas
Nkhalala *Brycinus imberi*	Shallow areas, SAV	SAV	SAV, rocky	EAV, shallow areas

4.1.4 Nursery Grounds

Co-management arrangements have fostered establishment of fish sanctuaries that are semi-permanent or temporary no-take zones. These fish sanctuaries consist of a network of deep pools located in Lake Chilwa affluent rivers (see figure 4.3), which are protected by River Management Committees (RMC) (Jamu 2011). During years of low rainfall, the lake recedes and rivers cease to flow. Fish from the lake and rivers seek refuge in these deep pools where they are protected by RMCs. With the resumption of normal rainfall, the lake fills up and rivers flow, connecting the deep pools to the main lake and thereby facilitating the fish from the deep pools to repopulate the lake. Natural repopulation of the lake from the deep pools and other fish sanctuaries is preferred than previous restocking efforts in the late 1960s in which juveniles were released from Domasi Fish Farm (WorldFish 2005).

The PRA field studies and local experts confirm that different habitat types, such as SAV and rocky shores surrounding the lake, serve as fish nursery habitat for the chambo species. They also confirm that matemba use most of the habitats with the exception of SAV and EAV. However, mlamba is present in those two habitats (Table 4.2, Figure 4.5).

4.1.5 Juvenile and Adult Feeding Habitats

Marshes are essential nursery areas and breeding grounds for the Lake Chilwa fishes (Jamu et al. 2006, Delaney et al. 2007). The shallowness is conducive to an efficient nutrient recycling system that makes Lake Chilwa one of the most productive in Africa (Chiotha 1996). Next to its primary productivity, high levels of zooplankton are important for fish survival and development. As the zooplankton are phytoplanktivores and facultative detritus feeders, the feeding habitats are sustained by the primary productivity and the production of detritus that takes place in the wetlands surrounded by *Typha* vegetation (Kalk 1979) (Figure 4.4).

Studies conducted by Bourn (1974) found that the juvenile fish of *Barbus spp.* (matemba), *Clarias spp.* (mlamba) and *Oreochromis spp.* (chambo) species had a gut content of 60%, 69%, and 48% zooplankton, respectively. The diet of the juvenile *B. paludinosus* consisted of insects and aquatic larvae of insects (Kirk 1972, Moss 1988); as it matured the fish varied its diet and could also feed on higher plants (Burn 1974). The survival of the juvenile stages of the wintering matemba is important for the restocking of the population after an intense fishing season (Macuiane 2006). The extensive feeding range for these species was confirmed by the communities' and experts' local knowledge: all habitat types serve as feeding grounds for juvenile chambo and juvenile matemba as well as for adult chambo and adult mlamba. Unlike these species, which are found to be associated with multiple habitats, nkhalala juveniles are said to be only in SAV, with adults in EAV (Table 4.2, Figure 4.4).

4.1.6 Bird Sanctuary - Lake Chilwa Ramsar Site

Lake Chilwa sustains a large waterfowl population estimated at 1,354,000 individuals for a select group of important species (Wilson & Zegeren 1996, Wilson & Zegeren 1998, Wilson 1999). This includes 153 resident species and 30 migratory water birds (Ramsar 2014). Because of its international importance, Lake Chilwa was designated a Ramsar site in 1997 (No. 865). Changes in the water level and seasonal fluctuations in the basin affect the different habitats that support the waterfowl species. For instance, the abundance of the Greater Flamingos is influenced by changes in the vegetation (Chironomid Fauna) that fluctuate with the lake levels (Kalk et al. 2012). During dry seasons when lake levels drop and there is less fish to catch, many residents hunt birds as a supplemental livelihood. Even during normal years, the harvest of water birds usually takes place during the rainy season (Bhima 2006).

4.1.7 Other Aquatic Biodiversity

The rich flora and fauna of Lake Chilwa are found in varying habitat types of its wetlands; these include: marshes, swamps (dominated by *Typha dominguesis*), rivers, open lake water, island

and floodplains. Their biodiversity is influenced by the fluctuation of the water levels in these habitats. In a normal year, one third of the lake is open water; one third is marshes; and one third is floodplains (Kalindekafe 2014).

Aquatic plants are found to dominate different habitats of the lake. Floating species such as *Pistia stratiotes, Ceraphyllum demersus* are on the lake edge of the swamp; large sedge *Scirpus littoralis* and the aquatic grass *Paspalidium germinatum* are commonly in open water.

Other groups represented are amphibians, which are sensitive to being used as fishing bait (Mfune & Mhango 1998) and are often preyed upon by birds and snakes, as well as other animals sensitive to long drought periods. A freshwater prawn, macrobrachium spp, is also present (Nsiku 1999).

Large mammals were abundant in the early 20th century: hippos, kudus, sable, antelope, bushbuck, reedbuck, hartebeest, lions, hyenas and leopards. Due to loss of habitat and predation, these have suffered a severe decline (Sweeney 1965). Recent assessments by Mfune & Mhango (1998) recorded only small groups of spiny mouse, four-toed hedgehog, and field rats (Kalindekafe 2014).

Lake Chilwa bird diversity is high. Many birds breed during the periods of January to July, favoring the river mouths and areas that are inaccessible to local hunters because dense marsh vegetation protects them (Bhima 2006). The vulnerability of the birds increases during nesting periods as this coincides with human seasonal hunger periods (i.e., stored crop reserves are dwindling). Local hunters use traps to capture large numbers of the common moorhen (*Gallinula chloropus*), lesser moorhen, Allens' gallinule, Blake-crake, fulvous whistling-duck, white-faced whistling-duck (*Dendrocyna viduata*) and Hottentot teal (*Anas hottentota*) (Wilson and van Zegeren 1998, Wilson 1999). It is estimated that about 1.2 million birds are trapped every year by 461 bird trappers (Maloya 2001); the migratory and resident waterfowl and birds are estimated at 1.5 million (Unesco 2011). For this reason, the Danish Hunters Association established Bird Hunting Committees and Associations to regulate hunting and advise communities about the sustainable management of water birds. There are currently over 1,300 registered bird hunters belonging to over 200 hunting clubs (UNESCO 2011). These groups work with various government agencies and NGOs conducting both research and monitoring work (DANIDA 2003), and DNPW also has a presence.

4.2 Trends in Small-Scale Fisheries

Over the past thirty years, the human population has greatly increased in the Lake Chilwa catchment area. Small-scale fisheries, livestock, and bird hunting complement food and income when other resources are low (Chiwaula et al. 2012, Kafumbata et al. 2013, Phipps 1973, Kalk et al. 1979). The increasing population levels have led to increased number of fishers and fish processors. The level of effort varies with the health of the fish stocks, with the number of fishing crew members fluctuating from 3,000 to a high of 6,000. Additionally, there is a similar number of people involved in processing and trading respectively (GOM DoF 2014; Machinga District Council, 2012 (UN Machinga Climate Proofing Profile)) (Table 4.3). Fish processing and trading are common livelihoods among women living in fishing communities. Fisheries reports indicate that fish landings from Lake Chilwa represent on average ~25-30% of Malawi's total catch (Macuiane et al 2009, Kalindekafe 2014), and that Lake Chilwa can yield ~344 kg/ha/yr. of fish. The main fish caught, *Barbus paludinosus* and *B. trimaculatus,* constitute up to

~70% of Lake Chilwa's 15,000 ton/yr total catch in 2000 (Environmental Affairs program 2000, Njaya 2001). However, the mean total catch has been on the decline since the highs in the 1990s from 12,000 mt to about 7,500 mt in 2009 (GoM 2010). This now represents only 10% of the country's fishery (GoM 2010). In 1995 when the lake dried up, the annual catch was only 1,328 mt or 4% of the national fish production for that year. Fish production rebounded a few years afterwards (Njaya 2001) though catches dropped again in 2012 from another dry period (Chiwaula et al. 2012) (Figure 4.6).

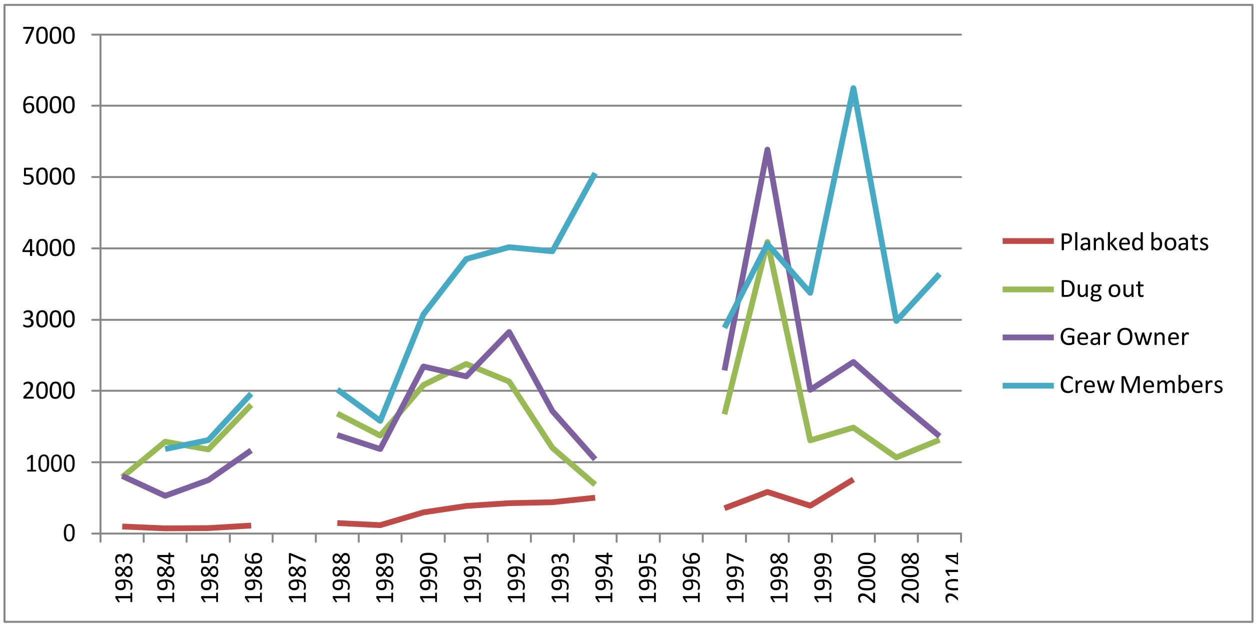

Figure 4.6: Trends in fishing effort in Lake Chilwa

Source: adapted from Njaya 2001, data from Fisheries Department 2000). Frame survey was not done in drought years of 1987, 1995, 1996. 2000 was the first year that the fishing community collected the data.

Table 4.2: Comparison of Annual Frame Survey capturing the gear and fishers in Lake Chilwa from 2008 and 2014

Statistic	**2008**	**2014**			
	Tally	**Tally of all 3 Stratums**	**Machinga Stratum**	**Phalombe Stratum**	**Zomba Stratum**
Male gear Owners	1,871	1,353	445	247	661
Females gear Owners	N/A –merged with above	9	N/A	N/A	9
Crew Members	2,980	3,638	621	397	2,620
Boat with engine (B+E)	60	2	2		
Boat without engine (B-E)	556	1,112	76	258	778

Statistic	2008	2014			
	Tally	**Tally of all 3 Stratums**	**Machinga Stratum**	**Phalombe Stratum**	**Zomba Stratum**
Dug out Canoe (DC)	1,066	1,316	648	270	398
Planked Canoe (PC)		376	53	79	244
Mosquito net (MN/US)	3737	14	2		12
Matemba seine net (MS) (most contain small net materials like mosquito netting)	396	1,070	66	250	754
Nkacha seine net (NK)		4			4
Gill Nets	10,740	9,097	326	2,215	6,556
Long Lines	1,115	1,431	312	443	676
Fish traps	6,669	31,898	10,076	9,744	12,078
Handlines	18	2		2	
Hook and Lines (chomanga)	5,814	30,562	10,820	5,840	13,902

Note data in yellow may be an error. Sources: 2008 data from Kanyerere et al. 2009, 2014 data from GoM DoF 2014.

The Catch per unit effort (CPUE) of *B. paludinosus* varies throughout the year. In 2001, this was estimated at $6,693.02 per seine fishing unit (Njaya 2001). CPUE considers periods of droughts, headline lengths of the seine nets, how water affects the catch rates as well as the use of various gear used in lake (Macuiane 2006) (Table 4.3). A low is observed between May and October. Physical properties of the water also influence the distribution of *B. paludinosus*. A negative correlation is seen in June, which is explained by an increase in the electrical-conductivity and total suspended solids in June (Macuiane 2006).

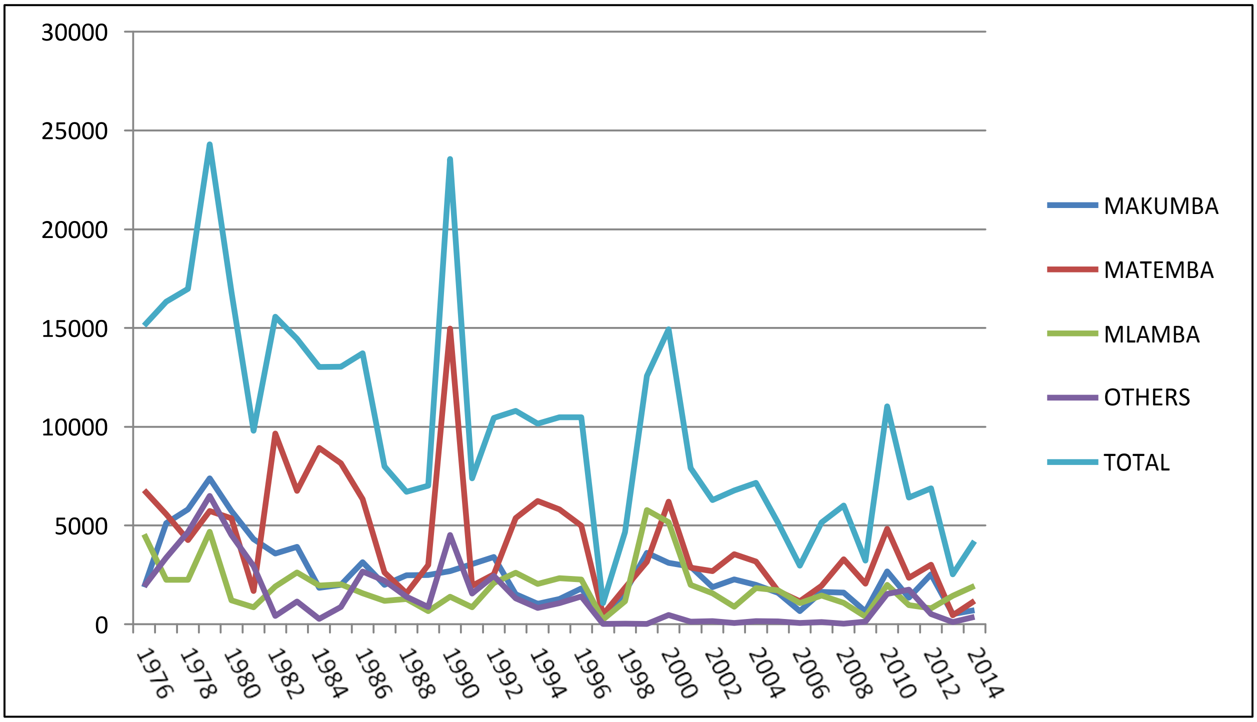

Figure 4.7: Lake Chilwa fish species catch (1976-2014)
Source: Chiwaula et al. 2012

Fish are caught using different types of gear: fish traps, gillnets, and long lines (Kanyerere et al., 2009; Njaya et al., 2011). Fish traps made with local materials are preferred by the fishers because they are less expensive and more selective allowing juveniles to escape. However, recent surveys show that the fish traps are now covered in mosquito nets, which makes them non-selective, taking all fish sizes including juveniles. Both seines and fish traps are used to catch matemba. Long lines and gillnets are used for makumba and mlamba (Njaya et al. 2011). The boats used by fishers are mostly dugout canoes. Some fishers have access to plank boats, which can be with or without engines. About 70% of the matemba landings are attributed to the matemba seines that are used, and these have been increasing since 1993 -1998 (Figure 4.6) (Kanyerere et al. 2009). Local experts report that most of these matemba seines incorporate small mesh materials such as mosquito nets and wire gauze.

The Fisheries Act of 2000 identifies several regulations on fishing gear and closed seasons for Lake Chilwa. Gillnet mesh size must be at least 70 mm and used at a maximum depth of 3 m (Chandilanga et al. 2013, p 40). Matemba seines, used to target small cyprinids, are exclusive to Lakes Chilwa and Chiuta (Kanyerere et al. 2009). Matemba seines are used along the shore and near the coastline. These are prohibited from December to February (Fisheries Act 2000). Beach seines are banned between 6 p.m. and 6 a.m. as well as from January to April (Fisheries Law 2000). Size restrictions are in place with a minimum mesh size of 76 mm, and the following depth restrictions: 4.5 m for gill nets and 10 m for seine nets (FAO.org). The use of Magalanga fish traps is illegal in Lake Chilwa, and mosquito nets and gauze wire nets are prohibited (Chandilanga et al. 2013, p 41). Despite these restrictions, there are reports of this illegal gear being used by the larger boat owners to seine in deeper open waters. Due to their illegal status, the nkacha nets are less prevalent in other lakes while their importance is on the rise in Lake

Chilwa (Kanyerere et al. 2009, Chandilanga et al. 2013). The use of chomanga, a passive gear consisting of a baited hook and float set in swampy areas, is exclusive to the Lake Chilwa fisheries (Kanyerere et al. 2009). In Mpoto lagoon, women mainly continue the traditional use of a plant called katupe (*Syzigium cordatum*) to catch fish (FAO.org). Its use is illegal because it kills non-target species and eggs. The aforementioned illegal gear is increasing the bycatch of juvenile fish (Chandilanga et al. 2013). The 2000 Fisheries Conservation Management regulation also banned the practice of fishing while on floating islands (chimbowela)—a technique commonly practiced by migrants.

It is valuable to understand the fisheries market to make wise fisheries management actions to reduce the pressures on biodiversity (Figure 4.5). A value chain analysis was conducted for Lake Chilwa's fishery in 2012 (WorldFish 2012). About 98% of the catch is sold to traders and processors that reach local and regional markets. Of this, about 77% of the catch is sold fresh, which is an increase from 10% in 2001 (Njaya 2001). The higher percentage of fresh catch is due to the increased usage of ice to reach the urban markets.

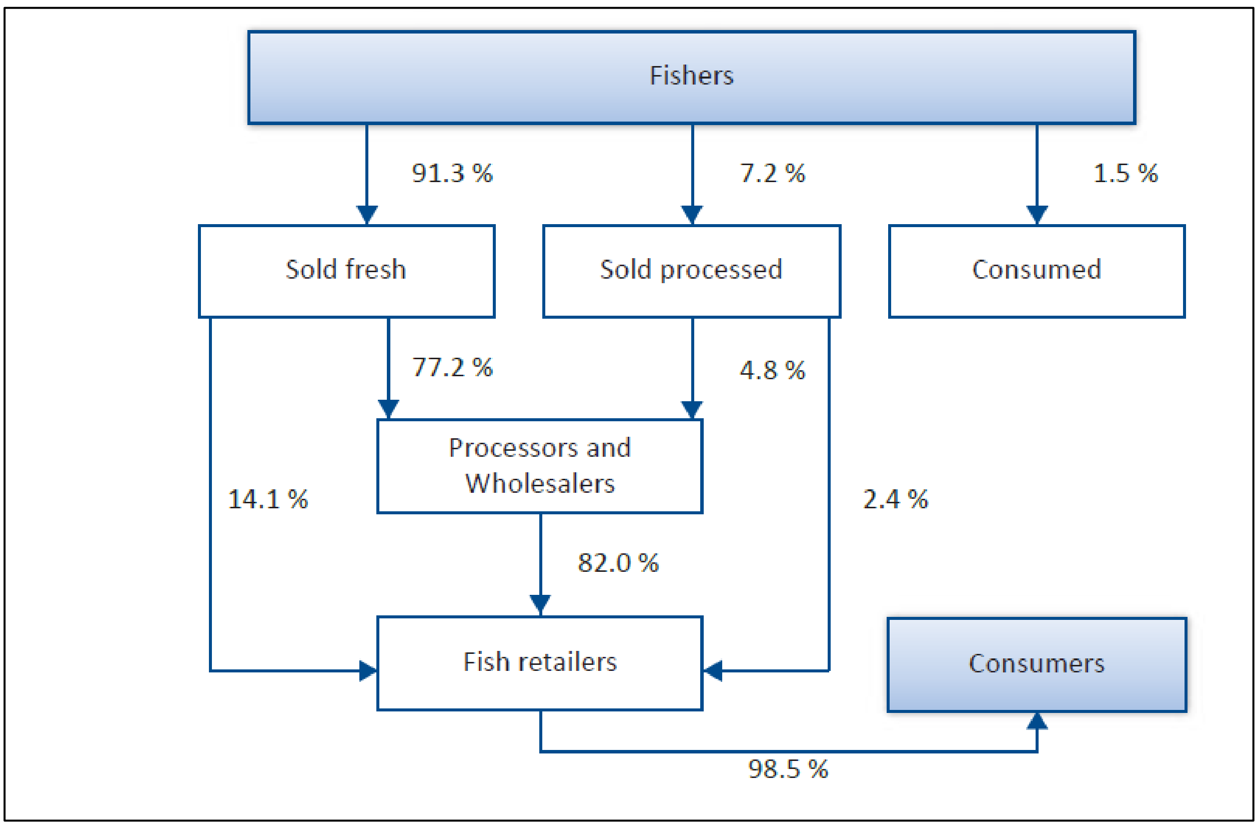

Figure 4.8: Use of fish from Lake Chilwa. Note percentages are based on the monetary value compared within each level of the chain of fresh fish in 2012
Source: WorldFish. The Structure and Margins of the Lake Chilwa Fisheries in Malawi: A Value Chain Analysis, 2012.

4.3 Primary Threats, Stressors and Drivers to Freshwater Biodiversity

Lake Chilwa is confronted with a variety of direct threats and stressors to the freshwater biodiversity. Communities and scientists generally agree on the major issues of overfishing, illegal and destructive fishing, sedimentation and nutrient loadings, invasive species, extreme weather events and habitat loss. Climate variability has always been central to the ecosystem though the impacts from long-term climate change are still not clear.

The primary drivers and contributing factors of threats to Lake Chilwa's biodiversity are a combination of human population density, a high degree of natural resource dependency in the catchment linked to limited alternative livelihood options and poor governance that creates confusion and hampers management effectiveness. There are 1.6 million people in the catchment at a density of 321 people/km.^{2} The density is three times greater than the national average of 104 people/km^2 (NSO 2008). The total fertility rate of 6.9 children per mother is one the highest in the country (UNDP 2014). Other threats are linked to sanitation and water availability; many documented diseases in the Lake Chilwa catchment area are linked to "either water abundance or the lack thereof." The more common illnesses include malaria, cholera, bilharzia, respiratory tract infections and diarrhea among others (Mtilatila et al. 2003).

Surrounding these demographic pressures is a governance system that tries to balance mixed incentives. The traditional leaders historically control tenure for land, wetlands, forest and fishing rights. Traditional leaders entrusted with sustaining resources, receive tributes from users in exchange for annual access to the resources. While legal, this practice often creates a state of insecure tenure and confusion for stakeholders who must navigate the conflicts between traditional leaders and government regulations or management plans. Direct threats and the drivers, stressors, and contributing factors are outlined in Table 4.4. Understanding and addressing these components is valuable to having long-term significant success in reducing immediate threats to freshwater biodiversity and sustaining people's livelihoods (Table 4.4).

Table 4.3: Primary threats, stressors, drivers, and contributing factors to Lake Chilwa's freshwater biodiversity

Threats	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Overfishing	X	X	X
Illegal (seasons)/destructive fishing	X	X	X
Deforestation	X	X	
Sedimentation and soil erosion	X	X	X
Invasive species in the lake (water hyacinths etc.)	X	X	
Nutrient Loadings			X
Habitat Loss (EAV)			X
Stressors	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Climate change	X	X	X
Climate variability	X	X	X
Extreme weather events (droughts/ floods)	X	X	X
Drivers	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Poor education and low literacy	X	X	X
Lack of power and knowledge to enforce	X	X	X
Poor governance: lack of capacity, resources, leadership, bylaws and other rules that restrict access and manages how much fish is taken out	X	X	X
Contributing Factors	**Literature Review**	**Local Communities**	**Scientists/ Managers**
High population growth rates	X	X	X
Poverty and food insecurity	X	X	X
Lack of alternate livelihood opportunities	X	X	X

4.3.1 Overfishing

There are around 4,000 to 5,000 fishers in Lake Chilwa. Based on observation and anecdotal stories, the catch is predominately composed of juveniles. This is attributed to the recent drying episode in 2012, from which many of the species are just now recovering, resulting in a large portion of juveniles (Juma 2015, personal communication). However, the current trends in reduced fish catches and the increased number of fishers lead to questions of whether the fish stocks will be able to rebound before the next dry period. Matemba makes up the majority of the catch when lake levels are normal, though recent catch reports indicate this species has not rebounded as quickly. This could be a temporary lag or a long-term change in the system.

One difficulty in estimating overfishing is that the relative fish downward catch levels also coincides with reduced water level (FAO 2005). Catch per unit effort (CPUE) rates coincided with water level and physical chemical properties of the water (Macuiane 2006). Macuiane explained correlations between the presence of important fish species that varied on the shore and open water in function of time of year and the water properties. For example, *B. paludinosus* in February was positively affected by pH and negatively influenced by electrical-conductivity (EC), and between April and June it was positively correlated with total suspended soils and EC (2006). A decrease in length at maturity is often seen as an indicator of overfishing (Thompson & Bell 1934, Froese 2004), which is equally attributed to environmental changes. As an example, matemba (*B. paludinosus*) maturity has been fluctuating over the last years with female maturity recorded at 75 mm TL, producing 2,200 eggs in the 1960s (Crass 1964). In the 1970s, a 50% length of maturity for female *B. paludinosus* was approximately 50 mm, producing 5,000 eggs per female (Furse 1979). The female matemba maturity was most recently recorded at length of 69 mm and *B. trimaculatus*, at 61.3 mm TL (Macuiane 2006). The maximum total lengths of female and male *B. paludinosus* were 130.0 mm and 113.0 mm, *B. trimaculatus* were 120.0 mm and 85.0 mm, respectively (Macuiane 2006). These values are not too different from those reported from surveys undertaken in the past 15 years (120-130 mm) (Kalk, 1978; Bell-Cross and Minshull, 1988; Njaya, 2001 and Msiska, 2001 as cited in Macuiane 2006). Male matemba matured at a shorter length, which could account for the 1:3 ratio in catches of males to females, respectively (Macuiane et al. 2009). This means females are more susceptible to capture, ultimately reducing fecundity in the system (Macuiane et al. 2009). However, the concern is that relative to the maximum lengths reported in the past, fishers and fish traders have observed a significant decline in the *Barbus* sizes over the past 15 years (Macuiane 2006).

4.3.2 Illegal and Destructive Fishing

Despite regulations, communities and government report that destructive and illegal fishing gear is still used. Mosquito nets, dande (greenhouse covering), koka (1/4 beach seine) and gauze wire nets are prohibited (Chandilanga et al. 2013, p 41), though there are reports of larger boat owners using them to seine in deeper open waters. Illegal nkacha nets are becoming more prevalent (Chandilanga et al. 2013, p 40) (Kanyerere et al. 2009). Communities report that Nkatcha nets are being adapted to fish deeper waters, which are increasing the catch of juveniles. Fishing with poisons, which is illegal, can kill non-target species and eggs (Chandilanga et al. 2013, p 35). Illegal gear is increasing bycatch of juvenile fish (Chandilanga et al. 2013, p 35). The species most impacted by the illegal and destructive gear are chambo, malamba, and matemba. Fishers say they use these types of gear because they are very effective at caching fish, and because they lack resources to buy proper gear.

The community has responded by confiscating the illegal gear and handing them over to the Police and Department of Fisheries. Reports are mixed on what happens next. Communities perceive that the illegal gear is returned to users without penalties. Some report that there is confusion over who can allocate penalties–village headman versus government.

4.3.3 Invasive Species

The biodiversity of the wetland habitats on the plains of Lake Chilwa in Swang'oma, Phalombe District, is threatened by the presence of the Central American mesquite tree, *Prosopis juliflora*. This invasive species has extended across the plains of Lake Chilwa in Phalombe District and in the Lower Shire Valley, where it threatens the habitats and biodiversity of the lake due to its prolific seed production and its spreading efficiency through the assistance of browsing animals. It has a strong tendency for allelopathic-induced (releasing chemicals) mono-cultural growth.

Other aquatic invasive species that threaten Lake Malawi's endemic species are: the water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), red water fern (*Azolla filiculoides*), and giant salvinia (*Salvinia molesta*). Some of these plants grow as extensive mats, interlocked, impeding the penetration of light interfering with indigenous flora, affecting invertebrate biodiversity, and changing the water chemistry (EAD 2010).

Issues regarding invasive species in Malawi are addressed in sectoral policies and legislations, and wildlife and fisheries policies that address biodiversity. A number of Acts are in place to prevent the introduction of invasive species. Unfortunately, the lack of enforcement of these acts does not stop the continuous introduction of exotic invasive species (EAD 2010).

Communities report that the invasive species can grow into very large migrating 'islands' which can impact the safety of the fishers. Fishers report capsizes and getting trapped when these 'islands' blow into a boat's vicinity during strong winds.

4.3.4 Land Use Changes leading to Sedimentation and Habitat Loss

Influenced by the increasing population density and high demand for land, there are significant land use pressures affecting the freshwater biodiversity of Lake Chilwa (Figure 4.9). Some areas that are affected are the catchment area of Likangala River and Domasi River, where increased deforestation has promoted the loss of soils (Jamu et al 2003). Deforestation, increased farming, and unstable riparian habitat have increased the sedimentation rates into Lake Chilwa–an already shallow system to begin with. Common throughout Malawi, deforestation is driven by the demand for firewood and charcoal industries, as well as increased agricultural production (Kafumbata et al. 2014). Combined with poor soil management and increased fertilizer use, the river systems are carrying increased sediments and nutrients into the lakes. During rainy season, nutrient load and silt enters the lake given to the wide lake degradation of *Cyperun papyrus* after a lake level decline (Kafumbata et al 2014). Maize, vegetables, and exotic tree farms often are placed directly adjacent to streams/water bodies. Increasing irrigation, demand for water by upstream communities, and deforestation negatively impact fish breeding habitat by reducing water flows and increasing sedimentation in the rainy season (vegetated shorelines) (Kafumbata et al. 2014). All of these livelihood strategies increase sediment loading/siltation into streams feeding Lake Chilwa.

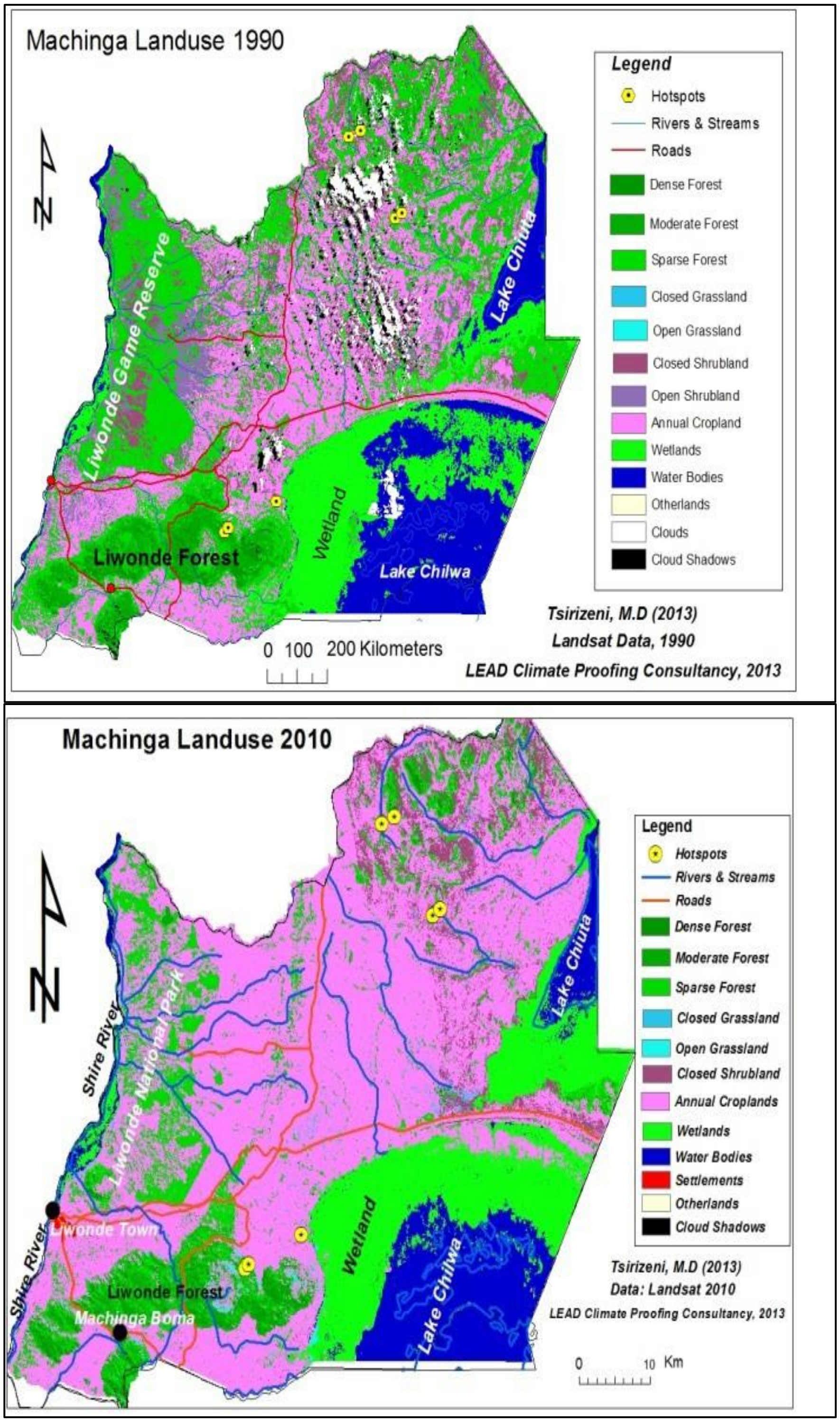

Figure 4.9: Land use changes around Lake Chilwa from 1990 and 2010

Source: UNDP 2014. Climate Proofing Malawi Project Document p. 24.

Lake Chilwa's typhae grass mitigates sedimentation pressures (Chandilanga et al. 2013).

However, mangers report that emergent vegetation near river mouths is transformed as the surrounding vegetation in the river catchment areas, including marshlands, (Likangala and Domasi) is burned during the wet season. This destroys breeding habitats, which are transformed into dry lands, losing valuable fish habitat (Macuiane et al. 2009).

Wetland livelihood opportunities have attracted many people seeking to make more money, and thus Chilwa's rich environs are among the most densely populated areas in the basin; ~321 people /km^2 (Kafumbata et al. 2014). There is a high demand for wetlands to use in agricultural production, due to their moist, nutrient rich soils and nearby water access. These wetlands are more likely to provide stable cash flow and food security from crops. In the 1980s, wetlands were partitioned as de facto private land to chiefs and special lineages (Kambewa 2006). These customary lands occur alongside public leasehold and freehold lands often near government irrigation schemes. To gain access to land, people must inherit it through family or be permitted by chiefs. Anyone can get access to land upon paying an annual tribute to the Chief. This increases the likelihood of migrants moving into the catchment. However, users of the wetlands have insecure tenure and thus are unlikely to fully invest in the lands or maintain environmental health (Kambewa PLAAS). Chiefs, who have retained the authority to allocate wetlands, charge an annual tribute. Users of the wetland cannot sell it, thus providing the Chiefs with long-term control, and therefore, a logical entry point for co-management. In response to the intensive land degradation and its bird biodiversity, Lake Chilwa and its northern wetlands were declared a RAMSAR site in 1997 (GoM 2010).

4.3.5 Climate Variability and Change

Lake Chilwa's defining characteristic is its historic lake level variability. Of all the major lakes in Malawi, Lake Chilwa has shown the greatest changes due to droughts. The lake has significantly or completely dried up about 11 times (1879, 1900, 1913-1916, 1922, 1934, 1943-44, 1967, 1973, 1975, 1995-96, and 2012) since 1879. In addition, lake level variability occurs on an annual basis (Njaya 2014) (Figure 4.10). Nyaya et al. explain that in years of high water level the open water increases in area to 1,054 km,^{2} and this same area decreases to 678 km^2 during low water level conditions (2014). Estimates from historical records indicate that the annual inflow into lake Chilwa is 3782 Mm^3/year (2310 Mm^3 from direct rainfall and 1472 mm^3 from river inflows) (Figure 4.8). The lake loses 3782 Mm^3 through evapotranspiration (LCBACCP 2012). The majority of rainfall occurs in the wet season from December to March (Figure 4.9) when the lake rises again.

The second last major drying cycle in 1995 was a result of two successive years of reduced rainfall—775 and 748 mm—when the Lake dried completely. While not a complete drying episode, 2012 was another drought period with rainfall totals of 1048 mm in 2011 and 655 mm in 2012 (from January to June). This shows that the lake dries up significantly after two preceding years of poor (<1000 mm) rainfall, influenced by reduced precipitation in catchment contributing to low river discharge (Figure 4.10) (LCBACCP 2012).

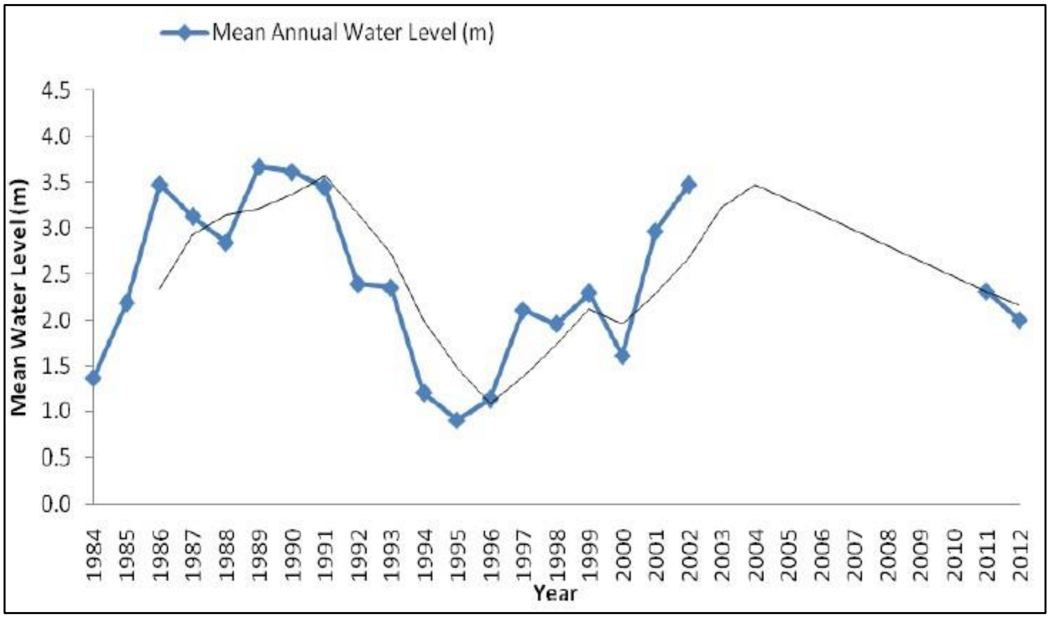

Figure 4.10: Trends in water levels, 1984-2001 and 2011- 2012.[3]

Figure 4.11: Lake Chilwa conditions during recovery in 1996 (left) and dry year (right) in 1995 at the same place in Kachulu (photos: Sosten Chiotha).

Source: LCBCCAP 2012 Briefing Note, 17th July 2012. Is Lake Chilwa Drying? Evidence from past trends and recent data

[3] Continuous water level records are unavailable in 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010 due to loss of recording equipment. Note: 3 -year moving average (except where marked mean annual water level). Mean Annual Water Level (meters) since 1984 for Lake Chilwa. Data source Lake Chilwa Program and Water Department as presented in LCBCCAP 2012 Briefing Note, 17th July 2012. Is Lake Chilwa Drying? Evidence from past trends and recent data.

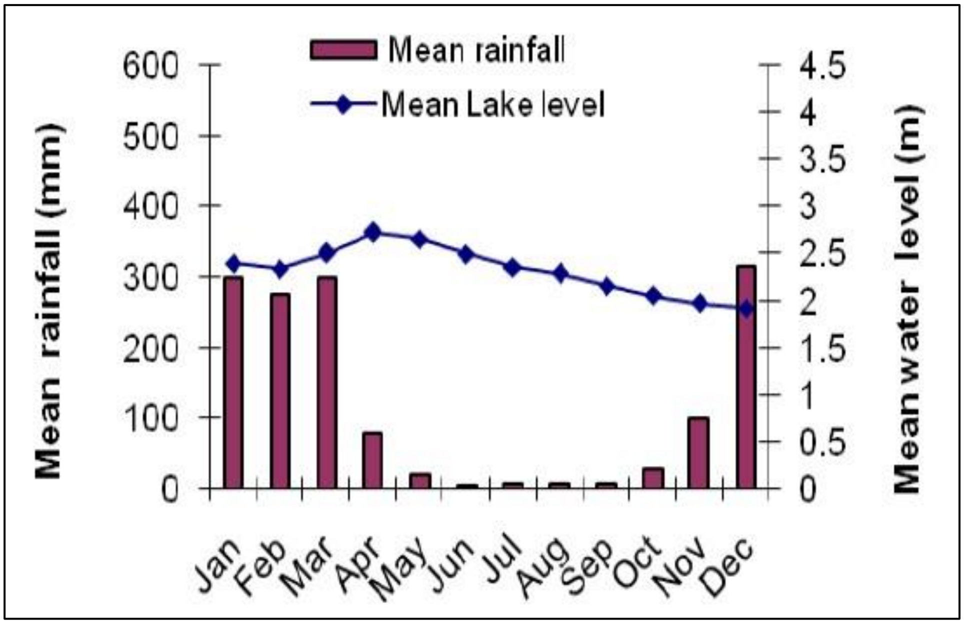

Figure 4.12 : Lake levels and mean monthly rainfall in Lake Chilwa in 2011

Data source Lake Chilwa Program and Water Department as presented in LCBCCAP 2012 Briefing Note, 17th July 2012. Is Lake Chilwa Drying? Evidence from past trends and recent data.

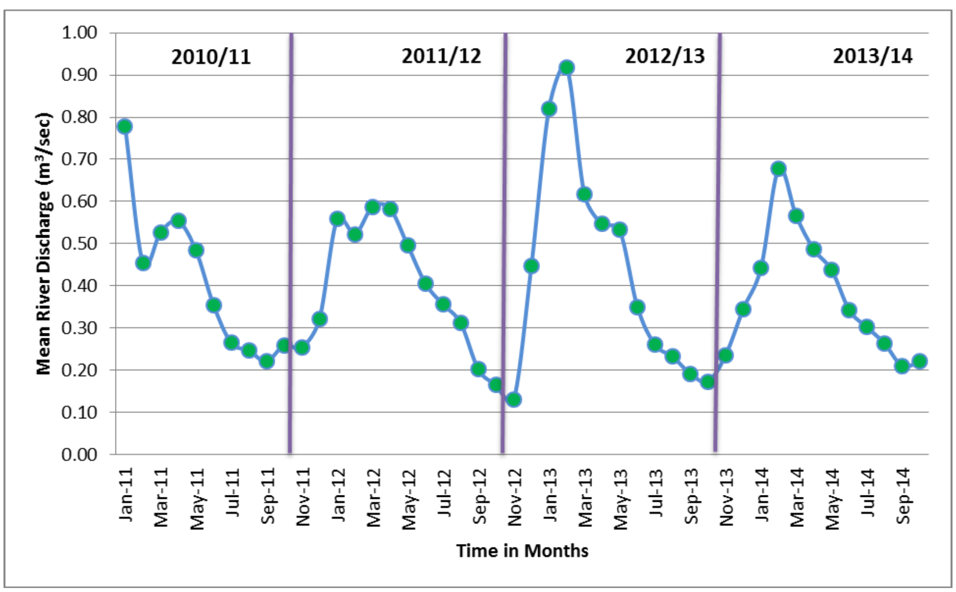

Figure 4.13: Mean river discharges by month from 2010-2014 in Lake Chilwa Catchment

Source : LCBCCAP 2015. Emailed data from Joseph Nagoli, WorldFish.

Fish catch sizes fluctuate with the lake levels by on average a two-year lag time as reported by fishers and local experts. The figure below shows annual catch in metric tons, alongside lake water levels from 1962 to 1999 (Macuiane et al. 2011). The Lake Chilwa fishery has historically shown great resilience to complete desiccation, recovering in as little as two years (Kafumbata et al. 2014). When lake levels drop, there are corresponding drops in fish catch that have a significant impact on the local economy (Figure 4.11), although the fish catches fully rebound 3-4 years later. A benefit of the lake bed drying out is that accelerates soil aeration, decomposition of organic matter, release of hydrogen sulphides, mineralization and nitrogen fixation, which can then allow for plant growth when the water and fish return. This process has resulted in transforming Lake Chilwa into one of the most biologically productive lakes in Africa: 344 kg/ha/yr (personal communication John Balarin 2015). The key to this rapid recovery is the protection of remaining fish in dry period refugia, such as the deltas of Likwenu, Domasi, Songani, Likangala, Namadzi, Thondwe, and Phalombe rivers and the Mpoto Lagoon on the southern end of the lake (Figure 4.1) (Kafumbata et al 2014). It is not certain, however, that the fish stocks will be able to rebound in the future when confronted with increased land use and degradation of the catchment.

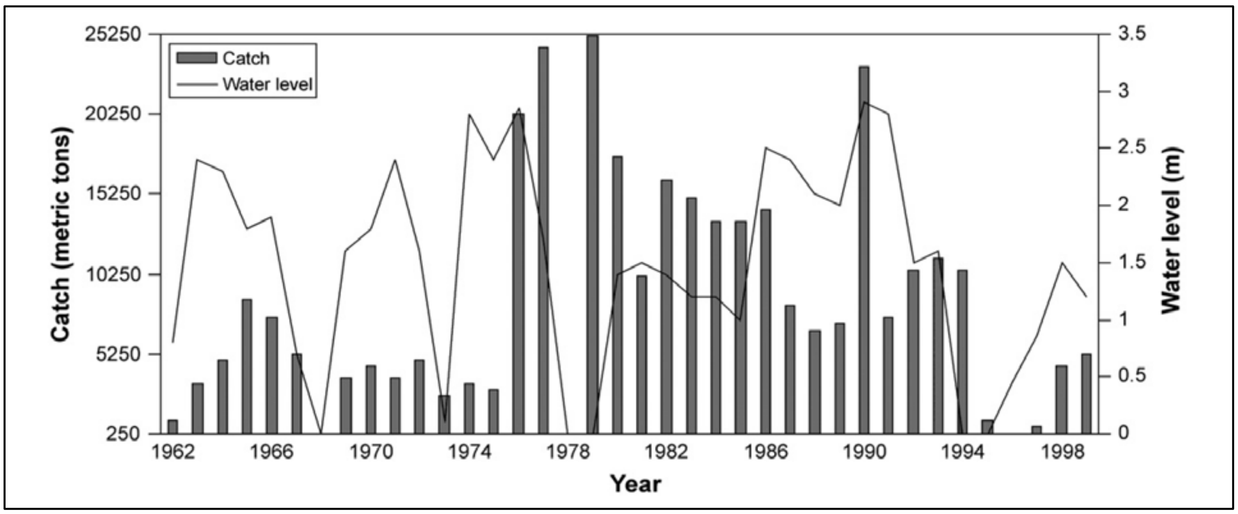

Figure 4.14: Variation in fish catch in Lake Chilwa compared to changes in lake levels

Source: Macuiane et al. 2011.

Historical evidence suggests that many flora species die out during extreme low lake level events (Kalindekafe 2014). The impact of changing lake levels due to climate variables since 1879 results in a highly variable environmental condition to which endemic species have evolved to cope. Shoreline vegetation species, such as the perennial *Typha dominguesis* and floating aquatic plants such as *Pistia stratiotes, Ceraphyllum demersus,* will vary annually based on water levels and the duration of dry soils. Studies suggest that predominance of specific aquatic plant growth forms, such as free floating and emergent, are determined by the presence of temporary dry periods, while the amplitude of lake level fluctuations is a key factor for individual vegetation taxa (Williams 1975) (See aquatic plants 4.1.7). There is a non-linear relationship with water level changes, where shallow shorelines respond significantly to small changes (Walker & Coupland 1968). This fluctuation in conditions does not allow any one species to dominate, thus increasing overall biodiversity.

4.4 Opportunities for Action/Management Suggestions

4.4.1 Governance

Due to the highly integrated linkages between flow of water, lake levels, fish production, fishers and traders, it would appear that a comprehensive lake wide management plan would be required to have significant impact on the health of the lake and associated fisheries. Community-based management does not appear to be the appropriate scale. A top down national enforcement program also would not seem feasible or desirable. A key to management is to be as flexible and adaptive as is the current environment and fishery. In 2000, the Fisheries Conservation and Management Regulations were approved by the Minister of Natural Resources and Environmental Affairs. The regulations specified the responsibilities of the BVCs to manage and conserve the fisheries resources within their area of jurisdiction (Wilson 2004),
The current fishery practices have emerged in time to be adaptive to changing weather and consequently fluctuations in fish stocks.

This inherent strength of the small-scale fishery should be retained going forward. The BVCs in the Lake Chilwa area seem weak and unable to generate collective action over the expanse of the lake; ideally, multiple BVCs could come together in a Fishery Association to make a co-management plan for specific species. Conflicting rules between the government, traditional authorities, and the BVCs will continue to create confusion and an easy excuse for government to avoid taking leadership in addressing destructive fishing activities.

A management plan, which we are unable to access at this time, is being developed for the Lake Chilwa Basin. There is the potential to build on this established catchment-wide governance body to improve fisheries issues. This could be linked to the ongoing BVC-based co-management system that is possible within existing legal frameworks but has not been fully implemented yet in any of the Malawian lakes. The law encourages multiple BVCs to form a single lake district Fisheries Association that can make a legally binding co-management plan for specific species and applicable to all BVC and users.

4.4.2 Habitat Protection / Measures Within and Adjacent to the Lake

A management program would need to incorporate the health and protection of the rivers, as they serve as key breeding habitat and refugia during drying periods. Initial steps could include locating environmentally destructive activities around key habitats and river mouths, such as those closest to biodiversity hotspots identified in the FISH maps. Rivers can be prioritized based on the likelihood of flowing water during droughts, especially if they have deep pools and healthy habitat at the river mouth. Finally, the goal should be to complete the process of mapping river deep pools and protect the most valuable deep pools in the rivers (and lake) that are used for spawning and refugia during droughts. Initial findings suggest priority sites in the Likangala, Domasi and Namadzi rivers. River Village Committees (RVC) have been effective in serving these roles and so should be supported with the potential for an expansion of roles to other areas such as riverbank stabilization (see below). Other experts have made similar recommendations in the past, including protection of previously established fish sanctuaries/protected areas in river mouths where *Barbus spp*. spawns (Macuiane et al. 2009).

4.4.3 Fishing Practices

To address the use of illegal gear and fishing in no-take zones, the communities request fast motor boats. This is an option although the maintenance and recurring costs of these vessels and the risk of diversion to fishing activities must be factored in to any long-term success. An alternative that indigenous groups have embraced in forestry surveillance is the use of aerial drones that can fly long distances and take video or photographs. It is worth exploring the costs and benefits of this approach, but the technological requirement may be prohibitive.

An option is to move the current seining closed season from December to April to October to February to allow target species that add significant biomass (Macuiane et al. 2009). Even better, would be to allow the local fishing authorities to set the closed season on an annual basis based on the variability of the temperature and rainfall that drives certain fish species' life cycles. This would provide the BVCs and lake wide fishing associations an annual responsibility to show their effectiveness and influence.

4.4.3.1 Reducing Post-Harvest Loss through Improved Fish Processing

Solar dryers have been piloted successfully in Lake Chilwa area under the support of NGOs and donors (Mustapha et al 2013, Luhanga & Jamu 2013). The design of the facilities and the drying effectiveness currently work well for three key species: utaka, ndunduma and parboiled usipa (see the case study in the synthesis chapter). The costs to build the pilot solar dryers average 1,000 US Dollars. There needs to be more information on the long-term management of these facilities, including ownership, cost-recovery and equitable allocation of the use of the facility across the communities, cooperatives, or other groupings. Testing of solar dryers has shown that they decrease processing and packaging time and increase the quality of the product (Luhanga & Jamu 2013; Chisale et al. undated). This influences the product's longevity in the market and the overall gains; and indirectly, the use of solar dryers reduces other threats to the environment.

In 1987, in order to minimize deforestation, improved fish-smoking kilns were introduced to fish processors through the Malawi-German Fisheries and Aquaculture Development Project. A recent study by Luhanga compared the efficiency of improved kilns to traditional fish smokers and found no significant difference in regards to their mean (technical) efficiency, but that the improved kilns used less firewood and labor to smoke a given amount of fresh fish. Recommendations were then made noting that if 170 fish smokers in the studied area used the improved kilns, a minimum of 74 ha of forestland would be saved over a year (Luhanga 2012).

Fuel-efficient smokers are another technology that can reduce pressures on the trees in the area while reducing the production costs for the processors. Since the fish is often sold to urban markets, there is the potential to add value through proper packaging and advertisement of the higher quality of well-handled and hygienic fish.

A review report completed by Chandilanga et al. (2013) has identified the fish species that are most impacted from poor post-harvest handling: Matemba *(Barbus spp.*), Makumba—*Oreochromis shiranus)*—locally called Makumba, and *Tilapia rendalli* (Chilunguni). The report finds that *Clarias gariepinus* (Mlamba) has a relatively higher pre-processing life. No economic data were presented. The report identifies several interventions to limit post-harvest losses in Lake Chilwa (Chandilanga et al. 2013, p 40). These include the following:

- Increase access to, and use of, ice on fishing boats to conserve catches until they can be landed
- Modify storage techniques to reduce bulking thereby limiting spoilage
- Improved processing and handling techniques to increase product hygiene.

4.4.3.2 Livelihoods

There are several livelihood types, such as farming, animal husbandry, and general hired labor (ganzu) related to the lakes and fishery beyond just the fishers catching fish. Thus a variety of livelihood strengthening and diversification schemes should be considered. There is not a conducive environment for adequately addressing fisheries in isolation based on the demographics, local economies dependent upon natural resources, and limited quality farm land. Greater impacts to reduce pressures on the fishery may be achieved through strengthening and diversifying non-fisheries activities. This could reduce the pressure on the fishery to allow for some reduction in fishing effort and habitat destruction. However, the population growth combined with an open access fishery likely negates small gains.

Many of the lakeside communities are requesting basic core skill development in business, banking, and management of natural resources, specifically fisheries and aquaculture. Some parts of Lake Chilwa, such as Kachulu, have access to the larger markets of Zomba while others will struggle to gain entry without taking on excessive costs.

A lack of capital is repeatedly cited by the BVC PRA groups as a limiting factor to improving the fishery and the larger community well-being. One option is to provide a loan for ecosystem services arrangement. Small business loans could be provided on the premise that an ecological service or protection is maintained, such as enforcement of illegal gear and no-fishing zones.

A key business advantage for lakeside communities is their access to the lake's water. Simple vacuum pumps or solar powered pumps could provide enough irrigation to the communities; although a rapid environmental impact assessment should be conducted to ensure there are no significant impacts to lake levels and habitat. While the fertility of the soils remains a challenge, the community can increase their use of house-gardens to build modest resilience during droughts and floods (hang vegetable planters from trees).

5 LAKE CHIUTA

Lake Chiuta 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 620 m, 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 the inflow from the Mpili River on the western side of the lake influences the water level of the lake. In the northeast, Lake Chiuta has an outflow 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). A sandbar about 20 m above lake levels separates Lake Chiuta’s wetlands from those of Lake Chilwa. The two lakes were once connected; separating sometime in the last 15,000 years (Dawson 1970, Njaya et al. 1999, Njaya 2008).

5.1 High Biodiversity Areas

5.1.1 High Fish Diversity

Lake Chiuta exhibits higher fish species richness than nearby Lake Chilwa, which is likely attributed to the lake’s lower levels of turbidity, salinity, and habitat degradation. The major species within the lake include *Oreochromis shiranus shiranus* (makumba), *Barbus paludinosus & Alestes imberi* (dondolo), *Clarias gariepinus & Clarias theodore* (mlamba), *Synodontis spp., Astatotilapia spp., Tilapia rendalirendali,* and *Marcasenius macrolepidotus* (Ngochera et al. 2001).

The regular season and weather determine fluctuation of the lake level. The surface area ranges from 25 to 300 sq. km., serving as a limiting factor to certain species (Ngochera et al. 2001). The absence of direct linkages to other nearby large waterbodies has prevented species introductions, protecting the endemic biodiversity from invasive species.

5.1.2 Habitat Types within Lake Chiuta

Lake Chiuta’s shallow waters host a number of vegetation types, both submerged and emergent. As seen in the map below of habitat areas, EAV dominates the central part of the lake (Figure 5.1). This provides valuable refugia for juvenile and breeding individuals and limits, to some extent, fishing access. Within the northern section of this EAV area lie two islands, Big and Little Chiuta. These larger islands on the Lake serve as species-rich breeding grounds and juvenile refugia. The northern part of the lake has a depth of about 5 m. It is this deeper area that feeds into the outlet during wet years, if the lake level is high enough. While the rest of the lake is relatively shallow, the shallowest areas follow the border of the shoreline. The only exceptions to this shallow rim are the deep northern area and the southeast corner of the lake.

SAV typically follows the shallow areas and shorelines of the lake. The western and southern banks see the most SAV, second to a large strip of vegetation running north-south along the northern half of the lake. Historically, SAV and EAV areas have been cut to facilitate the use of what is known as illegal gear. Currently, only a select few areas are still being cut by Mozambican fishers to increase accessibility. These areas include the southeast border of the large central EAV zone and the eastern side of the central SAV strip.

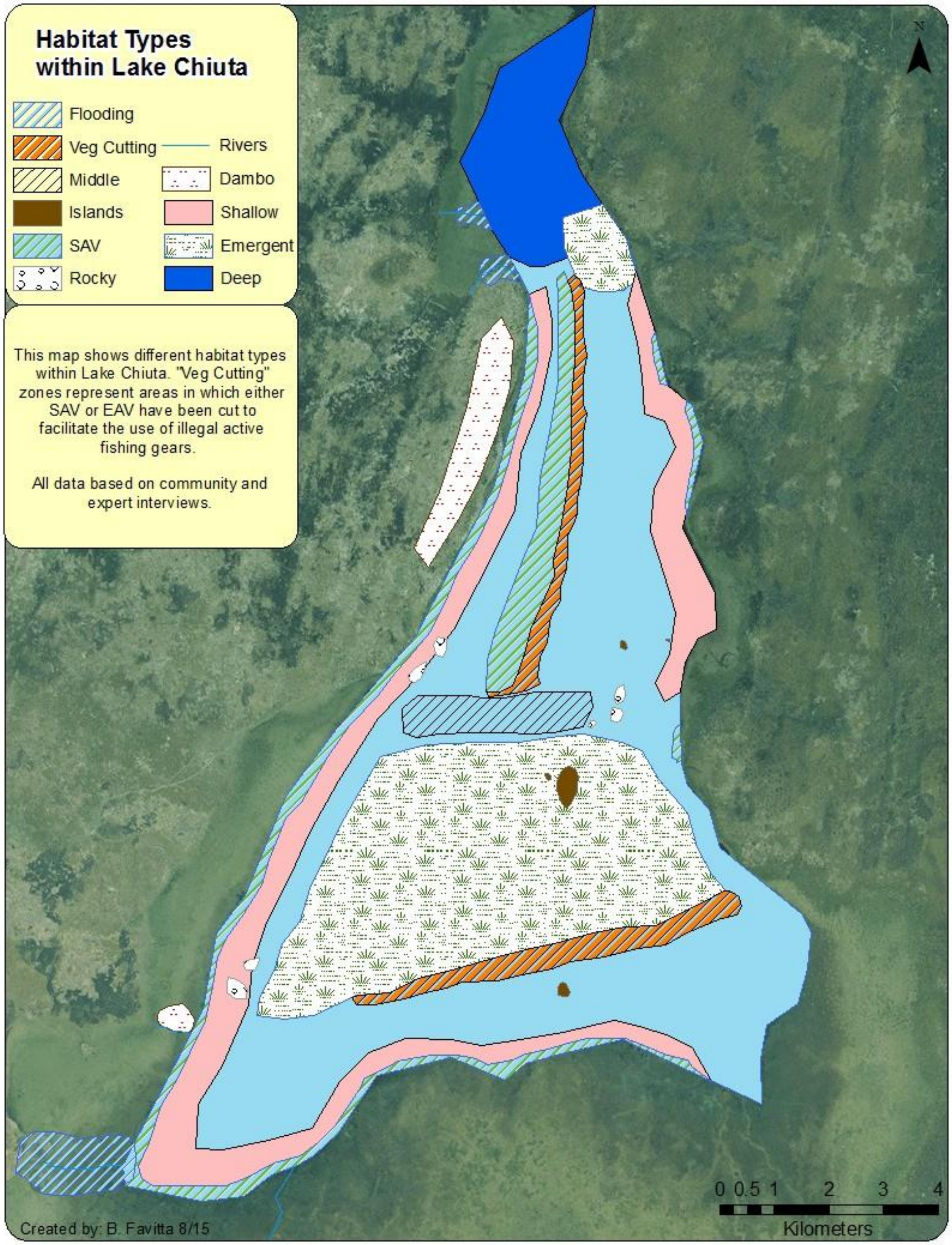

Figure 5.1: Distribution of fish habitats within Lake Chiuta based upon local ecological knowledge gathered from community PRA assessments and local expert workshop

The different types of habitats serve as breeding, nursery, and feeding habitats multiple fish species (See also Figure 5.2 and Table 5.1).

5.1.3 High Fish Abundance

Fish are evenly distributed across the lake's habitat in various life stages (Table 5.1). Lake Chiuta is well known for its SAV and muddy substrate, which is ideal habitat for the locally harvested catfish species. Fish species abundance is highest in the mid-section and northern parts of the lake, as the latter areas have high habitat diversity, lending it useful to a wider array of species. The southern end of the lake is thick with emergent vegetation. The magnitude of this vegetation results in a limited number of niches for fish species to populate, and outside of a few channels passable by canoe, the remaining area of the southern end of the lake is impassable to all fishers (Ngochera et al. 2001). As seen in the below Figure (5.2), fish abundance is highest along the SAV along the edge of the lake and in the center of the lake near the islands, Big and Little Chiuta. Emergent and submerged vegetation see the highest abundance of mlamba (*Clarias gariepinus)*, matemba (*Barbus paludinosus*), and mphuta (*Marcusenius macrolepidotus*). The rocky areas adjacent to the islands typically see more nkahala (*Brycinus imberi*), chitondolo (*Haplochromine spp.*), and chilenje. Chambo (*Oreochromis shiranus)* is one of a few fish inhabiting the deeper northern section of the lake.

Table 5.1: Summary of key habitats for critical life stages of the main fish species groups within Lake Chiuta

Species	Breeding Habitat	Nursery Grounds	Juvenile Habitat	Adult Feeding Grounds
Makumba *Oreochromis shiranus*	EAV, river inlets/outlets, shallow areas	Shallow areas	Shallow areas, EAV	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake
Mlamba *Clarias gariepinus and Bathyclarias spp.* (catfish)	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas	EAV, SAV, river inlets/outlets, shallow areas, middle of the lake, deep areas
Matemba *Barbus spp.* (catfish)	EAV, river inlets/outlets, shallow areas	EAV, SAV, river inlets/outlets	SAV, river inlets/outlets, shallow areas	SAV, river inlets/outlets, shallow areas
Ntchila* *Labeo mesops*	Rivers, River inlets	SAV, shallow areas	EAV, Rocky areas in the vicinity of islands	Shallow areas, middle of the lake

Species	Breeding Habitat	Nursery Grounds	Juvenile Habitat	Adult Feeding Grounds
Mphuta *Marcusenius macrolepidotus*	River inlets/outlets	River inlets/outlets	River inlets/outlets, middle of the lake	EAV
Nkhalala *Brycinus imberi*	EAV, SAV, river inlets/outlets	EAV, SAV, river inlets/outlets, shallow areas	EAV, river inlets/outlets, shallow areas	EAV, SAV, shallow areas
Chitondolo *Haplochromine spp.*	SAV	EAV, Rocky areas in the vicinity of islands	EAV, Rocky areas in the vicinity of islands	River inlets/outlets, deep areas, shallow areas, middle of the lake
Dande *Paretropius longifilis*	Rocky areas	EAV, Rocky areas in the vicinity of islands	EAV, Rocky areas in the vicinity of islands	
Chilenje	River inlets/outlets, Rocky areas	Rocky areas, River inlets	Rocky, River inlets/outlets	River inlets/outlets; rocky areas

The map below highlights species-rich zones within Lake Chiuta (Figure 5.2). Colors on the map represent the cumulative score of fish species with at least one critical life stage occupying the given habitat area. Life stages are given a value of '1' and were not weighted. Multiple life stages of a single species coexisting within a habitat area are not double counted. The highest species richness was present in the central island areas of the lake and along the SAV zones, specifically the western and southern banks. EAV zones also exhibited high species richness, second only to the aforementioned areas.

HIGH BIODIVERSITY AREAS WITHIN LAKE CHIUTA

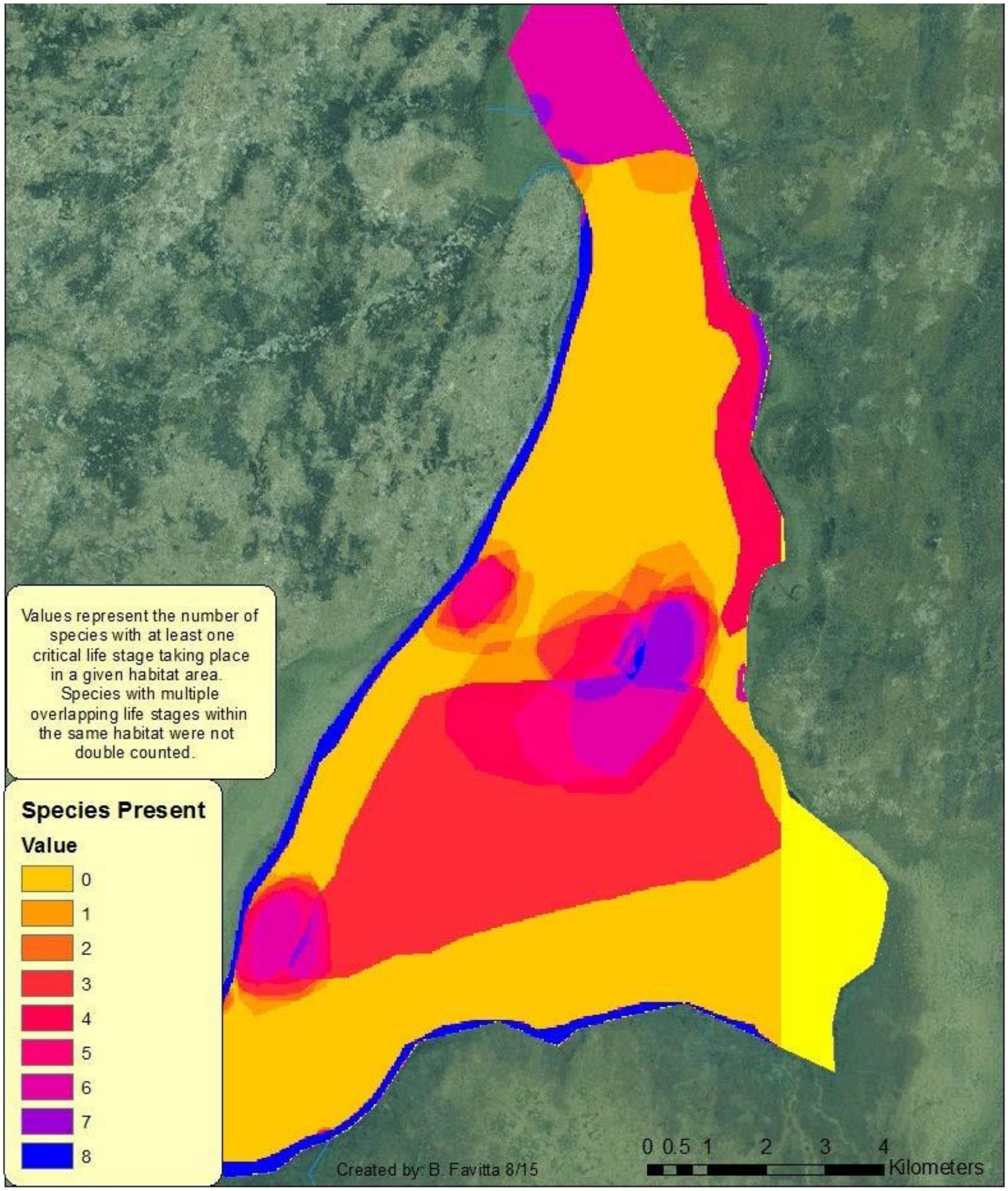

Figure 5.2: Different habitat types where the important fish species are found within Lake Chiuta based on community perceptions collected through the PRA and validated by local experts

5.1.4 Fish Breeding Habitats

The tilapia *Oreochromis shiranus* (chambo) typically breed within SAV areas between September and March; peak spawning rates are reached from October to early February (Palsson et al. 1995). *Oreochromis spp.* eggs are kept in the mouth of the female until yolk sac stores are depleted, at which time they are expelled but remain near their mother until reaching about 15 mm. Once they have grown, they seek refuge in reedy shoreline areas (Palsson et al. 1995). Nkhalala, chitondolo, and *Tilapia rendalli* also utilize the SAV as breeding areas. This provides ample refugia during mating and for subsequent juvenile protection. According to the local communities, the Mlamba utilize a number of different breeding habitats; including SAV, EAV, rocky habitats, deep areas, and shallow areas. This level of adaptability reduces species vulnerability to climate variability and lake level change. It ensures breeding cycles remain unaffected independent of lake conditions in a given year, increasing resilience. Matemba, on the other hand, breed more selectively. They prefer EAV, rocky areas, and river mouths. Mphuta and nkhalala typically share shallow areas and river mouths while breeding. *Paretropius longifilis* also breeds in rocky outcrops, which are prevalent surrounding the islands of Big Chiuta and Little Chiuta.

5.1.5 Fish Nursery Grounds

Thick SAV supplies ample refugia for juvenile fish (Ngochera et al. 2001). The shoreline inlets and stream outlets offer ideal nursery ground habitat for *Oreochromis shiranus*; while near-shore areas are sometimes used as well (Palsson et al. 1995). Mlamba and mphuta share river mouths and stream inlets with chambo species. Rocky or sandy shorelines are also suitable habitat for all *Oreochromis* and *Paretropius* species. Fry are independent and prefer shallow, calm water among reeds or isolated lagoons. Juvenile Matemba tend to stick around the rocky areas until adulthood; at which point they are large enough to venture out into open waters to reach SAV and EAV areas. *Tilapia rendalli (chilinguni)* nurse their young most commonly in SAV areas; however they have been known to nurse young in shallow, river/stream inlets as well. Nkhalala also utilize shallow areas, which provide more refuge from predators during their nursing and juvenile life stages.

5.1.6 Fish Feeding Habitats

The muddy substrate along the bottom of Lake Chiuta and SAV, which lines its shores, provide ample niche space for many kinds of insects and algae that serve as food sources for species such as makumba (Irvine et al. 1998, Ngochera et al. 2001). Larger catfish species forage along the lake bottom and scavenge for food. Most species in Lake Chiuta transition to deeper, more open water in the northern end of the Lake near the outlet. Adult chambo, matemba, mlamba, mphuta, nkhalala, and *Bargus* species all feed in this space as adults. Many of the above species (chambo, mlamba, and matemba) frequently are found near the rocky/SAV habitats surrounding Big Chiuta.

5.2 Trends in Fisheries

Historically, the makumba and mlamba have been the target species in Lake Chiuta’s fishery. Both catfish and *Bargus spp*. are consumed locally rather than sold (Ngochera et al. 2001). Since 1979, the primary catches consist of makumba (54%), mlamba (13%), matemba (12%), and 21% miscellaneous (Figure 5.3) (GoM 1999). Mormyrids are also consumed locally, while the makumba species are the primary export with approximately 60 tons/month harvested and sold (Ngochera et al. 2001) in the late 1990s. Catch levels have remained relatively stable for most species, except for makumba, which has decreased. Passive gear is used to harvest the majority of fish from Lake Chiuta, and SAV areas prevent large-scale fishing. Gill nets are the most popularly deployed gear and account for 90% and 95% of makumba and mlamba catches, respectively (Ngochera et al. 2001).

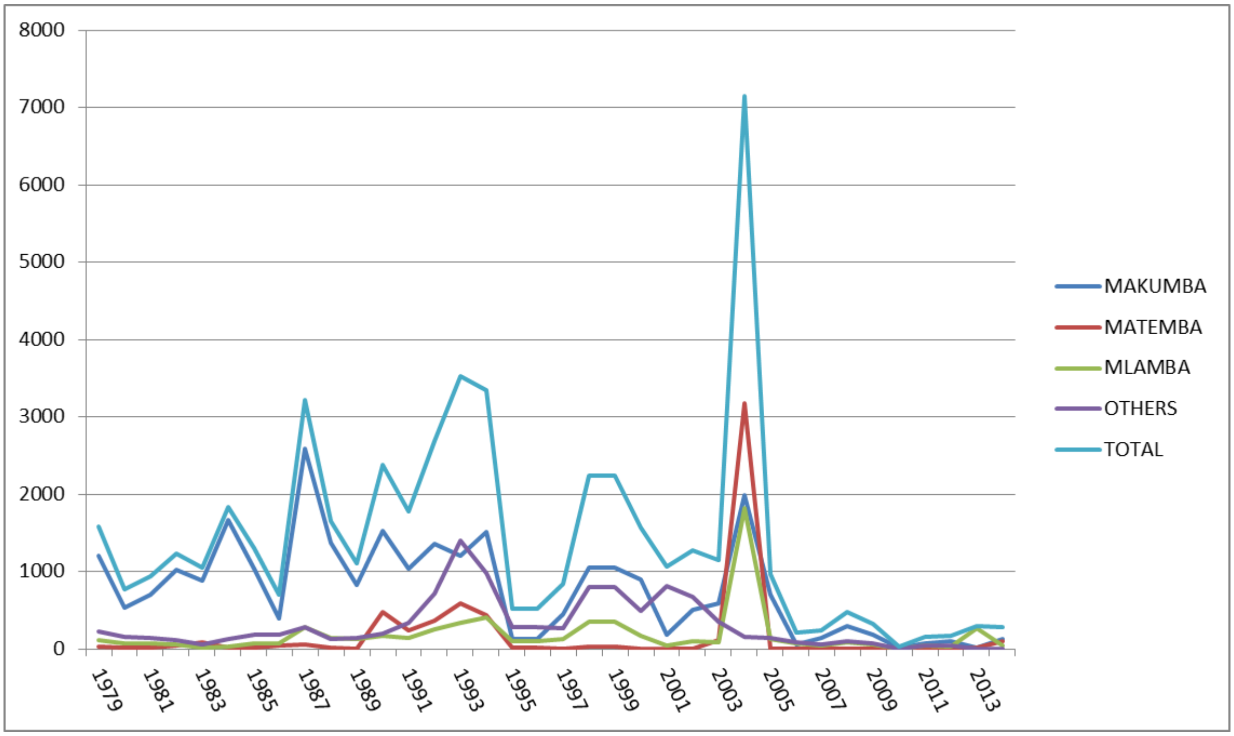

Figure 5.3: Total annual catch in Lake Chiuta from 1979 to 2014 by species (GOM DOF, 2015)

Matemba seines are exclusive to Lakes Chiuta and Chilwa, however, their relevance in Lake Chiuta is dwindling. Chomanga nets are also found explicitly in Lakes Chiuta and Chilwa (Kanyerere et al. 2009). Gill nets comprise 95% of the total catch on Lake Chiuta; CPUE for gill nets was highest in the 1980s and has steadily dropped since (Figure 5.4)(GoM 1999). Gill nets account for 90% and 95% of makumba and mlamba catches, respectively (Ngochera et al. 2001). SAV prohibits the use of large-scale boats or active fishing gear (i.e. trawling). Passive gear is much more popular on Lake Chiuta. Seine netters, however, are fined when caught and sometimes even forcefully removed from the lake (Ngochera et al. 2001).

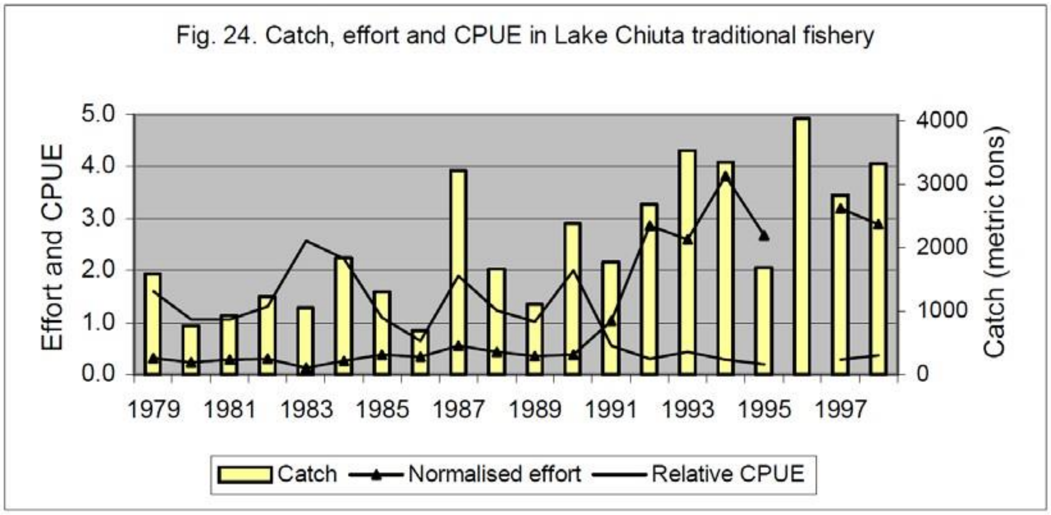

Figure 5.4: Fisheries catch and effort data from 1979 to 1997

Source: GoM 1999

5.2.1 Summary of Frame Survey Results

The frame survey data collected between 2003 and 2014 shows a declining trend in the number of gear owners, crew members, dugout canoes, and most fishing gear with the exception of chomanga and hand lines (Tables 5.2 and 5.3). This corresponds with the overall significant drop in fish catch for the past 15-20 years.

Table 5.2: Estimated numbers of gear owners, crew members and fishing craft in Lake Chiuta in 2003, 2005 and 2014

Indicator	2003	2005	2014
Fishers Gear Owners	875 900*	556 550*	no data 100
Crew Members	170	56	50
Plank boats with engines	0	0	0
Plank boats without engines	5	2	4
Dugout canoes	424	359	136

Source of the original data: 2005 and 2014 Department of Fisheries Annual Frame Survey Reports
**These figures were estimated from the Figure 3.8.2.2 on p. 59 of the 2005 Frame Survey Report*

Table 5.3: Estimated numbers of fishing gear in Lake Chiuta in 2003, 2005 and 2014

Indicator	2003	2005	2014
Chomanga	540	734	1,700
Fish traps	3,443	4,476	2,642
Gill nets	10,702	6,580	93
Hand lines	10	5	34
Longlines	151	118	14
Mosquito nets	2	1	no data

Source of the original data: 2005 and 2014 Department of Fisheries Annual Frame Survey Reports

5.2.2 Local Fisheries Management Practices

Lake Chiuta currently serves as one of the best examples of successful participatory long-term co-management between the local fisheries and DoF in Malawi (Donda 2011), even though the fishery is not managed at a sustainable level.

The strength of this co-management arrangement finds its origins back in the early 1990s, when local fishers began to grow wary of migrant fishers using a different type of net. These new nets, nkacha seines, were known to overharvest and increase bycatch (Njaya 2008). In response, a group of community members formed a group to rid their lake of seine netters and brought their complaint to the village headmen/chiefs. When it was discovered that the chiefs had accepted bribes to allow seine netters to fish, the village headmen/chiefs were forcefully removed from office and replaced by reliable chiefs.

Locals then appealed to the Malawi Department of Fisheries (DoF) for support of their new regulations, including the ban of nkacha nets and restrictions for migratory fishers. These were endorsed by the DoF without funding (Donda 2011). The community created one of the first BVCs as a regulatory/enforcement entity on the lake with the support of the DoF. Local funding for enforcement is created through fisher taxation and licensing; this money is then used to pay patrols to ensure their work. This system of putting the money back into the community has greatly enhanced the fishery. It has allowed the self-funded co-management program to delegate and manage the system rather than the DoF alone (Njaya 2008). In other areas, it is common for all licensing money to be funneled directly to the Malawi DoF, which does not provide enforcement incentive to the community (Njaya 2008, Donda 2011). Additionally, the remoteness and isolation of Lake Chiuta also likely helps to reduce migrant fishing pressures from within Malawi (Njaya 2008), although there is pressure from Mozambican fishers.

Existing fishing regulations include gill net mesh size limits of two inches to protect juveniles and immature fish. There is currently no licensing program because the majority of gear typically licensed in Malawi is illegal on the Lake (active gear: seines, nkacha nets, etc.). While general consensus among community members indicates that the regulations help protect the fisheries, there is still concern regarding those who knowingly ignore regulations and utilize destructive gear in order to earn an income.

The communities of Njerwa and Misala believe that all of their fisheries will collapse if preventative measures are not taken. They listed few coping mechanisms for dealing with this occurrence. These include farming, fish farming, small businesses, or migrating elsewhere. When no fish are being caught, most turn to farming arable lands and dimba (riparian zone vegetable gardens). Others may invest in small businesses, such as produce trading enterprises. Some may partake in ganyu, also known as short-term hired work or piece work, or turn to illegal fishing gear out of desperation to feed their families.

5.3 Primary Threats, Stressors, and Drivers to Freshwater Biodiversity

The threats and stressors to freshwater biodiversity in Lake Chiuta are similar to other lakes in Malawi (Table 5.4). The communities and local experts agree on most of the threats, stressors, drivers, and contributing factors.

Table 5.4: Primary threats, stressors, drivers, and contributing factors to Lake Chiuta's freshwater biodiversity

Threats	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Loss/fragmentation of SAV and EAV	X	X	X
Destructive/illegal gear	X	X	X
Overfishing	X	X	X
Sedimentation (river inlets/lake bottom)	X	X	X
Stressors	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Climate change	X	X	X
Climate variability	X	X	X
Rainfall variability and Lake level changes	X	X	X
Drivers	**Literature Review**	**Local Communities**	**Scientists/ Managers**
Open access nature of the fisheries	X	X	X
Non-compliance closed areas/seasons		X	X
Poor education and low literacy		X	X
Poor governance	X	X	X
Lack of knowledge about enforcement		X	X
Lack of political will		X	X
Contributing Factors	**Literature Review**	**Local Communities**	**Scientists/ Managers**
High population growth rates	X	X	X
Immigration	X	X	X
Limited income generating alternatives	X	X	X
Food insecurity	X	X	X

5.3.1 Overfishing

Lake Chiuta experiences both growth overfishing, when the juvenile "recruits" are overfished, and recruitment overfishing, when the breeding or parent stock is reduced. While the Malawi side of Lake Chiuta has strict regulations regarding the types of gear that can be used (active gear are forbidden), the Mozambican side has little-to-no gear restrictions. Fishers from Mozambique often fish with illegal to increase catches; Malawians have also been known to travel to the Mozambique side of the lake to take advantage of this gear.

The total catch levels from Lake Chiuta have fallen dramatically since the 1990s. There was a brief period when fishing effort increased in hopes of catching the remaining fish. However, based on the recent Frame Survey, effort has reduced significantly. The increased CPUE in the 1980s is a hallmark sign of overfishing. In order to maintain a sustainable fishery in Lake Chiuta, it is recommended that total effort is reduced to a manageable level (GoM 1999).

Illegal gear is one of the primary contributors to overfishing in Lake Chiuta. BVCs banned seine nets in 1995 to reduce habitat degradation (removal of SAV) and to reduce bycatch (juveniles, non-target species). Mesh sizes have also been strictly enforced on the lake since the 1990s to reduce the bycatch of juvenile fish (Ngochera et al. 2001). Mesh sizes are restricted to 64 mm for gill nets in Lake Chiuta and are strictly enforced (Ngochera et al. 2001). Those caught using illegal gear are fined MK 35,000; gear is often confiscated and burned; and in extreme cases; individuals are forcibly removed from the area. Unfortunately, many, if not all, of these regulations are enforced exclusively on the Malawian side of the lake. This leaves an opening for excessive, illegal fishing on the Mozambican side.

5.3.2 Conflicting Governance Systems

Corruption is a major issue throughout Malawian fisheries. Traditionally, chiefs are seen as the final authority over the fisheries. It is their decision to let people fish or deny them access. In order to thank the chiefs for allowing them to fish, fishers present them with a bucket of fish every week as a gift. This practice, which is legal, provides an incentive for chiefs to allow more fishers into the fishery, including migrants and those individuals using illegal gear.

Disparities in governance exacerbate the problem by indirectly empowering chiefs. With different regulations in different countries, and even across different sectors within Malawi, there is rarely consensus among the people about what is legal or illegal. This conflicted management turns the people towards the traditional authorities for answers. Chiefs then take it upon themselves to regulate access, often sacrificing fishery health for personal gain.

5.3.3 Post-Harvest Losses

Improper and inefficient processing techniques create a large deficit between total catch and profit. Fishers sell 90% of their fish catch—either fresh or more often dried. According to local consensus, up to half of the total catch goes rotten during transport and/or processing. However, according to expert knowledge, this rotten fish is still sold at a lower price and consumed, encouraging a culture of acceptance for these incredible losses and poor fish quality.

Inadequate fish handling facilities, poverty, and a general culture of acceptance towards rotten fish consumption drive these vast losses. The processors at Lake Chiuta have not yet tried any of the new drying or smoking technologies seen in the other lakes, possibly due to the cost required to establish them. Traditional smokers and dryers are not efficient and amplify spoilage, especially in the rainy season when solar drying is a protracted affair and fish rot on the racks. Additionally, much of the catch spoils before even being landed because there is no adequate storage aboard fishing vessels to prevent crushing and spoilage during transport.

Although not directly linked to post-harvest loss, the communities indicate that food insecurity increases during the rainy season. However, they also say that they catch plenty of fish during this period. The traders do not get out to the lakeside villages during this rainy season due to the poor quality of roads. Fishers smoke their catch inside huts and store the dried fish for up to two months before taking a large volume to the market some hours away. More information is needed to understand these dynamics.

5.3.4 Land Use Change

Lake Chiuta lies in a very rural area, and as such, many community members utilize agriculture to feed their families and generate income. Trees are cleared for agricultural development and harvested for fuel and construction leading to high rates of deforestation. The deforestation that occurs near the streams and inlets increases both erosion rates and nutrient loading/sedimentation into Lake Chiuta. Another important factor contributing to the increase in erosion rates includes the cultivation of steep slopes, loose soils and riparian zones (GoM 2014). The resultant high erosion rates further exacerbate land degradation, which in turn leads to less fertile land and increased risk of flash flooding.

In addition to the upland deforestation, it is not uncommon for fishers to physically remove SAV to increase the feasibility of seine netting. This is less prevalent in Lake Chiuta than the other lakes, given the successful BVC management regulations prohibiting the use of seines on the Malawi side of Lake Chiuta, however, it is still an issue with Mozambican fishers (Ngochera et al. 2001).

5.3.5 Rainfall Variability and Climate Change

Chiuta remains one of the most vulnerable water bodies in Malawi due to its unique basin and hydrologic characteristics. It fluctuates dramatically from year to year and is almost entirely dependent on rainfall for level regulation. Driven by climate variability, lake level fluctuations drastically affects Lake Chiuta habitat. Drought can expose EAV and SAV beds, destroying and reducing breeding habitat. Similarly, flooding can drown EAV beds and nearby farmland, further degrading adjacent and breeding habitat within the lake. Dependence on the lake as a primary resource of food and income, along with a lack of alternative livelihoods and proper infrastructure, also severely reduces the communities' ability to cope with extreme drought and flooding events.

The communities attribute the changing lake levels to climate change and sedimentation. They report that rains historically came from December to April, although recently the rains are arriving and ending sooner. When it does rain, they say it is spotty and intense. They believe that excessive deforestation throughout the catchment is causing high levels of erosion in river banks, the sediment from which then flows directly into the lake habitat areas.

Table 5.5: Variations of lake surface area in Lake Chiuta between 1973 and 2008

Year	km^2	%
1973	41.8	20.9
1975	20	10
1979	49	42.5
1984	87	43.5
1989	193.5	96.8
1994	80	40
2002	80	47.9
2008	97	48.5

Source: Dulanya et al. 2013, p. 117

Lake Chiuta has historically fluctuated between 20 and 300 km^2 depending upon season and rainfall levels, and is extremely susceptible to variations in precipitation and climate change (Ngochera et al. 2001). The pan-shaped basin in which the lake lies markedly amplifies climatic influences and fluctuations (Dulanya 2013) (Table 5.5). In 1975, the lake shrank to 20 km^2 (i.e., only 10% of the maximum published size of the lake). In 1989, the lake reached an above average surface area of 193.5 km^2 (i.e., ~97% of the maximum published lake surface area (Dulanya et al. 2013)(Figure 5.5).

Studies of Lake Chiuta's hydrological attributes (flow regime, hydro-period, rainfall patterns, etc.) have shown that it is highly susceptible to climatic pressures (Dawson 1970, Dulanya et al. 2013). Additionally, it has been noted that there is a marked lag time between high rainfall events and subsequent high lake levels, sometimes up to two years. This suggests other influences have yet to be recorded. Variations in these systems could further increase vulnerability to regional climate change (Ngochera et al. 2001, Dulanya et al. 2013).

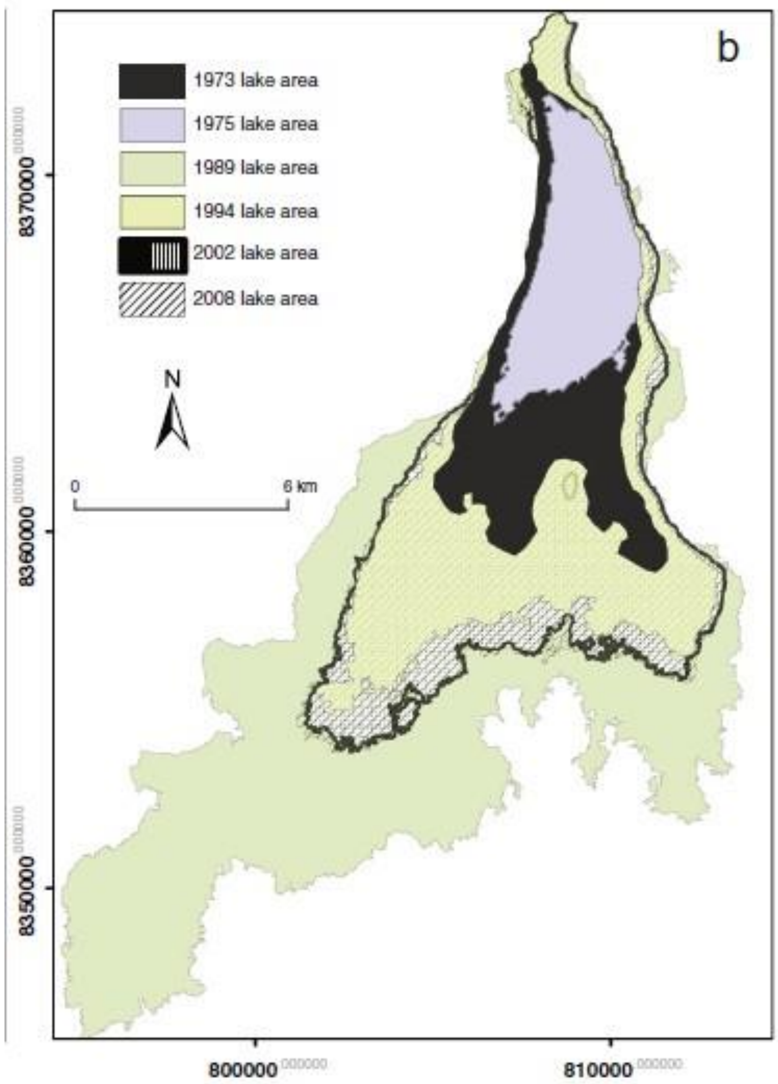

Figure 5.5: Color composite images of Lake Malombe and Lake Chiuta between 1973 and 2008
Source: Dulanya et al. 2013

The characteristics of the Lake makes it sensitive to climate variability (van Zegeren, 1998), this is also influenced dried up by the intensity and seasonal migration of the Intertropical Convergence Zone, the topography of the Lake and a low pressure belt that influences both wind patterns and precipitation (Dulanya et al 2013). This pattern is similar to those observed in other lakes due to dry periods in the region in late 1960s and early 1970s (Moss & Moss 1969, Nicholson 1998—as cited by Dulanya et al 2013). Low water levels in these periods "coincided with El Niño phenomenon in 1972 and 1991, while the higher water levels around the late 1980s coincided with the La Niña phenomenon in equatorial eastern Africa" (Ntale & Gan 2004).

Studies of images by Dulanya et al. (2013) show a reduction of the lake area in 1973 and 1975. The area of the lake grew to its maximum from 1979 to 1989 (see Table 5.5) (2013); this work was published in GOM/FAO/UNDP (1993). The pan-shape basin of Lake Chiuta has shown large amplitude of its surface area variation of Lake Chiuta (10-90%) compared to contrasting smaller variation of area of Lake Malombe (~6%).

5.4 Opportunities for Action/Management Suggestions

A number of opportunities were identified as potential additions to current management tactics. Any action needs to appreciate the remote nature of Lake Chiuta, the artisanal nature of the fishery, and the challenges of shared management with Mozambique.

5.4.1 Governance Actions

BVC effectiveness could be enhanced by providing boats and engines for increasing enforcement success, though their ability to maintain the equipment needs to be assessed and the temptation to use it for fishing is great. Uniforms and identification for BVC members could also bolster the authority of the BVCs.

The fishers' most significant achievement through collaboration included reaching an agreement with Mozambican fishers stating that they cannot use beach seines and nkacha nets in Lake Chiuta. The fishers say that the fishery is recovering and that their catches are higher, however catch trends from 2010, suggest otherwise. The communities felt that migrant fishers could be better controlled by establishing stronger regulations for closed areas and seasons. Establishment of formal collaboration with Mozambique on fishery management and instituting more regular fishing patrols were also suggested. However, community members are still concerned that there is little incentive to maintain the treaty and that it will soon fall apart as tension continues to rise over illegal migrant operations. To aid with the discussion, a Memorandum of understanding (MOU) has been created, however it has yet to be implemented. Implementation of the MOU could increase transparency and accountability for both countries regarding their dealings with Lake Chiuta. Transboundary resource management is an important step forward for Lake Chiuta. Community level management must be scaled up if it is to have a real impact on the system. Regulations need to be put in place that cannot be sidestepped by fishing across the lake instead of near the village, since some Malawians fish in Mozambican waters to avoid punishment Although the community members lack expertise in large scale management, assistance could greatly increase their chances of making a difference.

The communities have identified strategies for better managing fisheries losses. The Njerwa community has learned that successful management has an impact by the return of the nkhalala. The community believes they can establish bylaws to ban the fishing of all juvenile fish. They also suggested putting into place a series of larger mesh size limits to better protect juvenile fish from inadvertent capture. It was also noted that better farming practices and reforestation could help to reduce sedimentation adversely impacting fish breeding grounds.

The existing strengths of the Lake Chiuta communities serve as a stark reminder of what they are capable of accomplishing. Past successes allow the people to see the fruits of their labor as encouragement to press on. Previous victories have included effective fisheries management as well as cooperation with Mozambique. These experiences can be shared with neighboring communities that seek more effective enforcement of fishing regulations and Village Savings and Loan Associations (VSLAs).

Any new regulations will require a balance of compliance along with strict and efficient enforcement on the lake. If there is no risk of being caught and punished, fishers are likely to continue malpractices and overharvesting techniques. In order to enhance enforcement, a series of investments could be made in uniforms, ID cards, and better boats. These things could increase authoritative and enforcement capacities while still recognizing the high compliance due to the perceived validity and efficacy of the BVCs.

In addition to the above actions, Lake Chiuta BVC managers desire training to further their management expertise. They believe that a little help could go a long way in helping them manage their relationship with Mozambique. One advantage the BVCs in Lake Chiuta have is a history of success. The removal of nkacha fishers stands as a building block showing the people that their efforts have tangible results. This can be used moving forward to encourage participation and quell any fears that pushing for stronger management is futile.

5.4.2 Habitat Actions

An updated management program for Lake Chiuta should include a number of new provisions for habitat protection and adaptive management. Multiple stakeholders attributed varying lake levels to climate change, upstream irrigation, and/or sedimentation from rivers. In addition to these factors, poor agricultural practices play a major role in the degradation of river and shoreline habitat. Community members lack the technology to more efficiently pump water to their crops, forcing them to use foot pumps over short distances. This concentrates agriculture in lakeshore and riverbank areas, ultimately increasing erosion and sedimentation.

Reforestation efforts have already begun on Big Chiuta and Little Chiuta islands. There is a visible desire to continue these efforts on the affected shorelines and riverbanks to mitigate erosion. Logistically, however, there are a few challenges with establishing a large-scale reforestation project at Lake Chiuta. There would be significant resources required to start the operation, and seedlings would have to be provided to the teams in the field. Once the program was underway, monitoring efforts would have to be made to ensure the seedlings were allowed to grow and not harvested after the project finished planting.

Climate smart agriculture is another option posited by both the communities and the stakeholder forum team. A need for more drought/flood resistant crops is crucial to increased adaptive capacity and eliminating agricultural vulnerabilities to climate change and variability. Another challenge arises here: seed provisions. Most rural farmers residing at Lake Chiuta do not have access to, or resources for, more expensive climate smart crop seeds.

5.4.3 Fish Processing

Inefficiencies in fish processing account for major losses of product and profit. Lake Chiuta is rather remote and as such has little access to technological updates when it comes to fish processing. Following the model piloted in Lake Chilwa, Lake Chiuta could adopt the new solar dryer technology. This would decrease the amount of spoilage while simultaneously increasing adaptive capacity to process fish during the rainy season. Despite the relatively high cost of establishing a solar drying system, the process has the ability to add value to the system. Increasing the number of fresh fish sold will increase profits for the fishers and processors, since rotten fish sells for significantly lower prices. Reducing the amount of spoiled fish sold within the communities would also have numerous health benefits. Disease prevention being the primary result, more efficient processing could also bolster small business income.

The biggest challenge thus far, at least within Lake Chilwa's solar dryer pilot communities, is the management of the facilities. It remains unclear who owns the facilities and if they are bought by processors or simply rented according to usage. It is important to know who stands to gain the most from the implementation of these new solar dryers because communities will be less likely to support another means of income for the already wealthier chiefs. Management plans for new solar dryers would also have to incorporate shared usage between communities. Placement would be at shared landing sites, meaning multiple communities would want access to the more efficient technology.

5.4.4 Alternative Livelihoods

As mentioned above, Lake Chiuta lies in a very rural area far from any towns or markets. Interviews with local fishers showed that the nearest fish market is approximately 3 hours by bicycle; a long way to transport fish. This level of isolation reduces the amount of income fishers can make purely from fishing. At this level, the majority of fish is sold locally to buyers for lower prices or consumed within the villages.

Agriculture plays a major role in the lives of Lake Chiuta residents; however they lack the technology to expand their operations. Access to the lake's water is a limiting factor to the amount of successful farming community members can accomplish. Currently, simple pedal pumps are used to water crops not more than 20 meters from the water's edge. If agriculture is to be expanded to a larger scale, better irrigation is required to supply fresh water to the crops. Limited access to rivers eliminates traditional irrigation, so it is important to look towards vacuum or pump technology to move the water.

Another challenge to consider when moving forward with a focus on intensifying agriculture is the capital required to do so. Starting new farms can be expensive, and many community members cannot afford to front the cost needed to get started. To compensate for this, Village Savings and Loans Associations VSLAs could be a potential solution. With the implementation of saving programs, community members would have access to financial planning and assistance. Given enough time to save, the majority of community members would theoretically be able to afford a new business venture, whether that is a small business or agriculture. Savings and loans operations could also enhance fisheries management and enforcement, as it would provide resources to pay enforcers and supply those out in the field collecting illegal gear and fines.

6 SYNTHESIS

The ecological, biodiversity, and socio-economic importance of the four lakes to Malawi as a nation and to local communities is well known. The lakes are the heartbeat of the country (Nyasaland means land of lakes). Lake Malawi alone covers 20% of the total surface area and holds the highest levels of freshwater fish biodiversity in the world (over 800 species). It also exhibits high levels of endemism. Particularly noteworthy are the 41 genera of cichlids. As shown in this ETOA, the contribution of Malawi's lake resources to livelihoods, the national and local economies, nutrition, biodiversity, ecosystem services, transportation, water for domestic use, hydropower, tourism, and landscape amenities is tremendous. However, in synthesizing of the findings from PRA exercises conducted as part of the ETOA, local communities state that multiple issues threaten the sustainability of the lake ecosystems. As shown in table 6.1, the lake ecosystems share the following priority threats, stressors, and contributing factors: overfishing, illegal fishing, sedimentation, aquatic vegetation destruction, rainfall variability, and post-harvest losses.

Table 6.1: Priority threats, stressors and contributing factors

Threat	SEA L Malawi	Malombe	Chilwa	Chiuta
Illegal and destructive fishing practices	X	X	X	X
Overfishing	X	X	X	X
Sedimentation		X	X	X
Destruction of submerged and EAV	X	X	X	
Stressor	**SEA L Malawi**	**Malombe**	**Chilwa**	**Chiuta**
Rainfall variability			X	X
Contributing Factor	**SEA L Malawi**	**Malombe**	**Chilwa**	**Chiuta**
Post-harvest losses	X			X

The following section provides an overview of the priority threats, stressors, and contributing factors synthesizing the information provided in the introduction and lake chapters.

Overfishing is primarily a result of unrestricted "open access." As a result of unmanaged open access, the number of fishers, gear, boats, and engines (fishing effort) continues to grow. While fishing effort is increasing, total catch has declined in all but Lake Malawi. Consumption per capita fell from 12.9 kg per person per year in 1976 to just 3.6 kilos in 2001. However, with the increase in usipa catches replacing the chambo fishery collapse, the consumption rate per capita has rebounded to 8.6 kg/p/y.

The conventional model of top-down, government-centered management is not working well to manage the lake fisheries across the four lakes. Even Lake Chiuta, which is touted as a good example of community-based management has not been able to sustain its fish stocks. Open access fisheries are complex and worldwide the co-management approach of partnership with resource users and government is seen as having a greater chance of success. In Malawi, the policies and legal enabling conditions for co-management exist on paper, but those policies have not been implemented in practice. Even though Malawi has had two decades of international support for policy development and implementation, the capacity and institutional frameworks have been too weak to implement the policies at District and BVC level. The strategy for co-management in Malawi (known as Participatory Fisheries Management (PFM)) supported by the Fisheries Act of 1997 and the Fisheries Conservation and Management Regulations of 2000, supplement to the Act is based on a 6-step process:

1. Form a registered Community Based Organization. BVCs should come together in a Fisheries Association to make the co-management plan for specific species
2. Define a clear management boundary
3. Conduct a stock assessment on key species
4. Formulate a management plan
5. Create By-Laws to implement, monitor, enforce, and fund the management plan
6. Agreement signed by the Director of Fisheries

Some but not all of these steps have been applied and tested by the over 300 BVCs that have been formed to date. An issue discussed in the introductory chapter (section 1.6) is that BVCs have no formal constitutions; decentralization institutions have no bylaws, and there are no PFM management plans and fishery agreements in place. The legal tools and instruments envisaged in the Act and Decentralization Policy as essential for PFM were not put in place effectively by the Director of Fisheries, local government and to communities.

Critical obstacles are a lack of coordination and conflicts among traditional and District leadership (chiefs vs councilors) and BVCs in fisheries management; ambiguity and confusion over what PFM means in terms of roles and responsibilities of the various institutions, local, district and national; incomplete (at least until recently) decentralization policy and administrative systems (specifically, a 10 year absence of District Commissioners who are authorized by law to approve co-management plans); and absence of champions and catalysts to facilitate piloting and demonstrations of co-management in practice (see also section 1.6).

Many BVCs noted issues of corruption with traditional leaders, and a widespread tendency of lack of dialogue and cooperation among BVCs, local Chiefs, and DoF, which itself is handicapped with resources that are completely inadequate to perform its mandate of fisheries research, extension, surveillance, and enforcement. This was highlighted frequently by BVC members and in the stakeholders' validation workshop.

In a few locations, especially Lake Chiuta, there are examples of community self-governance and self-management with positive intermediate results. This is the other end of the spectrum of power sharing in which the community makes the decisions and enforces fishery rules and management without input from DoF. However, even though Lake Chiuta communities have been able to enforce fisheries management rules, there is no sign of improved fish stocks.

Illegal and destructive fishing refer to:

- *The use of illegal and destructive gear.* On the SEA of Lake Malawi, for example, most beach seine and gillnets used have illegal small mesh size and headline length. In particular, a high proportion of *nkacha*, *chilimira* (an open-water seine net) and *kambuzi* nets are of illegal mesh size. Therefore, catch is dominated by juveniles and immature fish, reducing the potential production levels and eliminating future breeding stocks. A key reason for the high level of use of illegal gear, especially in lakes Chilwa, Malombe and SE Malawi is the near absence of actions taken against non-compliance with fisheries regulations. Lake Chiuta is unique in that on the Malawi side of the lake all active gear is forbidden and while there are violations, compliance is higher. On Lake Chilwa, mosquito nets and gauze wire nets are illegal but used. They remove fish of all size from the water column, even the smallest juveniles. Nkacha nets are also illegal on Lake Chilwa, but are prevalent. Finally, the ETOA assessment team learned that harvesting fish using poison in the water has been practiced on Lake Chilwa. This is especially destructive since poison kills non-target species and eggs.

- *Illegal harvest size* on certain species (especially chambo and mpasa for which there are harvest size regulations).
- *Violation of closed seasons* (Lake Malawi, Lake Chilwa, and Lake Malombe). There is widespread violation of closed breeding seasons for chambo. Consequently, because of the concentration of chambo when breeding, they are easily being caught while trying to spawn. This is believed to have reduced the recruitment rate dramatically.
- *Violation of protected areas* close to the shore, at harvest reserves, and around national parks (Lake Malawi National Park and Liwonde National Park, Lake Malombe). These protected areas are under threat from encroachment and poaching. On Lake Chilwa, non-compliance with fish sanctuaries/protected areas in river mouths where *Barbus spp*. spawns is prevalent.
- *Illegal trawler fishing* on Lake Malawi, violating fishing rules, such as closed areas (i.e. in waters of less than 18 meters and within one nautical mile from the shoreline). The stocks of the SEA are exploited by the semi-industrial and the industrial fisheries. The semi-industrial fishery mainly uses pair trawls, the industrial fishery bottom trawls, mid-water trawls and ring nets. The semi-industrial fishery in the SEA has grown to 10 vessels and there is a large list of fishing license applicants.

Post-harvest losses can be as high as 40% of total catch in some species. The reasons are poor storage and handling in boats (no storage containers, no ice) and transfer to landing areas and processing sites, length of time the fish are in the boat after catch, traditional open air and often on the ground drying (exposed to contaminants and flies), and absence of packaging aside from open baskets. Losses are highest during the rainy season when fish abundance is also highest as a result of open-air fish drying (and consequent exposure to precipitation during periods of intermittent rain).

Habitat destruction was referred to as removal of SAV beds and EAV that expose certain juvenile species to predation and to being netted. Beach seines and nkacha nets cause physical damage, removing oxygen weed beds in the SEA of Lake Malawi and in Lake Malombe. The damage is so extensive that many former juvenile nursery areas no longer exist.

Declining or changing lake levels were identified as affecting aquatic biodiversity and fisheries on all lakes. Low lake levels disturb breeding of species that breed in deeper water. Chiuta is one of the most vulnerable water bodies in Malawi due to annual water level fluctuations. On all lakes, siltation and variable precipitation patterns are the direct threats of lake level change; deforestation, habitat change, and climate change and climate variability are among the root causes of sedimentation. According to the Fisheries Act, there is a 10-meter no-development buffer around the lakes, but this is largely unenforced. Deforestation, habitat change, and more intense periods of rainfall have led to increased run-off and the resultant erosion and siltation of rivers has reduced fish breeding grounds (e.g. rocky areas) and degraded water quality, which in turn has led to a loss of fish biodiversity. The inshore areas contain many of the unique sedentary–and thus higher risk—fish species.

Because the lake fisheries are so critical to the economy of Malawi, the highest priority must be the creation and maintenance of the environmental conditions necessary to sustain their productive potential as much as possible in such a fluctuating system. This includes not only the lakes themselves, but also their connectivity with river basins that are under severe pressures due to deforestation, unsustainable agriculture, and settlements.

These threats, stressors, drivers, contributing factors and their impacts—and possible responses to address them—are described in more detail in in separate sections for each lake (section 6.1 to 6.4).

There are numerous causes of the biodiversity and socio-economic threats to the lakes' ecosystems. This updated lake fisheries ETOA finds most of them to be similar to the generalized country ETOA completed in 2011. Key root causes, described in more detail in section 1.8, identified by literature review and validated by PRA findings, and key informant interviews are:

- Population growth putting demand on increased need for food and livelihoods (driven by early marriage, high birth rate, and migration)
- Poverty and its many manifestations which means the poor turn to NR use for coping strategies (low educational levels, nutritional deficits, poor health, and weak infrastructure, transportation, and markets)
- Climate change and climate variability puts pressure on the lake and lower rainfall, higher evaporation leads to lowering levels, raising water temperature (which make all existing threats worse)
- Absence of broad-based economic growth and alternative livelihood opportunities beyond dependence on small-scale agriculture (the majority of the population has less than 1 ha on which to cultivate) means NR still provide an economic base for poor communities
- Weak national-district governance system that impact the effectiveness of most policies, and fails to create trust among local communities—leading to the continuation of the informal governance system that dominates in lake areas

These root causes relate to degradation of natural resources (especially deforestation driven by high demand of wood and charcoal for fuel) and resulting changes in catchment productivity, microclimates, water availability, sediment runoff, and agricultural productivity. Malawi is highly dependent on wood and charcoal for cooking fuel.

Climate change and climate variability effects on the lakes include warming due to increasing temperatures and resulting disruptions in nutrient cycling; increased severity and frequency of droughts and floods that contribute to fluctuations in water levels and siltation and negatively affect the fisheries sector; and lower water levels, partly owing to lower total annual rainfall, as well as higher evaporation. The impacts have exacerbated existing threats such as sediment loading and over fishing that all together result in lower fish production and reduced capacity of fishing communities to adapt to climate change. A summary of climate change effects, impacts, and responses are listed in Table 6.2 below.

Table 6.2: Summary of climate change effects, impacts and common responses

Climate change impact	Primary biophysical Impacts	Secondary biophysical impacts	Fisheries consequences	Coping strategies	Adaptation options
Ambient temperature increase	Warmer lake water	Changes in timing of spawning, migration and peak abundance, Disruptions in nutrient cycling. Change in production rates	Altered timing and location of fishing. Algal blooms	Fishing in deeper water; use of illegal nets	Alternative livelihoods
	Increased evaporation rate	Reduced lake water levels, Biophysical changes to the water column	Migration of fish, seasonal closures	Use of nkacha nets in deeper water where fish migrate	Management of riverine pools to protect remnant fish populations
Rainfall change and more intense but shorter rainfall events	Drought	Reduced river flow to lakes Reduced lake depth Drying of wetlands	decreased fishery livelihood, agriculture conflicts and competition for resources; low beach sanitation	Alternative livelihoods; use of lake water for agriculture; migration to and crowding of villages with adequate water	• Participatory fisheries management of riverine pools • More efficient irrigation • Drought resistant agriculture
	Flooding	Erosion, sediment loading, and nutrient runoff into the lakes	Population displacement More dangerous fishing Loss of catch to spoilage	Relocation Changes in target species	Afforestation River setbacks

Below, highlights are drawn on each of the four lake ecosystems:

6.1 SEA Lake Malawi

6.1.1 Threats, Drivers, Contributing Factors, Impacts

The threats, drivers, contributing factors to and impacts on aquatic biodiversity identified in literature review, PRA, and expert workshop are summarized below:

Table 6.3: Summary of threats, drivers, contributing factors, and impacts for Lake Malawi

Threats	Drivers and Contributing Factors	Impacts
Overfishing (growth in numbers of fishers, boats and gear)	Open access and lack of effective governance limits on fishing capacity and catch drive exploitation beyond biological and economic sustainability. Post-harvest losses are due to inadequate fish handling and processing practices, poverty, and a general culture of acceptance of spoiled/poor fish quality consumption. Other contributing factors are population growth and lack of alternative livelihood opportunities.	• Reduced abundance and size of fish • Post harvest losses reduce value added to the fishery and total available protein for consumption
Illegal fishing	Poor governance capacity (especially compliance and enforcement of rules). Also corruption characterized by disparities in traditional fishery management across fishing villages, and ineffective coordination of traditional and formal fisheries management	Catch of juveniles, destruction of habitat, and reduced abundance and size of fish
Sedimentation	Expanding agriculture, charcoal production and shoreline development have caused high levels of deforestation in the catchment surrounding the SEA resulting in increased rates of soil erosion, nutrient loading and the siltation of the lake bottom	• Higher water turbidity and lower light penetration reduces the photosynthetic rates of primary producers • Loss of benthic habitat complexity and the smothering of important spawning grounds and feeding habitats • Adversely affects the reproductive behavior of haplochromine cichlids that rely highly on visual cues for mate selection
Destruction of aquatic vegetation	Fishers physically remove SAV to increase the feasibility of seine netting	• Loss of habitat buffer for filtering sediment • Loss of benthic habitat complexity

6.1.2 Opportunities

There are formal fishing regulations that apply to SE Lake Malawi, but compliance and enforcement are poor. Opportunities for effective co-management through existing policy and legal frameworks have not been taken advantage of by fishing communities. Among the fish regulations are:

- Areas closed to trawler fishing (within 1 nautical mile to shore, less than 18 meters depth, and areas around Lake Malawi national park) and daily limits on times allowable for trawler fishing
- Prohibition on the use of beach seines between November 1 and December 31 to protect chambo during spawning period
- Minimum mesh sizes, legal catch size, and net head length (e.g. maximum legal length of 150 meters for kambuzi seine net) for certain species

Participants to the ETOA expert workshop propose that the closed season should be reviewed so that it is not based only on chambo management but reflects the multispecies nature of the fishery. Other opportunities include:

- Training on fisheries co-management policies, procedures, rules, and institutions
- Outreach to increase understanding among the fishing sector on what represents illegal gear (and for what areas and when)
- Enforce trawler company registration a condition of fish licensing
- Strengthen BVCs and Fisheries Association to demonstrate how the co-management system should work to manage a fishery and support self-enforcement
- Support best practice innovation in fish handling from boat to processing site and processing (especially solar dryers)/packaging

6.2 Lake Malombe

6.2.1 Threats, Stressors, Drivers, Contributing Factors, Impacts

The threats, stressors, drivers, contributing factors to and impacts on aquatic biodiversity identified in literature review, PRA, and expert workshop are summarized below:

Table 6.4: Summary of threats, stressors, drivers, contributing factors, and impacts for Lake Malombe

Threats and Stressors	Drivers and Contributing Factors	Impacts
Loss and fragmentation of SAV and EAV	Large areas of reed beds and SAV were removed in the 1970s to enable beach seining. The spatial extent of EAV has also declined considerably due to removal by the local communities to create beach landing sites and additional fishing grounds.	Decline in fish abundance due to loss of habitat for diverse species: breeding habitat, nursery grounds, juvenile habitat, and adult feeding grounds; loss of buffer to capture sedimentation
Overfishing (growth in number of fishers, boats, engines, and	Open access and lack of effective governance limits on fishing capacity and catch drive exploitation beyond biological and economic sustainability. Post-harvest losses are due to inadequate fish handling and processing	• Reduced abundance and size of fish • Post harvest losses reduce value added to the fishery and total available protein

Threats and Stressors	Drivers and Contributing Factors	Impacts
gear)	practices, poverty, and a general culture of acceptance of spoiled/poor fish quality consumption. Other contributing factors are population growth and lack of alternative livelihood opportunities.	for consumption
Illegal and destructive fishing	Poor governance capacity (and low compliance and enforcement of rules including non-compliance with closed areas/seasons and use of gear). Also corruption that is often characterized by disparities in traditional fishery management across fishing villages, and ineffective coordination of traditional and formal fisheries management systems.	Catch of juveniles, destruction of habitat, and reduced abundance and size of fish
Sedimentation	Land use change/deforestation causing erosion and sediment run-off and climate change (causing intense periods of rain and flooding). Non-compliance with regulations on buffer zone around the lake.	Silt on river inlets and lake bed lowers lake level and affects lake habitat and species abundance and diversity
Annual rainfall variability	Natural and anthropogenic caused climate change and variability	Lower lake level affects lake habitat and species abundance and diversity

6.2.2 Opportunities

Improved fisheries management. Opportunities to reduce illegal fishing and improve fisheries management include:

- Strengthening co-management awareness and capacity, including passing bylaws to empower BVCs and funding equipment for patrolling (i.e., uniforms, identification cards, whistles, rain boots, and boats)
- Better dialogue and cooperation among the local, district, and national levels of government, and stronger partnership between the DoF and BVCs. Put in place measures to enable more effective dialogue and cooperation between the Chiefs, police, magistrates, DoF personnel, District Councilors, and the local communities (e.g., ADC, VDC and BVC).
- Dedicating more resources for enforcement
- Use of underwater brush parks to act as “silent police” to deter illegal fishing activities
- Apply self-enforcement in which local community members act as beach scouts and data recorders in coordination with DoF enforcement officials. The Lakeshore Community Project could potentially serve as a guide given that they have demonstrated success in linking community members trained in collecting water quality data with the Water Department.

- Declare certain areas within Lake Malombe as sanctuaries to protect important EAV and SAV serving as critical breeding and nursery grounds. Some of the specific areas suggested by the community include the following: Mwalija, Mtenje, Mphwanya, Likala, and Changamire.

Improved aquatic habitat management and land management within the Catchment. Suggestions for managing sedimentation and aquatic habitat loss include:

- Ban removal of EAV for creating additional fishing areas and beach landing sites. The regulations banning EAV removal could be enforced at the VDC level by actively incorporating community members in a partnership with the Department of Forestry.
- Provide outreach on the ecosystem values of EAV, including the breeding, nursery, and juvenile refugia functions provided by EAV
- Extension on climate smart agriculture that integrates soil and water conservation, watershed management and ecosystem management
- Creation of a collaborative forum to help weave and integrate the various projects around Lake Malombe together. In this forum, methodologies, good practices, and adaptive management measures could be shared.
- Reduce encroachment of agriculture activities and the construction of buildings within the regulated 10-meter buffer zone along the lakeshore through efforts to remove conflicting policies between different governmental departments and enhancing enforcement efforts.
- Work with Liwonde National Park and Mangochi Forest Reserve to see if blocks for sustainable community use can be set aside adjacent to these protected areas following the model used in the Zomba forest management reserve.

6.3 Lake Chilwa

6.3.1 Threats, Stressors, Drivers, Contributing Factors, Impacts

The threats, stressors, drivers, contributing factors to and impacts on aquatic biodiversity identified in literature review, PRA, and expert workshop are summarized below:

Table 6.5: Summary of threats, stressors, drivers, contributing factors, and impacts for Lake Chilwa

Threats and Stressors	Drivers and Contributing Factors	Impacts
Overfishing (growth in number of fishers, boats and gear)	Open access (characteristic of growing number of fishers, boats and gear) in this case in a transboundary system. Open access nature of fishery drives fishers to maximize catch in the short run at the cost of long-term biological and economic sustainability. Post-harvest losses are to inadequate fish handling and processing practices, poverty, and a general culture of acceptance of spoiled/poor fish quality consumption. Other factors are population growth and lack of governance limits on fishing capacity. There are currently an estimated 6,000 fishers in Lake Chilwa catchment.	• Reduced abundance and size of fish • Post-harvest losses reduce value added to the fishery and total available protein for consumption
Illegal and destructive fishing	Poor governance capacity (and low compliance and enforcement of rules). Also corruption characterized by disparities in traditional fishery management across fishing villages, and ineffective coordination of traditional and formal fisheries management	Catch of juveniles, destruction of habitat, and reduced abundance and size of fish
Sedimentation	Land use change/deforestation causing erosion and sediment run-off and climate change (causing intense periods of rain and flooding)	Fluctuations in lake level affects lake habitat and species abundance and diversity
Annual rainfall variability	Natural and anthropogenic caused climate change and variability	Fluctuations in lake level affects lake habitat and species abundance and diversity
Destruction of aquatic vegetation	Fishers physically remove SAV to increase the feasibility of seine netting.	Fish lose protection and easily caught by larger active gear

In terms of illegal and destructive fishing, mosquito nets and gauze wire nets are prohibited, but used, including by the larger boats using them to seine in the deeper open waters. They catch all types of juvenile fish. While nkacha nets are illegal, they are prevalent. Fishing with poisons is used, killing non-target species and eggs.

Lake Chilwa is unique in terms of its wetlands. There is a high demand for wetlands for agricultural production, due to their moist soils, even during droughts, and water access. These wetlands are more likely to provide stable cash flow and food security. Anyone can get access to the land, dependent upon paying an annual tribute to the local Chief. This increases the likelihood of migrants moving into the catchment. In response to intensive land degradation threats, Lake Chilwa's northern wetlands were declared a RAMSAR site in 1997. Wetland livelihood opportunities have attracted many people seeking to make more money, and thus is one of the most densely populated areas in the basin (about 321 people per/km^2). Habitat change, siltation, runoff, and more people in the area who will also fish, are reasons for overfishing, siltation, loss of biodiversity, and lake level change.

6.3.2 Opportunities

- Test co-management in a process that strengthens BVCs and promotes cooperation and collaboration among DoF, BVCs, and traditional authorities (local chiefs)
- Protect previously established fish sanctuaries/protected areas in river mouths where *Barbus spp*. spawns
- Improve and adapt seining closed season rules (currently fixed from December – April) to better match weather conditions, fish movement, and fish spawning
- Reduce post-harvest losses with best practice innovations in fish handling from boat to processing site and processing (especially solar dryers)/packaging

6.4 Lake Chiuta

6.4.1 Threats, Stressors, Drivers, Contributing Factors, Impacts

The threats, stressors, drivers, contributing factors to and impacts on aquatic biodiversity identified in literature review, PRA, and expert workshop are summarized below:

Table 6.6: Summary of threats, stressors, drivers, contributing factors, and impacts for Lake Chiuta

Threats and Stressors	Drivers and Contributing Factors	Impacts
Sedimentation	Land use change/deforestation causing erosion and sediment run-off and climate change (causing intense periods of rain and flooding)	Fluctuations in lake level affects lake habitat and species abundance and diversity
Annual rainfall variability	Natural and anthropogenic caused climate change and variability	Fluctuations in lake level affects lake habitat and species abundance and diversity
Overfishing (growth in number of fishers, boats and gear)	Open access (characteristic of growing number of fishers, boats and gear) in this case in a transboundary system. Open access nature of fishery drives fishers to maximize catch in the short run at the cost of long-term biological and economic sustainability. Post-harvest losses are due to inadequate fish handling and processing practices, poverty, and a general culture of acceptance of spoiled/poor fish quality consumption Other drivers are population growth and inadequate governance systems.	• Reduced abundance and size of fish • Post-harvest losses reduce value added to the fishery and total available protein for consumption

Threats and Stressors	Drivers and Contributing Factors	Impacts
Illegal fishing	Inadequate governance capacity (and low compliance/incomplete enforcement of rules)	Catch of juveniles, destruction of habitat, and reduced abundance and size of fish
Destruction of aquatic vegetation	Fishers physically remove SAV to increase the feasibility of seine netting.	Main problem is the Malawi side of the lake. This is less of a problem on Lake Chiuta than the other lakes given more successful BVC management regulations prohibiting the use of seine nets on the Malawi side of Lake Chiuta

6.4.2 Opportunities

Among the four lakes, Chiuta over the last decades has the most successful history of fisheries management. Using licensing fees and fines to support and pay BVC enforcers, the local communities have been able to maintain a series of working BVCs that effectively monitor and enforce fishing regulations and manage the fishery in partnership with DoF. n BVC focus group meetings in the communities of Dinji and Saleya, the PRA team was told that they believe that their fisheries will collapse if preventative measures are not taken. Existing fishing regulations include gill net mesh size limits of 2 inches to protect juveniles and immature fish and restriction on active gear.

The most significant achievement is an effort to collaborate with Mozambican fishers that lead to an agreement in which Mozambican fishers agree not to use beach seines and nkachas in Malawian waters. The fishers say that the fishery is recovering and catch is higher as a result. At the same time, community members voiced concern that there is little incentive for Mozambican fishers to maintain the treaty and that it could fall apart as tension rises.

There has also been success with compliance of rules on the Malawi side, but there are still violations. Opportunities identified by BVC members include:

- Boats and engines for increasing surveillance and enforcement
- Introduction of uniforms and identification cards for BVC members to bolster their authority
- Reduced capture of juvenile fish through larger mesh size rules
- Rehabilitation of breeding areas by planting trees throughout the watershed to reduce sedimentation adversely impacting fish breeding grounds
- Migrant fishers could be better controlled by establishing stronger regulations for closed areas and seasons

- Establishment of formal collaboration with Mozambique on fishery management and instituting more regular fishing patrols

6.5 Building Blocks across the Lakes

The ETOA findings from literature review, fishing village, BVCs and key informant workshop and interviews demonstrate the economic, social, human health, and natural ecosystem significance of lake resources for all of Malawi, but also the urgency to take actions to transform lake fisheries and lake aquatic ecosystems to be more sustainable. Malawi continues, at least in the near to medium term, on a trajectory of high population growth, deforestation, serious public health issues, growing deficits in animal protein availability for the poor, and high levels of unemployment and underemployment. Following the advice of researchers and local communities, fisheries management should ideally be transformed to include the following characteristics:

- From open access to managed access
- From input controls to catch controls
- From a commons to use rights
- From top down control to co-management
- From static to adaptive management
- Managing at ecosystem scales
- Integrating management of the resource with improvements in the value chain
- Inclusion of women in management decision making and livelihood improvement
- Integrating livelihood development and fishing community resilience.
- A stakeholder and process oriented approach
- A focus on impact and documentation of results

Making progress in resolving threats and stressors and addressing the drivers and contributing factors requires behavior change, which takes time, and evidence of ecosystem improvements take time. In the near future, it is important to support interventions that build the enabling conditions to move in the direction of resolving threats and to support small doable actions that have more immediate benefits. The ETOA exercise identifies building blocks in the lake communities to resolve aquatic biodiversity threats, they include:

- Strong historical community identity with and ecological knowledge of lake fishing
- Willingness to improve enforcement of fishing rules
- Openness to innovative technologies, e.g. improved (fuel efficient) smokers and solar fish dryers
- Community-lead habitat restoration
- Conservation agriculture
- Dialogue and coordination between different actors in the fisheries value chain
- Interest and experience with supplemental livelihoods and alternative agricultural practices
- Community-based and collaborative surveillance and enforcement of fishing rules
- Community-based conflict resolution with migrant fishers
- Local reforestation efforts (community tree nurseries)
- Organizational and entrepreneurial skills of women fish processors

- Lake Chilwa was named a Ramsar (Convention on Wetlands of International Importance) site in 1997 to protect it from anthropogenic pressures
- Limited but successful examples of cooperation between fishers, BVC, and traditional leaders

There are also concrete actions, or good practices, being conducted with support from local organizations in response to the issues surrounding threats and drivers noted and observed in the ETOA exercise that are capable of producing immediate benefits for livelihoods and the natural environment. For example, the best practice of solar dryers and modern packaging/improved marketing and brush parks/silent police are described below. Other good practices and ideas/opportunities that emerged from field visits, participatory rural appraisal, and key informant interviews are briefly characterized below.

Table 6.7: Summary of good practices

Action and *locations of proposed pilot trials*	Description	Partners	Benefits
Fisheries Management Best Practices			
Brush parks to deter illegal fishing activities *SEA of Lake Malawi*	Brush parks use natural materials (bamboo poles, tree trunks, etc.) that are sunk into the water. The brush parks are used to attract fish and deter destructive gears, like beach seines	BVCs, DoF	Aquatic biodiversity
Establishment of fish sanctuaries and closed areas *Lake Malawi National Park; Liwonde National Park, selected river mouths; Lake Chilwa and Chiuta*	Sanctuaries are no-take zones where fishing is prohibited. These were established by BVCs and regulated by the village head. Large vessels are not allowed to fish in waters of less than 18 meters. In Chilwa and Chiuta, they included areas with submerged and EAV, and also encompass the deep hole refugia in Chilwa affluent rivers.	BVCs, DoF, National Parks	Aquatic biodiversity
Closed seasons *Lake Malawi, Malombe, and Chilwa*	Closing in-shore areas and river mouths during breeding season of fish.	DoF, BVCs	Aquatic biodiversity, fish abundance
Gear limitations and harvest size limits	Mesh and harvest size limitations meant to	DoF, BVCs	Aquatic biodiversity, fish abundance,

Action and *locations of proposed pilot trials*	Description	Partners	Benefits
Implemented across all lakes	control the size of fish caught. Prohibition of destructive gears are implemented to prevent environmental damage		habitats
Physical removal of water hyacinths *Lake Malawi*	Physical removal of water hyacinths that outcompete natural vegetation	DoF	Aquatic biodiversity
Fish Licensing *Used for commercial trawlers, could be expanded to include artisanal fishers*	Control the number of fishing vessels, brings funding to enforce fisheries regulations	DoF, local licenses could be managed by BVCs	Aquatic biodiversity, fish abundance
Collaborate with local communities in fisheries management and enforcement	Train and empower BVCs, equip BVCs with resources needed for monitoring, control, and surveillance, use local data recorders and fish scouts	BVCs and DoF	Aquatic biodiversity, fish abundance
Establish bylaws that spell out local fisheries rules *Lake Chiuta*	Bylaws can include input and output controls, limiting who can fish and how much fish can be taken out. Bylaws can be the first step towards broader territorial use rights. An example is the ban on fishing of all juvenile fish in Lake Chiuta.	BVCs, DoF	Aquatic biodiversity, fish abundance.
Exchange visits to increase exposure to successful fisheries management efforts (e.g. in northern Lake Malawi and Lake Chiuta)	Allow for the sharing of information between BVCs on the problems they have encountered, and discuss what has worked and not worked, and why.	BVCs., DOF	Aquatic biodiversity, habitat protection, fish abundance

Action and *locations of proposed pilot trials*	Description	Partners	Benefits
Climate Change, Livelihoods, and Value Addition Best Practices			
Tree planting on mountain slopes and along river banks *Pilots across the four lakes*	Multiple projects and communities are piloting planting trees to reduce erosion and increase forest cover	VNRMC	Reduced erosion rates, increased forest cover, potential income from harvesting trees.
Solar dryers and modern packaging – 9 dryer units in three fishing villages on Lake Chilwa – 5 dryer units in construction in fishing villages on the SEA of Lake Malawi	Since 2011, solar dryers have been tested on Lake Chilwa and now Lake Malawi. Dryers are enclosed and protect from flies, contaminants in the air, and precipitation.	DoF/Fisheries Research Unit WorldFish/Malawi Chancellor College, University of Malawi	Reduces drying time and increases the quality and value of sun dried fish. Reduces fish loss and increases economic benefit for fish value chain actors. Greater fish volume available for protein without increasing fishing effort. Promotes collective action, business skills and new marketing opportunities.
Fuel efficient fish smoking kilns *Chisi Island, Lake Chilwa*	The improved kilns use 30 percent less firewood and produce 12 percent less hazardous smoke particles than traditional kilns. The merits of these kilns also include good quality products and high batch capacity.	WorldFish/Malawi Forest Research Institute of Malawi	Reduced pressure on wood resources and deforestation, improved quality of processed products.
Fish storage bins designed for the artisanal fishing fleet to improve handling of small pelagics. *Not applied in Malawi to date.*	Containers can be designed and tested for storing fish in the boat that are stackable, do not crush small, fragile fish, and that allow liquid to pass through for improved hygiene	DoF/FRU	Reduced fish loss and improved quality of product.
Conservation enterprise development, such as aquaculture *Piloted in the Mangochi District*	Enterprises that depend on intact biodiversity and the environment, and that motivate local communities to	BVCs, VNRCs	Biodiversity conservation, income diversification, resilience

Action and *locations of proposed pilot trials*	Description	Partners	Benefits
	protect natural resources		
Climate smart agriculture	FISH will adopt the newly developed Ministry of Agriculture, Irrigation, and Water Development (MOAIWD) training manual for climate smart agriculture (CSA). Using lead farmers, the project will include the following approaches: conservation agriculture, drought resistant crops and agro-forestry. Following the manual lays out the community extension delivery structure using lead farmers.	MOAIWD, VNRCs	Climate change resilience, improved livelihoods.
Village Savings and Loans Associations *Applied across all four lakes*	Promotion of community led savings and loans schemes.		Improved access to capital for microenterprise development. Associated trainings in business development and management.

Integrating these projects in the local development plans can help to scale-up these actions, while DoF provides "how to do" outreach and guidance in synergy with local organizations, and links them with an integrated set of fisheries sustainable development strategies.

6.6 Reducing Fish Loss in the Value Chain from Climate Change: Enclosed Solar Fish Dryer Technology and Modern Packaging

ISSUE: Post-harvest fish loss is a major challenge to fisheries in Malawi, as identified by stakeholders and research. Losses are due to multiple factors including poor storage and handling in boats and transfer to landing areas and processing sites, length of time on the water after catch, and poor processing and packaging methods. A changing climate will increase the threat due to unpredictable rainy seasons and hotter weather.

BACKGROUND: Open rack sun drying and fish smoking are the oldest traditional fish processing and preservation methods used by the majority of fish processors/traders in Malawi. Species composition has shifted from large cichlids (such as the most popular national fish—chambo), catfish and cyprinids to small forage fish species such as usipa (*Engraulicypris sardella*), kambuzi (*Haplochromines*), and matemba (*Barbus spp.*). The smaller fish are dried, whereas the higher value species are smoked or sold fresh.

Photo 1. Traditional open-air sun drying fish rack.

IMPORTANCE: Usipa presently accounts for 70% of the estimated 116,128 tons of total fish caught in Malawi lake waters, with a landed value alone of approximately $170 million. Taking into account the entire value chain that includes processing, transport, and retail sales, the total direct and indirect economic value of this fish species may approach $1 billion a year. If 30% of what is caught is wasted or its value degraded because of spoilage, reducing the loss is a great opportunity. To make the situation worse, Malawi's climate is changing, which will bring hotter temperatures, more unpredictable rains, and an increase in drying of Lake Chilwa and Chiuta.

ADVANTAGES: There are numerous advantages to solar dryers, including the ability to capitalize on the abundant free solar energy, reduce fish loss, ensure food safety, reduce the time to dry the product, gain cost effectiveness, and quickly recover investment and process fish during the rainy season. Low cost constructions for structures (Photo 2). The Solar dryers reduce drying time in half compared to traditional open air drying, isolates contaminants, protects the product from moisture and increases shelf life by months. They also produce a higher quality product—better taste, texture, smell and palatability. Solar dried fish packed in

Photo 2. Solar fish dryers are house-like structures with clear UV resistant polythene plastic and venting for air circulation. The size is about 12 x 5 meters.

small, nicely marked and air tight plastic bags, have a value as much as 30 times more than similar dried fish sold on the ground in open air. The use of solar dryers has been successfully implemented in other countries such as Kenya, Namibia, Ghana, India, and Malaysia.

MALAWI FISH SOLAR DRYER EXPERIENCES: Two initiatives have piloted solar dryers for fish processing of small pelagic fish: one in Lake Chilwa and the other in Mangochi district on Lake Malawi. Both have engaged the Department of Fisheries/Fisheries Research Unit (FRU), WorldFish, and the University of Malawi. The Lake Chilwa solar dryer activities began in 2010 and the Lake Malawi, in 2014.

RESULTS Since the introduction and use of solar fish-drying systems, the quality and value of the sun-dried fish has greatly increased, and the losses have been reduced. Most fish are caught during the 3-month long rain season, so covered sun drying prevents spoilage. Using the sun as a renewable source of energy has the important benefit of reducing pressure on wood resources and deforestation. Experimental data are collected from dryer at the DoF/FRU extension site at Cape Maclear has been collecting. The results of the demonstration dryer on Lake Malawi and community-operated dryers on Lake Chilwa have been significant in terms of the quality, market, and value of the dried fish. Three species are generating high quality results and are ready for scaling up: utaka, ndunduma and parboiled usipa. There are nine solar dryers in three fishing communities in Lake Chilwa, and plans for five dryers to be constructed in five fishing communities in Mangochi District, Lake Malawi in the next months (See structures photo 2).

CHALLENGES Despite the success in drying quality product, there are costs that need to be considered. It costs about MK 550,000.00 (US $1,000) to build a 12 x 5 meter shelter. Then there is the long-term maintenance, including the replacement of the covering. A group will need to equitably manage access and collect fees that go back into maintenance. Some communities would prefer to use open-air racks to avoid the price and wait.

OPPORTUNITY Based on the proven success in constructing solar dryers and drying quality fish, there is an opportunity for increasing the knowledge and application of solar dryers to improve the quality and price of dried fish products. While the technology is effective, there remains a need to research how these dryers can be managed and maintained. A coordinated program is recommended focused on expanding efforts in solar drying; improving construction designs, demonstrating good operational practices, and assisting with packaging and marketing.

Photos 3 and 4. Solar fish dryer racks and packaged product. In the interior of the dryers, shelves or holding trays are fitted where the fish are placed to dry. The final product is *packaged in 100 gram fish bags. (photo credit: James Tobey)*

6.7 Increasing Production in Malawian Fisheries by Utilizing Brush Parks

THREAT: Growing fishing effort in Malawi continues to over-exploit target species such as Chambo (*Oreochromis spp.*), kambuzi (*Haplochromine spp.*), and matemba (*Barbus spp.*). Unsustainable fishing practices have already caused the collapse of Chambo fisheries without leaving any room for populations to recover.

BACKGROUND: Malawians have utilized aquaculture to offset the damage to their fisheries for years. Within the realm of aquaculture, a select few communities have begun to establish brush parks. Typically, fish populations see little recovery time, as the DoF's regulations are not always heeded. The use of brush parks could serve to boost production in an otherwise stressed environment. As seen in West Africa and even in Malawi (Makanjira, Madzedze, & Nkhota kota), well maintained brush parks stand to increase production as a source for population growth.

Photo 1. Utaka: a typical brush park harvest.

IMPORTANCE: After the collapse of the chambo fishery in 1995, Malawians recognized the impacts of constant overexploitation. Currently, the fisheries are under pressure from both subsistence and commercial fisheries. This level of pressure on a system has led to multiple collapses already, and will likely lead to more. Creating a more sustainable practice in the fisheries industry is an important step forward for the warm heart of Africa.

ADVANTAGES Brush parks offer a number of advantages for those communities willing to take part. The most obvious advantage is an increase in fish production, the benefits of which would be clear in adjacent waters. Having a protected source area for fish to breed and grow ensures populations have adequate recovery time before being harvested as adults. Additionally, communities involved would be able to directly control the outputs by regulating inputs. Multiple brush parks being maintained would increase production even further. Furthermore, brush parks serve as a deterrent for trawlers. Pair trawlers in the area would learn to avoid these underwater structures or risk damaging their valuable fishing gears. Finally, the brush park strategy encourages communities, BVCs, and fishers alike to be involved and invest in their futures. This type of co-management would greatly benefit a system, which currently lacks effective communication between communities.

MALAWI BRUSH PARK EXPERIENCES: Multiple communities in Malawi have established artificial reefs. Makanjira and Nkhota kota are both currently using artificial reefs to increase catches. This provides the first step towards implementing brush parks as producers. Each community is familiar with the construction and maintenance of brush parks, however they are currently dropping them in deep water to be used for fish aggregation. A pilot study would have them create similar constructs for shallower depths to be used as breeding grounds; these areas would not be harvested.

RESULTS: As seen in other freshwater systems (i.e. Lake Chilwa), brush parks have the potential to yield between 0.01 and 3.8 kg/m2/yr (Jamu et al. 2003). This level of production could add value to fishing grounds over time, if able to be implemented properly.

Photo 2. Community members from Makenjira who actively use brush parks.

CHALLENGES: Although establishing brush parks is relatively cheap, the biggest concern is rallying the communities around a new idea. Thus far, brush parks have been used only as fish aggregation devices to enhance catch. It remains unclear whether or not it is realistic to implement them for another function in a system where there is no other reliable source of protein. Ownership and co-management would also take some getting used to. Having individuals own brush parks could limit their use and community involvement, making them seem like less attractive opportunities.

OPPORTUNITY: Currently, there remains a need to further research brush parks as producers. Ideally, they could offset the tremendous pressure on fisheries and provide communities a way to give back to the system. However, as a relatively new technology (in its current context), brush parks do not have the support of multiple studies to back their claims. A successful pilot study could launch the implementation of brush parks forward, giving people more concrete evidence regarding their efficacy.

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APPENDICES

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Appendix A1 – ETOA Participatory Rapid Appraisal Methodology

Objectives of the Environmental Threats and Opportunities Assessment Participatory Rapid Appraisal

The aim of the ETOA PRA is to augment and ground truth the information gathered in the Environmental Threats and Opportunities Assessment (ETOA) desktop literature review. Specifically, the participatory rapid appraisal (PRA) exercises are designed to

1) gather local ecological knowledge (LEK) on the biodiversity and ecological hotspots within the Southeast Arm of Lake Malawi, Lake Malombe, Lake Chilwa, and Lake Chiuta;

2) understand the local communities perceptions regarding the greatest threats to the fisheries and current management efforts; and

3) identify best management practices as well as intrinsic qualities of the co-management communities that the FISH project can build upon.

Assist in narrowing down the geographic areas and hotspots for focused and more fast track mitigation activities

Expected Outputs

Geographic positioning (for future development of GIS data layers) of key biodiversity hotspots (defined as prime areas of biodiversity concentration) and threats identified by the local communities for the Southeast arm of Lake Malawi, Lake Malombe, Lake Chilwa, and Lake Chiuta.

Additional, first hand data and information that will be incorporated into the ETOA report (e.g., the identification and prioritization of anthropogenic threats, identification of best practices (i.e. in management as well as climate resilience, etc.) that have the potential to be scaled up, etc.).

Methodology

Sampling Design

The PRA activities will be conducted in 16 villages (with the number of villages for each lake proportionate to the number of villages/BVCs)

The specific villages will be selected to ensure broad geographic coverage around the peripheral of the lakes and the inclusion of as many TAs as practical.

At each village, two concurrent focus groups will be held comprised of the following participants:

8-12 VDC members selected by the VDC Chairman.

8-12 individuals directly involved in fishing (e.g. 6-9 fishermen capturing different fish species w/variety of methods, 1-2 fish processors, 1 female trader, and if possible, 1 female gear owner).

Overall, the entire PRA activity will include 32 focus groups comprising a total ~320 individuals.

The PRA activities will include consultative mapping exercises (defined as geographic location as well as road map of trends) and focus group discussions (FGD) based on a structured questionnaire (See Appendix A, part 2. The PRA will look at questions pertaining to

1) the composition of fish catch over time,

2) the location of key important biodiversity hotspots,

3) the greatest threats to the fisheries,

4) existing management measures (e.g., sanctuaries, no take zones, etc.), and

5) lessons learned from previous project activities (i.e., where the communities have introduced new approaches) (please refer to the attached data capture tool (appendix 2.2) and see below for further details).

Estimated time for this activity

2.5-3 hours for the mapping activities and focus group discussions followed by 30-45 minutes of internal team debriefing.

Materials

Hand held GPS, digital camera, flip chart paper, two flip chart stands, two pre-drawn maps of the locality of the meeting and lakes, markers (red, orange, green, blue, purple and black), data recording forms (Appendix 2, part 2) clipboard, notebook, pens, refreshments and bread.

The PRA Team's Roles and Responsibilities

The PRA field team will be comprised of eight individuals broken up into two smaller teams consisting of four members each with the following roles and responsibilities:

<u>Facilitator</u>: This is a core member of the team and will be consistent throughout. The primary responsibility of the facilitator is to direct the discussion, keep it structured, and flowing, and ensure that all of the focus group members have the opportunity to participate. The facilitator is also responsible for taking the lead on the mapping exercise and drawing out on flip charts the ecological hotspots and threats identified by the focus group participants on the map.

<u>Assistant Facilitator</u>: This is a core member of the team and will be consistent throughout. The primary responsibility of the assistant facilitator is to capture the responses, fill out the data recording form (Appendix 2.2). Given the nature of focus group discussions, some of the relevant information may be brought up and discussed before the Facilitator reaches that part of the data collection form. Therefore, it is imperative that the assistant facilitator is very familiar and comfortable with the layout of the data collection form so that he/she can flip through and find the relevant sections very quickly to add in the information as it is discussed. Please write neatly so that the data can easily be entered into Excel and/or SPSS. Near the end of the discussion, the facilitator may ask the assistant facilitator to feedback and follow up on specific topics of interest.

<u>Note Takers</u>: One note taker is a core member of the team while the other note taker will vary by location. The Local Fisheries Extension Assistant will join one team while the Partner FISH Technician will work with the other. The primary responsibility of the note takers is to write detailed notes for the data analyst. Since the assistant facilitator will be flipping back and forth between the various sections of the data collection form, the note takers' notes will provide a chronological record of the discussion. These notes will augment the data entered in the form, help provide important context, and enrich the quality of the analysis and report. Please write as neatly as possible so that the text can be entered into Atlasti.

The PRA team included 6 core members (one PACT employee, Mr. Patrick Mfungwe, and two District Fisheries Officers, Ms. Monica Mazuwa and Mr. Barnett Kaphuke, and three fisheries extension officer, Ms. Elizabeth Chiwala, Mr. Shadreck Mphande, and Mr. Othaniel Dube) and two local members, one drawn from the local fisheries extension officer(s) from the targeted villages and the other the local FISH technicians from partners located in the area (i.e., CISER, Emmanuel International, WESM). The six core members identified above have been instrumental in developing the data capture tool and have undergone rigorous training. Furthermore, Mr. Patrick Mfungwe will be assisted by Dr. Elin Torell and Dr. Catherine McNally from the Coastal Resources Center at the University of Rhode Island in the data entry and analysis. The local fisheries assistants and Fish Technicians will be trained prior to the commencement of the fieldwork by the six core team members who underwent their training in April 2015.

Instructions for the PRA Exercise

Please begin by introducing the PRA exercise to the gathered community members.

Prior to a PRA meeting, through the local FISH Technician and DoF staff, the FISH project Mangochi Office through the respective DFO's will notify the community of the planned dates for a PRA so that the community is assembled when the team arrives. This letter to the community should clarify the purpose and intent, consult that the community has no objections to the PRA, and explain that the project will provide refreshments and snacks, but no allowances.

<u>The letter should specify, as above:</u>

At each village, two concurrent focus groups will be held comprised of the following participants:

8-12 BVC members selected by the BVC Chairman.

8-12 2 individuals directly involved in fishing (e.g. 6-9 fishermen capturing different fish species w/variety of methods, 1-2 fish processors, 1 female trader, and if possible, 1 female gear owner).

Welcome the assembled community members and thank them for coming. Next, please recognize the Village Headman and let him/her know that we are very proud to have their presence in today's activities. Then introduce the members of the research team.

Please bear in mind that the first few minutes of a focus group discussion are often the most critical. In this brief time, the facilitator must create a welcoming and non-judgmental atmosphere and provide enough information to the participants to make them comfortable with the topic and activities that they will be asked to partake in as a group. Research has shown that much of the success of group interviewing can be attributed to the 3-5 minute introduction (Krueger and Casey, 2015).

Provide a brief overview of the FISH project as a whole using the message taught to the FISH project personnel during the first FISH project training workshop.

Provide an overview of the purpose of the focus group discussion

The Facilitator will read this out loud:

The purpose of today's discussion is to gather information on locations within the lake with high levels of fish biodiversity (defined as areas of large concentrations of many species of fish), high fish abundance, and the specific areas serving as important breeding, nursery, juvenile, and feeding habitats for the different types of fish inhabiting the lake. We are very interested in learning from you today about how the species composition of your harvested fish catch has changed over time, your perceptions of the greatest threats to the fisheries, and your ideas regarding existing fisheries co-management efforts. The information that you share with us today will be used to help guide and develop other components of the FISH project to help overcome some of the challenges in fisheries co-management.

Set the ground rules

- The facilitator will read this out loud:
- Please remember that there are no right or wrong answers.
- We expect that you will all have differing points of view and are very much looking forward to hearing them.
- Please feel at ease and free to share your point of view even if it differs from what others in the group have said.
- My role as the Facilitator in this exercise is to ask questions, listen, and make sure that everyone has a chance to share.
- Again, we are very interested in hearing from each of you today to ensure that everyone has the opportunity to share their knowledge, thoughts and ideas with us.

After the introduction, the Facilitator should ask the group to introduce themselves, and it is important to get the group to pre-register with the assistant facilitator to check you have the right composition.

A participants list should look like the following:

Sl No… Name… Designation… Gender…. Member of a BVC…… Signature in consent to be interviewed

Group 1: VDC members

Group 2: Fishing Community/BVC members

Facilitators, please divide the participants into two groups. Group 1 shall be the VDC and Group 2 shall be the Fishing Community/BVC members. One facilitator, assistant facilitator, and note taker will work with each focus group. The two groups will sit away from each other as to not influence each other's outputs. The Village Headman may sit and observe, but please let him/her know that there will be a special time allotted at the end of the activity to hear his/her thoughts on the topics discussed.

Detailed Methodology

As an ice breaker, ask each person to introduce themselves and say what fish they like to eat and why. After everyone has answered the opening question, the facilitator can invite a more open discussion by saying, we are not going around the group in order anymore, so please just jump into the conversation whenever you want. From this point on, the facilitator takes on the role of questioner, listener, and guide rather than leader. The facilitator gives more control to the group and encourages the group to have a conversation about each question.

The detailed methodology outlined below is also included in the relevant sections on the data capture tool. The facilitator can use the instructions on the data capture tool when in the field while the information below should be used during the training sessions.

Ask each group the following questions:

i) In this fishing area, what were the key fish species caught in their village area in the last 12 months, 5 years ago, and 10 years ago? (Instructions: please do not read the participants the names of the fish listed on the data recording form, but rather just ask them to identify themselves which fish have been the most commonly caught during those three time periods).

ii) Rank of those listed, which four species were caught the most of in the last 12 months, 5 years ago, and 10 years ago? (Instructions: please have them rank the top four species caught in order of importance for each time period with 1 denoting the most important species, 2 the second most important species, 3 the third most important species, and 4 the fourth most important species).

iii) Rank what 4 species are/were the most expensive in the last 12 months, 5 years ago, and 10 years ago? (Instructions: please have them rank the species in order of importance for each time period using the same method as above).

iv) Rank what 4 species did you bring home mostly for consumption in the last 12 months, 5 years ago, and 10 years ago? (Instructions: please have them rank the species in order of importance for each time period using the same method as above).

v) Rank what fishing gear is used in this fishery area in the last 12 months, 5 years ago, and 10 years ago? (Instructions: please have them rank the nets in order of importance for each time period using the same method as above)

vi) What gear catches what fish? Probe as to whether there has been a change in gear use (e.g., more mosquito nets)? (Instructions: List the gear type(s) used for each species using the codes listed below the question on the data capture form).

Next, please show the participants an outline map of their part of the lake. Ask the participants the following set of questions:

i) Where is your village located on this map?

ii) Can you please pinpoint other points of reference? (Instructions: the points of reference can include other villages, landmarks and/or facilities (Monkey Bay Research Center, hotels etc.)

iii) Before moving into the lake area itself, please ask the participants to identify on the map the following critical systems and services: major roads, medical clinics, sources of potable water (e.g., wells, pumps, etc.), and sources of electricity/location of back-up generators (if applicable). Then ask them to map the location of infrastructure critical to the fisheries (i.e., areas where the boats are moored, landing sites, any processing facilities within the villages, transportation routes to the main market(s). (Instructions: please label the village, points of reference, and critical systems, services, and infrastructure on the base map).

iv) Where are the submerged aquatic vegetation (SAV) areas (i.e., oxygen weed)? (Instructions – draw these on the map as sold green polygons)

v) Where are the emergent aquatic vegetation (EAV) areas (i.e., reed banks)? (Instructions – draw these on the map as green lines)

vi) Where are the rocky areas? (Instructions – draw these on the map in black)

vii) Where are the river inlets and outlets? (Instructions – draw these on the map in blue)

viii) Where are the deep areas of the lake? (Instructions – draw these on the map in purple)

ix) Where are the shallow areas of the lake? (Instructions – draw these on the map in blue)

x) Where do you today catch the various fish species identified in the first set of questions? (Instructions: Have the focus group participants pinpoint on the map where they catch the different species identified in the last activity (Question F1_C). Please check in the adjacent boxes on the data capture tool which species are caught in which type(s) of habitat. It is VERY important to make the linkage between the fish species and type(s) of habitat since this identifies the biodiversity hotspot. Please write the fish name/code in those identified area(s) on the map in black).

xi) Where did your village fishermen used to catch fish that are no longer caught? Map by species. (Instructions: For the areas where the fish species used to be harvested, please write the fish code in those area(s) of the lake in red. For the areas where the fish species used to be harvested 5 years ago, please write the fish code in those area(s) of the lake in red followed by a 5 (e.g., USI_5). For the areas where the fish species used to be harvested 10 years ago, please write the fish code in those area(s) of the lake in red followed by a 10 (e.g., USI_10).The Facilitator should probe to find out why the fish are no longer in those areas).

xii) For each fish species discussed under section (iii_i), ask the participants to map the location(s) of important breeding/mating/nesting, nursery, juvenile, and feeding habitats. (Instructions: Have the focus group participants pinpoint on the map where the different species breed/mate/nest, nurse their young, spend time as juveniles, and feed as adults. Again, it is VERY important to make the linkage between the fish species and type(s) of habitat where these critical life stages occur since this identifies the hotspot. Please denote these areas on the map in black using the species code and M for mating, N for nursery, J for juvenile, and F for feeding (i.e., USI_M written in black would denote an area where usipa currently mates, USI_N would denote where the usipa currently nurse their young, etc.).

Once the group has finished mapping the critical habitats for the fish species, please ask them to map the areas in the lake with other types of high aquatic biodiversity and abundance of other important aquatic fauna (e.g., mbuna, hippos, turtles, crocodiles, snails, fish eating or aquatic birds, lake fly etc.). (Instructions: Please mark the areas with high other biodiversity in red, high fish abundance in orange, and use the following codes for the aquatic fauna: mbuna = MBU, turtles = TUR, crocodiles = CROC).

Looking at the map created in the last activity, please ask the group to name the greatest factors affecting the fish species identified in the opening activity (i.e., Question F1C). Please do not read the options listed below in this data capture form aloud, but rather ask the respondents to share their perceptions and continue to probe until all of the focus group participants have had a chance to speak and no more answers are put forth by the group. Circle each factor (i.e., threat and driver) mentioned by the participants on the data capture form. Please also list all of the factors given by the focus group participants on a separate piece of flipchart paper. Ask each participant to identify the most critical threat, second most critical threat, and third most critical threat through a one on one voting exercise. This will be done by asking the note taker to go around the circle of focus group participants and have them quietly tell him/her their top three threats. Repeat this voting exercise for each fish species identified in Question F1C. For each factor identified, ask the participants to collectively indicate in the group setting where the issue/problem is taking place and mark it on the map. If some of the factors do not have a geographic "home", please note that it is area wide. For each factor/issue identified, ask which species are affected and circle it on the species list in the column adjacent to that specific factor on the data capture form.

Then ask the follow up questions listed under each threat/driver and note the responses on the data capture form. Again, please do not mention any of the threats/drivers directly, even if they have NOT mentioned them. It must be a free flowing discussion.

Please then proceed to the questions pertaining to the management of the fisheries. (Instructions: The facilitator is to ask each question in turn, and list which species they apply to. Begin by asking if the group feels that the fishery has collapsed, or will collapse? What types of regulations have been put in place, for what species, and by whom? Please do not read the regulations aloud to the focus group participants, but rather circle the regulations identified by the focus group participants on the data capture form. For each regulation identified, ask whether it has been effective or ineffective and why. Please note the responses on the data capture form. If any of the fisheries regulations were not identified by the focus group participants, please go back and ask the specific questions pertaining to each one, but be sure to check in the box that this regulation was NOT identified by the group themselves).

Finally, ask the focus group participants

i) What was the last shock or impact experienced by your community? (Instructions: probe for what happened, why, what their response was to this shock/impact, how well that response performed, and whether any lessons were learned from that experience).

ii) Do you have any lessons learned good or bad, to share from past fisheries management? If yes, please explain.

iii) What was the most significant achievement the community produced through cooperation to address a fisheries problem?

iv) What intrinsic strengths in fish management does your village have that the FISH project can build upon?

v) In your opinion, what best practices should the FISH project support?

(Instructions: The note taker needs to listen very attentively to the answers given to these questions and be very thoughtful, thorough, and detailed in recording the notes capturing this discussion).

Once each group has finished, bring them all back together to present their results and discuss. At the end of the group presentation/discussion, please ask the Village Headman and leader(s) if there is any additional information that they would like to add either publicly or privately afterwards. Does s/he agree/disagree strongly with any of the conclusions?

Each team will then separate and privately debrief for approximately 30-45 minutes following the focus group discussions. During this time, the map will be translated into a narrative for the data analyst and the team members will review the data capture tool and notes to ensure that the most important points were captured. Before departing the village, please make sure that all of the materials have been collected and gather GPS points of nearby hotspots reachable on land (i.e., lakeshore aquatic vegetation etc.). While in the field, please take a picture of each map as well as the village, its fishing infrastructure, processing areas, etc.

Data Analysis

- The local ecological knowledge (LEK) gathered on the biodiversity and ecological hotspots will be heads up digitized in ArcGIS to create additional data layers for the maps that will be included in the ETOA report.
- The trends in fish species composition and importance in regards to income generation and food provisioning over the past one, five, and ten year increments will be placed on a excel spread sheet and analyzed to compare with the scientific findings reported in the gray and peer reviewed literature.
- The greatest threats to the fisheries and underlying drivers identified by the communities will be summarized in excel tabular format and analyzed for trends... The perceived causes and effects of each will be synthesized and compared with findings in the literature.
- The participants' perceptions regarding the likelihood of collapse for each major fishery will be quantified and the current coping mechanisms and best practices put forth by the community members will be summarized. Interesting discoveries (e.g., use of artificial reefs) will immediately be flagged and written up as case studies for follow-up so as to recommend fast track interventions.
- The participants' understanding and perceptions of the current fisheries management regime will be analyzed both quantitatively (e.g., the percentage of regulations recognized, the percentage of those perceived as effective, the number and functions of the various governance bodies recognized, etc.) and qualitatively (e.g., the reasons given for why the regulations are effective/ineffective will be synthesized and compared with findings in the literature).
- The lessons learned from previous projects, recognition of the community's intrinsic strengths, and identification of best management practices that the FISH project can build upon will be used to augment the findings of the ETOA literature review and identify potential best practices that the FISH project can implement as part of its fisheries management activities.

Appendix A2 – PRA Data Capture Tool

Table A.2.1. Fishing

SECTION 1: FISHING (1 of 2)											
Code	**Question**	**Instructions**	**Fish Species**								
F1.	**In this fishing area, what are the fish species caught**	**Please do not read the fish species names to the focus group participants**	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
F1_C	**in the last 12 months?**	Check the species caught in the village in columns 1-7. If others are mentioned, write the name(s) in columns 8-9.									
F1_F	**5 years ago?**	Check the species caught 5 years ago. Ask if they caught species that are not caught today. If so, list them in columns 8-9									
F1_T	**10 years ago?**	Check the species caught 10 years ago. Ask if they caught species that are not caught today. If so, list them in columns 8-9									
F2.	**Which four species are caught the most of**		**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
F2_C	**in the last 12 months?**	Rank (1,2,3....) which species the fishermen catch the most of, which one is second most important, etc. **1 equals most, 2 equals second most, etc.**									
F2_F	**5 years ago?**										
F2_T	**10 years ago?**										
F3.	**What species fetch the most money**		**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
F3_C	**in the last 12 months?**	Rank (1,2,3....) which species fetch the most money/expensive of, which one was second most important, etc. **1 equals most, 2 equals second most, etc.**									
F3_F	**5 years ago?**										
F3_T	**10 years ago?**										
F4.	**What species did you bring home mostly for consumption**		**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
F4_C	**in the last 12 months?**	Rank (1,2,3....) which species they consume the most of, which one was second most important, etc. **1 equals most, 2 equals second most, etc.**									
F4_F	**5 years ago?**										
F4_T	**10 years ago?**										

Table A.2.2. Fishing Cont.

SECTION 1: FISHING (CONT.) (2 of 2)											
F5.	**What fishing gears have been used in this fishing area**										
F5_C	**in the last 12 months?**	Please list the gear types in the adjacent columns using the codes listed at the bottom of this page.									
F5_F	**5 years ago?**										
F5_T	**10 years ago?**										
F6.	**Of those fishing gears used within the last 12 months, which are the most common?**	List the most common gear types in the adjacent boxes **1 equals most common, 2 equals second most common, etc.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
F7.	**Which fishing gears target which species? Probe as to whether there has been a change in gear used (e.g., more mosquito nets, etc.).**	List the specific gear type(s) used for each species in the adjacent columns using the codes listed below.	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**

Fishing Gear Codes				
1. Open water seines	5. Beach seines	9. Kandwindwi	13. Ngongongo	17. Cast nets
2. Chilimira	6. Chambo	10. Gill nets	14. Active - chikwekwesa	18. Longlines
3. Matemba	7. Kambuzi	11. Passive-mtayo	15. Traps	19. Handlines
4. Nkacha	8. Mosquito	12. Mbuka	16. Scoop nets	20. Other (specifiy)

Table A.2.3.1. Habitats

SECTION 2: IDENTIFICATION OF ECOLOGICAL HOTSPOTS (1 of 3)

Code	Question	Instructions	Fish Species								
HO	**Pinpoint on the map the following areas;**	*Instructions:* Prior to asking about the specific areas listed in the column to the left and below, please ask the focus group respondents to pinpoint on the map the location of their village and a few other points of reference of their choosing to help everyone get their bearings. The points of reference can include other villages, landmarks and/or facilities (Monkey Bay Research Center, hotels etc.). Before moving into the lake area itself, please ask the participants to identify on the map the following critical systems and services: major roads, medical clinics, sources of potable water (e.g., wells, pumps, etc.), and sources of electricity/location of back-up generators (if applicable). Then ask them to map the location of infrastructure critical to the fisheries (i.e., areas where the boats are moored, landing sites, any processing facilities within the villages, transportation routes to the main market(s). Please label the village, points of reference,and critical systems, services, and infrastructure on the base map. Then please draw the aquatic vegetation labelling the submerged aquatic vegetation (SAV) as solid green polygons and the emergent aquatic vegetation (EAV) (e.g., reed banks) as green lines, the rocky areas in black, the river inlets and outlets in blue, the deep areas in purple, and the shallow areas in blue. Please fill out the information below using the fish species that were identified in question F1C (i.e., the fish species caught within the fishing area in the past 12 months). Please see the accompanying data collection guide for additional detailed instructions (see Materials, ii. on p. X)									
HO_V	Village										
HO_PR	Points of Reference										
HO_SY	Critical systems										
HO_SE	Critical services										
HO_FI	Critical fishing infrastructure										
HO_SAV	Submerged aquatic vegetation										
HO_EAV	Emergent aquatic vegetation										
HO_RO	Rocky areas										
HO_RI	River inlets/outlets										
HO_DA	Deep areas										
HO_SH	Shallow areas										
HO_ML	Middle of the lake										
HO_OTH	Other										
HH	**Where (i.e. in what habitats) have the fishermen from your village caught fish in the past 12 months?**	*Instructions:* Have the focus group participants pinpoint on the map where they catch the different species identified in the last activity (Question F1_C). Please check in the adjacent boxes which species are caught in which type(s) of habitat. **It is VERY important to make the linkage between the fish species and type(s) of habitat since this identifies the biodiversity hotspot.** Please write the fish code in those identified area(s) on the map in black.	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
HH_SAV	Submerged aquatic vegetation areas										
HH_EAV	Emergent aquatic vegetation areas										
HH_RO	Rocky areas										
HH_RI	River inlets/outlets										
HH_DA	Deep areas										
HH_SH	Shallow areas										
HH_ML	Middle of the lake										
HH_OTH	Other										
H_PF	**Where did your village used to catch fish 5 years ago?**	*Instructions:* For the areas where the fish species used to be harvested 5 years ago, please write the fish code in those area(s) of the lake in red followed by a 5 (e.g., USI_5). The Facilitator should probe to find out why the fish are no longer in those areas.	*Notes:*								
H_PT	**Where did your village used to catch fish 10 years ago?**	*Instructions:* For the areas where the fish species used to be harvested 10 years ago, please write the fish code in those area(s) of the lake in red followed by a 10 (e.g., USI_10). The Facilitator should probe to find out why the fish are no longer in those areas.	*Notes:*								

Table A.2.3.11. Habitats Cont.

SECTION 2: IDENTIFICATION OF ECOLOGICAL HOTSPOTS (CONT.) (2 of 3)											
HM	**Where do the fish species mate?**	*Instructions:* Have the focus group participants pinpoint on the map where the different species mate. Please check in the adjacent boxes which species mate in which type(s) of habitat. **It is VERY important to make the linkage between the fish species and type(s) of mating habitat since this identifies the hotspot**. Please write the fish code_M (e.g., USI_M) in those identified area(s) on the map in black. (See Materials, iv. on p. X)	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
HM_SAV	Submerged aquatic vegetation areas										
HM_EAV	Emergent aquatic vegetation areas										
HM_RO	Rocky areas										
HM_RI	River inlets/outlets										
HM_DA	Deep areas										
HM_SH	Shallow areas										
HM_ML	Middle of the lake										
HM_OTH	Other										
HN	**Where do the fish species nurse their young?**	*Instructions* : Have the focus group participants pinpoint on the map where the different species nurse their young. Please check in the adjacent boxes which species nurse their young in which type(s) of habitat. **It is VERY important to make the linkage between the fish species and type(s) of nursing habitat since this identifies the hotspot**. Please write the fish code_N (e.g., USI_N) in those identified area(s) on the map in black. (See Materials, iv. on p. X)	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
HN_SAV	Submerged aquatic vegetation areas										
HN_EAV	Emergent aquatic vegetation areas										
HN_RO	Rocky areas										
HN_RI	River inlets/outlets										
HN_DA	Deep areas										
HN_SH	Shallow areas										
HN_ML	Middle of the lake										
HN_OTH	Other										
HJ	**Where do the fish species spend their time as juveniles?**	*Instructions:* Have the focus group participants pinpoint on the map where the different species spend their time as juveniles. Please check in the adjacent boxes which species spend their juvenile stages in which type(s) of habitat. **It is VERY important to make the linkage between the fish species and type(s) of juvenile habitat since this identifies the hotspot.** Please write the fish code_J (e.g., USI_J) in those identified area(s) on the map in black. (See Materials, iv. on p. X)	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
HJ_SAV	Submerged aquatic vegetation areas										
HJ_EAV	Emergent aquatic vegetation areas										
HJ_RO	Rocky areas										
HJ_RI	River inlets/outlets										
HJ_DA	Deep areas										
HJ_SH	Shallow areas										
HJ_ML	Middle of the lake										

Table A.2.3.11. Habitats Cont.

SECTION 2: IDENTIFICATION OF ECOLOGICAL HOTSPOTS (CONT.) (3 of 3)												
HF	**Where do the fish species feed as adults?**	*Instructions:* Have the focus group participants pinpoint on the map where the different species feed as adults. Please check in the adjacent boxes which type(s) of habitat are used by the adult fish for feeding. **It is VERY important to make the linkage between the fish species and type(s) of feeding habitat since this identifies the hotspot**. Please write the fish code_F (e.g., USI_F) in those identified area(s) on the map in black. (See Materials, iv. on p. X)	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
HF_SAV	Submerged aquatic vegetation areas										
HF_EAV	Emergent aquatic vegetation areas										
HF_RO	Rocky areas										
HF_RI	River inlets/outlets										
HF_DA	Deep areas										
HF_SH	Shallow areas										
HF_ML	Middle of the lake										
HF_OTH	Other										
H_OH	**Where are the other biodiversity hotspots?** (The Facilitator should probe for areas with high non-fish biodiversity such as high abundance of other important aquatic fauna)	*Instructions:* Once the group has finished mapping the critical habitats for the fish species, please ask them to map the areas in the lake with high non-fish biodiversity and high abundance of other important aquatic fauna (e.g., mbuna, turtles, crocodiles etc.). Please mark the areas with high fish biodiversity in red, high fish abundance in orange, and use the following codes for the aquatic fauna: mbuna = MBU, turtles = TUR, crocodiles = CROC. (See Materials, v. on p. X)	*Notes:*								

Table A.2.4.1. Threats

SECTION 3: THREATS AND DRIVERS (1 of 4)											
Code	**Threats**										
T1.	**What affects the success of your fisheries?**	*Instructions:* Looking at the map created in the last activity, please ask the group to name the greatest factors affecting the fish species identified in the opening activity (i.e., Question F1C). **Please do not read the options listed below in this data capture form aloud, but rather ask the respondents to share their perceptions and continue to probe until all of the focus group participants have had a chance to speak and no more answers are put forth by the group.** Circle each factor (i.e., threat and driver) mentioned by the participants on the data capture form. Please also list all of the factors given by the focus group participants on a separate piece of flipchart paper. Ask each participant to identify the most critical threat, second most critical threat, and third most critical threat through a one on one voting exercise. Repeat this voting exercise for each fish species identified in Question F1C. For each factor identified, ask the participants to indicate where the issue/problem is playing out and mark it on the map. If some of the factors do not have a geographic "home", please note that it is area wide. For each factor/issue identified, ask which species are affected and circle it on the species list in the column adjacent to that specific factor on the data capture form. Then ask the follow up questions listed under each threat/driver and note the responses on the data capture form. **Again, please do not mention any of the factors (i.e., threats/drivers) directly.**									
T2.	**Of the factors (i.e., threats/drivers) identified above, which do you see as the most critical, second most critical, third most critical OVERALL?**	Most Critical Factor Overall	A. Most Critical Factor By Species:								
		1	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
		2									
		3									
		4	B. Second Most Critical Factor By Species:								
		5	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
T3.	**Of the factors (i.e., threats/drivers) identified above, which do you see as the most critical, second most critical, third most critical FOR EACH SPECIES?**	6									
		7									
		8	C. Third Most Critical Factor By Species:								
		9	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
		10									

Factor Codes	1. Illegal Gear	6. HD - River Inlets/Outlets	11. Population Growth	16. Food Insecurity	21. Lack of knowledge
	2. Habitat Destruction (HD) (General)	7. Sedimentation	12. Migration	17. Poor Educ/Illiteracy	22. Other (specifiy)
	3. HD Submerged Rocky Areas	8. Other Water Quality Issues	13. Climate Change	18. Poor Sanitation	23. Other (specifiy)
	4. HD - Submerged Aquatic Vegetation	9. Lake Level Changes	14. Lack of Alt. Livelihoods	19. Disease	24. Other (specifiy)
	5. HD - Emergent Aquatic Vegetation	10. Trawlers	15. Credit Access	20. No coordination	25. Other (specifiy)

IG	**ILLEGAL GEAR**	*Instructions: The facilitator can use the map as a visual aid in asking this question.*									
		Illegal Gears	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
IG_1	Which illegal gears present the greatest threat? To which species?										
IG_2	Why are illegal gears being used? For which species?										
IG_3	What is the effect of the illegal gear on the lake's fish species?										
IG_4	How do you and your village respond to these changes caused by illegal uses?										
IG_5	Who mostly uses illegal gears (i.e., local fishermen vs. migratory fishermen)?										
HD	**HABITAT DESTRUCTION**	Circle the species that apply	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
HD_1	What habitats are destroyed?	*Instructions: Probe for specific type(s) of habitats, but do not read the list below.*									
HD_SRA	***** OVERFISHING SUBMERGED ROCKY AREAS**	Circle the species that apply	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
HD_SRA1	Why are the rocky areas important?										
HD_SRA2	Why have the rocky areas changed?										
HD_SRA3	What is the effect of this change?										
HD_SRA4	How do you and your village respond to these changes?										

Table A.2.4.11. Threats Cont.

SECTION 3: THREATS AND DRIVERS 2 of 4)											
HD_SAV	*** SUBMERGED AQUATIC VEGETATION LOSS	Circle the species that apply	USI	CHA	UTA	KAM	MLA	JAM	MBU	Other	Other
HD_SAV1	Why is the SAV important?										
HD_SAV2	Why has the SAV been reduced?										
HD_SAV3	What is the effect of SAV loss on fish?										
HD_SAV4	How do you and your village respond to these changes?										
HD_EAV	*** EMERGENT AQUATIC VEGETATION LOSS	Circle the species that apply	USI	CHA	UTA	KAM	MLA	JAM	MBU	Other	Other
HD_EAV1	Why is the EAV important?										
HD_EAV2	Why has the EAV been reduced?										
HD_EAV3	What is the effect of EAV loss on fish?										
HD_EAV4	How do you and your household respond to these changes?										
HD_RI	*** RIVER INLETS/OUTLETS	Circle the species that apply	USI	CHA	UTA	KAM	MLA	JAM	MBU	Other	Other
HD_RI1	Why are the rivers important?										
HD_RI2	Why have the rivers changed?										
HD_RI3	What is the effect of this change?										
HD_RI4	How do you and your household respond to these changes?										
SED	*** SEDIMENTATION	Circle the species that apply	USI	CHA	UTA	KAM	MLA	JAM	MBU	Other	Other
SED1	What are the effects of sedimentation?										
SED2	What causes sedimentation?										
SED3	How do you and your household respond to these changes?										
WQ	***OTHER WATER QUALITY ISSUES	Circle the species that apply	USI	CHA	UTA	KAM	MLA	JAM	MBU	Other	Other
WQ1	Specify the issue										
WQ2	What are the effects?										
WQ3	What causes these changes?										
WQ4	How do you and your household respond to these changes?										
LL	**LAKE LEVEL CHANGES**	Circle the species that apply	USI	CHA	UTA	KAM	MLA	JAM	MBU	Other	Other
	Have lake levels changed in 1, 5 or 10 years, and how										
LL1	What are the effects of lake level changes?										
LL2	What causes lake level changes?										
LL3	How do you and your household respond to these changes?										
TR	**TRAWLERS (Fishing in areas where they are not supposed to fish)**	Circle the species that apply	USI	CHA	UTA	KAM	MLA	JAM	MBU	Other (specify)	Other (specify)
TR1	Do trawlers fish in areas where they are not supposed to fish?										

Table A.2.5.1. Drivers

SECTION 3: THREATS AND DRIVERS (CONT.) (3 of 4)											
Code	**Drivers**										
POP	**POPULATION GROWTH (Higher birth rates/family sizes)**	If applicable, circle the species that apply	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
POP_1	What is the reason behind the village population growth?										
POP_2	What is the effect of population growth on fisheries?										
POP_3	How do you and your village respond to these changes?										
MIG	**MIGRATION**	If applicable, circle the species that	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
MIG_1	Who (what group(s)) is migrating to this area to fish?										
MIG_2	Where are the people coming from?										
MIG_3	What is the effect of migration?										
MIG_4	How do you and your household respond to these changes?										
MIG_5	Can you stop them from fishing in this lake? How?										
CC	**CLIMATE CHANGE**	If applicable, circle the species that	**USI**	**CHA**	**UTA**	**KAM**	**MLA**	**JAM**	**MBU**	**Other**	**Other**
CC_1	What is the specific weather phenomenon that you have seen changing the fishery?										
CC_2	What are the effects of these changes on the village community?										
CC_3	How does your village community respond to these changes?										
CC_4	What are the effects of climate change on the fisheries?										
CC_5	How do you and your village respond to these changes in the fishery now?										
CC_6	What are the potential long-term adaptations you and your household are considering to respond to these changes?										
LAL	**LACK OF ALTERNATIVE LIVELIHOODS**										
LAL_1	Are there alternatives to fishing in this village? If yes, please list										
LAL_2	Are there any livelihoods that you are currently engaged in as profitable as the fisheries? If yes, please list them.										
LAL_3	How do you add value to the fisheries without increasing pressure?										

Table A.2.5.11. Drivers Cont.

SECTION 3: THREATS AND DRIVERS (CONT.) (4 of 4)

Code	Drivers (continued)										
CRE	**LACK OF SAVINGS/ACCESS TO CREDIT**										
CRE_1	What is the effect of lack of savings/access to credit on fishing?										
CRE_2	How do you and your village respond to the lack of savings/access to credit for fishing?										
MRT	**MARKET FORCES**										
MRT_1	What are the market forces influencing fishermen, fish processors and fish traders or the community?										
MRT_2	What are the effects of these market forces?										
POV	**FOOD INSECURITY**										
POV_1	Are there any changes in fisheries that has caused your food insecurity?										
POV_2	What is the effect of food insecurity?										
ILL	**POOR EDUCATION/ILLITERACY**										
ILL_1	What are the effects of less education on fishing management										
SAN	**POOR SANITATION (e.g. cholera)**										
SAN_1	What are the effects of poor sanitation/hygeine on fish?										
DZ	**DISEASE (e.g., HIV/AIDS)**										
DZ_1	What are the effects of disease on fishing?										
INF	**POOR INFRASTRUCTURE**										
INF_1	What are the effects of poor infrastructure on fisheries/value chains?										
GOV	**POOR GOVERNANCE**										
GOV_1	What are the effects of no rules in fishing?										
GOV_2	What are the effects of conflicting rules in fishing?										
GOV_3	What are the effects of poor coordination between the BVCs, Village Headman and Department of Fisheries?										
ENF	**LACK OF KNOWLEDGE ABOUT THE ENFORCEMENT PROCESS**										
ENF_1	What are the effects of lack of knowledge about the enforcement process in fishing?										
OTH	**OTHER**	*Instructions:* List and specify the other threats or drivers identified by the focus group participants below. If applicable, circle which species is affected. For each threat/driver, ask about the cause and effect.									
OTH_1			USI	CHA	UTA	KAM	MLA	JAM	MBU	Other	Other
OTH_2			USI	CHA	UTA	KAM	MLA	JAM	MBU	Other	Other
OTH_3			USI	CHA	UTA	KAM	MLA	JAM	MBU	Other	Other

Appendix A3 – Additional PRA Climate Change Questions

CLIMATE CHANGE QUESTIONS

When it **floods** every year or two, where does it flood? Circle on the map.

How much of your homes, roads and buildings are in the **flood areas**? Few, Some, Most

During storms are **roads and bridges** (important to selling fish and village products) impacted? Rarely, sometime, always

Where are **dambos** located? Circle on the map general areas

How **productive is the farmland** per hectare? High, Medium, or Low based on area averages?

How common are **drought tolerant crops** in the community? High, Medium or Low?

How many different types of **fishing gear** are used? 1, 2-3, or 4

How many families have **livestock**? None/few, half, most

How many people use **illegal fishing gear** in your area? Few, half, most

How many households have **savings** (either in bank or at home)? Few, Half, Most

How much remittance money (from family/friends outside the community) do you receive during difficult times or disasters? High, Medium, Low

Appendix B – Lake Malawi – PRA Reports

Bakili Community: Data Fish Biodiversity

Table B.1.1. Fish Biodiversity reported in Lake Malawi by the community of Bakili. Around 18 species were reported to be harvested in the last 12 months. For the focus group the most abundant were: usipa (1st), kambuzi (2nd), chambo (3rd), utaka (4th), mlamba (5th). For focus group 2 the most abundant were: usipa (1st), dowadowa (2nd), chambo (3rd). The preferred habitat for breeding, nursing and feeding were further refined during the PRA second visit.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	Utaka, mcheni, chisawasawa, silibanga, chambo	kambuzi,utaka,mlamba,matemba, silibanga, dowadowa, mcheni, fwilili, chambo	kambuzi,utaka,mlamba, matemba, silibanga, dowadowa, fwilili, mlamba, chambo	Yes	utaka, mlamba, dowadowa, mlamba, chambo	chambo, utaka, mlamba, dowadowa, mbaba	Bluefish, mbaba, chambo	chambo, mlamba, kambuzi, dowadowa, kambuzi, chisawasawa
EAV	chisawasawa, utaka, mcheni, chambo, mlamba, fwilili (makumba)	chisawasawa, utaka, mcheni, chambo, mlamba, fwilili (Makumba)	chisawasawa, utaka, mcheni, chambo, mlamba, fwilili (Makumba), ntchira, mpasa, kadyakoro, mapanda, chigonthi	Yes	chisawasawa, utaka, mcheni, chambo, mlamba, fwilili (likumba), ntchira, mpasa, kadyakoro, mapanda, chigonthi	chisawasawa, utaka, mcheni, chambo, mlamba, fwilili (likumba), ntchira, mpasa, kadyakoro, mapanda, chigonthi	chisawasawa, utaka, mcheni, chambo, mlamba, fwilili (likumba), ntchira, mpasa, kadyakoro, mapanda, chigonthi	kambuzi, mlamba, chambo, mcheni
Rocky Area	usipa, chambo, utaka, kambuzi, mlamba, mbalule, dondolo, chisawasawa	usipa, utaka, kampango. Mlamba, chisawasawa, mbalule, dondolo.	usipa, utaka, kampango. Mlamba, sawasawa, mbalule, dondolo	Yes	dondolo, chisawasawa, mbalule, mbaba	kambuzi, mlamba, dowadowa, mpasa, matemba	utaka, kambuzi, mlamba, dondolo, chisawasawa	kambuzi, mlamba, mbuna
River inlets/outlets	chambo, mlamba, mpasa, sanjika, matemba	chambo,sanjika,ntchira,mpasa,mlamba	chambo,sanjika,ntchira, mpasa,mlamba	Yes (But no change between 5years and 10 years)	mlamba, matamba, matemba, sanjika	chambo, mlamba, mpasa, mpasa	mlamba, ntchira, sanjika, mpasa	chambo, kambuzi, mlamba, kampango, ntchira, sanjika
Deep Areas	usipa, chambo, utaka, kampango, mlamba, mcheni	chambo,utaka, mlamba, kambuzi,usipa	chambo,utaka,mlamba, kambuzi,usipa	Yes (But no Change between 5years and 10 years)	mcheni, kampango, bombe, jamison, usipa, nkholokolo	usipa, chambo, utaka, kambuzi, mlamba, jamizon, mpasa, mbaba, matemba	usipa, chambo, kmbuzi, mlamba, bombe, mcheni	usipa, chambo, utaka, kambuzi, mlamba, jamison, bombe, mbaba, mpasa, chisawasawa
Shallow Areas	usipa, utaka, chambo, kambuzi, mlamba, mcheni, dondolo, chisawasawa, mbaba, ntchira, kanjanga	usipa, utaka, chambo, kambuzi, mlamba, mcheni, dondolo, chisawasawa, mbaba, ntchira, kanjanga	usipa, utaka, chambo, kambuzi, mlamba, mcheni, dondolo, chisawasawa, mbaba, ntchira, kanjanga	No	chambo, kanjenga, mbaba, chimbenje	chambo, utaka, kambuzi, chisawasawa	usipa, chambo, mlamba	usipa, chambo, utaka, kambuzi, mlamba, jamison, mpasa, chisawasawa
Middle of the lake	usipa,kambuzi, chambo,jamison	usipa, chambo, utaka, kambuzi, mlamba, jamison, bluefish, mbaba, kanjanga	usipa, chambo, utaka, kambuzi, mlamba, jamison, bluefish, mbaba, kanjanga	yes	usipa, utaka, mlamba, dowadowa, mcheni	usipa, utaka, kambuzi, mlamba, dondolo, mcheni, mbamba, kanjenga	usipa, chambo, kambuzi, mlamba, mcheni, bombe	usipa, chambo, utaka, kambuzi, mlamba, jamison, kampango, chisawasawa

Table B.1.2. The community of Bakili identified threats to their community related to fisheries and explained the reasons behind the threats, how the community responds, and what constitute good practices to counteract these threats.

Threats (Bakili)
Illegal Fish Gear Used *(i.e., kandwidwi, wogo, nkacha, ngongongo)* *Affected Fish Species* ▪ All species. Their juveniles are caught. *Communities Perceptions on the reasons behind the threat* ▪ Fishers use illegal gear to catch a lot of fish and make more profits. ▪ Lack of respect for the rules and regulations of the fisheries. *Community's response to threat / Perceived Strength and Good Practices* ▪ Having bylaws that enforce the use of legal gears. ▪ The confiscation of illegal gears is a strength. *Perceived Weaknesses* ▪ They do not know the fisheries rules and regulations. Corruption: illegal gears are easily returned to the owners. Enforcement is weak, because the chiefs 'say' dominates. *Perceived Avenues for the Project to Intervene* ▪ Hold meetings for the fishers regularly, provide trainings and help to fully empower the BVC. ▪ Providing fishers with boat engines, IDs to the BVC members, life jacket, uniforms and bicycle will help them in the enforcement.
Trawlers *(Fishing in areas where they are not supposed to fish)* *Affected Fish Species* ▪ All species and their habitats. *Communities Perceptions on the reasons behind the threat* ▪ The use of fish trawls produces scarcity of fish. This poses a challenge to fishers without trawlers. ▪ Fishers are also not fishing in designated areas, and other fishing gear such as traps are destroyed. *Community's response to threat / Perceived Strength and Good Practices* ▪ Nothing *Perceived Weaknesses* ▪ There is no cooperation between the BVC and Fisheries Department. They have no say on the trawlers. *Perceived Avenues for the Project to Intervene* ▪ To liaise with the government to encourage proper licensing and patrolling. ▪ BVCs need an engine and boat to be able to chase out fishers present in non-designated areas.

Table B.1.3. The community of Bakili identified the drivers to the threats to their community related to fisheries and explained the reasons behind the drivers, how the community responds, and what constitutes good practices to counteract the drivers of the threats.

Drivers (Bakili)
Population Growth *(Higher birth rates leads to big family sizes)* *Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the threat* ▪ Lack of community planning *Community's response to driver / Good practices* ▪ They are practicing family planning on a small scale; mostly the use of condoms. *Perceived Weaknesses* ▪ Men discourage women on family planning due to the bad side effects of family planning methods. They believe that family planning reduces libido. There is a lack of proper advice on family planning. *Perceived Avenues for the Project to Intervene* ▪ Training and creating awareness on the merits of family planning. ▪ Loans for small scale businesses to help ease pressure on the fishery.
Climate Change *Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the threat* ▪ There are now different types of winds that make it difficult to fish. ▪ The community members reported lower lake levels and higher levels of fish mortality due to higher water velocities caused by heavy rains and strong winds. *Community's response to threat* ▪ Reforestation Community *Perceived Strength and Good Practices* ▪ Reforestation is seen as a strength. They also have a forest extension worker. *Perceived Weaknesses* ▪ A failure to replace depleting vegetation *Perceived Avenues for the Project to Intervene* ▪ Need for tools such as wheelbarrows, water canes, hoes, shovels, 'panga' knives. ▪ Need for tubes used for nursery development and different types of tree seeds.

Kadango Community: Data Fish Biodiversity

Table B.2.1. Fish Biodiversity reported in Lake Malawi by the community of Kadango. Around 18 species were reported to be harvested in the last 12 months. Focus group one listed the most abundant of them being: usipa (1st), kambuzi (2nd), dowadowa (3rd), chambo (4th), mlamba (5th), mbaba (6th). Focus group 2 listed them in following order; usipa (1st), kambuzi (2nd), mbaba (3rd), mcheni (4th), utaka (5th). The preferred habitat for breeding, nursing and feeding were further refined during the PRA second visit.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	chambo, kambuzi, silibanga, mbaba, mlamba	utaka, kambuzi, mbaba, silibanga, mlamba	utaka, kambuzi, mbaba, silibanga, mlamba	Yes	chambo, kambuzi, mbuna, mbaba	kambuzi, mbaba, chambo, fwilili	usipa, chambo, kambuzi, mlamba	chambo, mlamba, matemba, tsungwa
EAV	Kambuzi, mbaba, fwiili, silibanga	Kambuzi, mbaba, fwiili, silibanga	Kambuzi, mbaba, fwiili, silibanga	No	chambo, kambuzi, mbuna, mbaba, fwilili	chambo, usipa, kambuzi, fwilili	mpasa, mbaba, mlamba	mpasa, mlamba, fwilili, tsungwa, mbaba
Rocky Areas	usipa, utaka, nkunga, samwamowa	usipa, utaka, chigonthi, nkunga	usipa, utaka, chigonthi, nkunga	yes	usipa, utaka, chisawasawa, chambo	chambo, kambuzi, mlamba, mbuna, utaka, usipa, njangwi, bombe, kampango,	chambo, kambuzi, mlamba, mbuna, utaka, usipa, njangwi, bombe, kampango,	chambo, kambuzi, mlamba, mbuna, utaka, usipa, njangwi, bombe, kampango, nkholokolo, ndunduma, mcheni
River inlets/outlets	chambo, sanjika, makumba, Chigonthi, matemba, mlamba	chambo, sanjika, mbaba, matemba, chigonthi , mlamba	chambo, sanjika, mbaba, matemba, chigonthi , mlamba	yes	mpasa, sanjika, chambo, mlamba, chigonthi, matemba	mpasa, sanjika, chambo, mlamba, chigonthi, matemba	mpasa, sanjika, chambo, mlamba, chigonthi, matemba	mpasa, sanjika, chambo, mlamba, chigonthi, matemba
Deep Areas	Utaka, usipa, mcheni, chambo, jamison, bombe, chisawasawa, kampango, nkholokolo	Utaka, usipa, mcheni, chambo, jamison, bombe, chisawasawa, kampango,	Utaka, usipa, mcheni, chambo, jamison, bombe, chisawasawa, kampango, nkholokolo	No	chambo, usipa, utaka, kambuzi, chisawasawa, mlamba	usipa, kambuzi, nkholokolo, mlamba, bombe	Jamison, chisawasawa, nkholokolo, mlamba	Utaka, usipa, mcheni, chambo, jamison, bombe, chisawasawa, kampango, nkholokolo, utaka
Shallow Areas	Kambuzi, mbaba, fwiili, silibanga, chambo, silibanga, usipa, chimbenje	Kambuzi, mbaba, fwiili, chambo, silibanga, usipa, chimbenje	Kambuzi, mbaba, fwiili, chambo, silibanga, usipa, chimbenje	No	chambo, usipa, mbaba, mlamba	usipa, chisawasawa, dowadowa	Kambuzi, mbaba, fwiili, silibanga, chambo, silibanga, usipa, chimbenje	Kambuzi, mbaba, fwiili, silibanga, chambo, silibanga, usipa, chimbenje
Middle of the lake	chambo, usipa, kambuzi, mcheni, mlamba, bombe, jamison	chambo, usipa, kambuzi, mcheni, mlamba, bombe, jamison	chambo, usipa, kambuzi, mcheni, mlamba, bombe, jamison	No	chambo, usipa, utaka, kambuzi, chisawasawa	chambo, usipa, kambuzi,mcheni, mlamba	chambo, usipa, kambuzi,mcheni, mlamba	chambo, usipa, kambuzi, mcheni, mlamba, bombe, jamison

Kadango Community - Threats and Drivers

Table B.2.2. The community of Kadango identified threats to their community related to fisheries and explained the reasons behind the threats, how the community responds, and what constitutes good practices to counteract these threats.

Threats (Kadango)
Illegal Fishing gear *(nkacha, ngongongo, kandwindwi, mosquito net)* *Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the threat* ▪ Increasing fish catch and profit. This is due to poverty and also high numbers of fishers on the lake there to catch as many fish as possible. *Community's response to threat* ▪ Confiscate gears, report illegal activity to proper authorities (i.e., DoF and the Chief). *Perceived Strength and Good Practices* ▪ Confiscating nkacha nets to protect fish species. *Perceived Weaknesses* ▪ Corruption - when they take the culprits to the chief, the chief returns the gears and there is not anything that the BVC can do about it. *Perceived Avenues for the Project to Intervene* ▪ Identification cards, uniforms, bicycles, boat and engine, and torches for better enforcement. BVC, fishermen and traditional leaders would like raining on their roles and responsibilities.
Trawlers *(Fishing in areas where they are not supposed to fish)* *Affected Fish Species* ▪ All species and their habitats *Communities Perceptions on the reasons behind the threat* ▪ The trawlers are fishing in areas that are designated for small gears hence depleting the fish available for small gear fishers. *Community's response to threat* ▪ Afforestation in the Ntelemanja area. *Perceived Strength and Good Practices* ▪ None *Perceived Weaknesses* ▪ Locals feel powerless to deal with trawlers. *Perceived Avenues for the Project to Intervene* ▪ Fishers want the project to work in collaboration with the Fisheries Department to enforce a rule that the closed season should also apply to the trawlers.

Table B.2.3. The community of Kadango identified the drivers to the threats to their community related to fisheries and explained the reasons behind the drivers, how the community responds, and what constitutes good practices to counteract the drivers of the threats.

Drivers (Kadango)
Population Growth *(Higher birth rates leads to big family sizes)* *Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the threat* ▪ Not following family planning procedures (most of community members are not keen on family planning). Further, some religions do not support family planning. *Community's response to threat* ▪ Establishing family planning; just 30% of the villagers at present. *Perceived Strength and Good Practices* ▪ They do not see a clear strength on this problem. *Perceived Weaknesses* ▪ Men do not want to practice family planning (they threaten to divorce the woman if she does). CBDAs are not supported by government hence low extension. ▪ Religion and also fear of losing families contribute to low levels of family planning. *Perceived Avenues for the Project to Intervene* ▪ Awareness and creating awareness on family planning issues. Encourage religious leaders to talk to their congregation about family planning.
Climate Change *Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the threat* ▪ Erratic rainfall patterns and droughts are leading to lake water level changes. ▪ The fish migrate further from the beach leading to low fish catches. ▪ Drought exacerbates poverty and food insecurity due to low harvests, which increases pressure on the fishery as it is the only way to get money and purchase food. *Community's response to threat* ▪ Afforestation; they have planted trees around Ntelemanja area. *Perceived Strength and Good Practices* ▪ Collaboration of the villagers to start planting trees and grass. ▪ The village also has a committee that deals with the protection of vegetation and tree planting efforts along Dowa river. *Perceived Weaknesses* ▪ Lack of support from NGOs and government. ▪ The Chief gives forest land to people for cultivation. This increases levels of deforestation. *Perceived Avenues for the Project to Intervene* ▪ Trainings on forest and environmental management. Creating awareness on the importance of the forest, especially for the traditional leaders.

Kera Community: Data Fish Biodiversity

Table B.3.1. Fish Biodiversity reported in Lake Malawi by the community of Kera. Around 17 species were reported to be harvested in the last 12 months. The most abundant being: usipa (1st), kambuzi (2nd), chambo (3rd), utaka (4th) and mcheni (5th). The preferred habitat for breeding, nursing and feeding were further refined during the PRA second visit.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	chambo, kambuzi, utaka	kambuzi, utaka, mlamba,	kambuzi, utaka, mlamba	Yes	chambo, mlamba	chambo, mlamba, kambuzi	chambo, mlamba, kambuzi	chambo, kambuzi, chisawasawa, mbaba
EAV	chambo, makumba, kambzi	Mlamba, makumba, kambuzi,fwilili, mbaba	mlamba, makumba, kambuzi	Yes	mlamba, chambo, mbaba	chambo, mlamba, kambuzi, makumba	chambo, mlamba, kambuzi, makumba	makumba, mlamba,fwilili,
River inlets/outlets	sanjika, chambo, mlamba, mpasa, ntchila,, ningwi	sanjika, chambo, mlamba, mpasa, ntchira	sanjika, chambo, mpasa, mlamba, ntchira	Yes	sanjika, mpasa, mlamba, chambo, nkholokolo	mlamba, chambo, makumba, sanjika, ningwi, kadyakoro, mpasa	mlamba, chambo, makumba, sanjika, ningwi, kadyakoro (mbuna), mpasa	chambo, mlamba, sanjika, mpasa,
Deep Areas	usipa, chambo, utaka, kambuzi, mcheni, kampango, chisawasawa, jamison	chambo, utaka, mlamba, usipa	chambo, utaka, mlamba, usipa	Yes	kampango, bombe, sawasawa (chisawasawa), jamison	mcheni, usipa,jamison, mbaba	mcheni,	usipa, utaka, kambuzi, jamison,
Middle Areas	usipa, chambo, utaka, kambuzi, mlamba, jamison, bombe	usipa, mlamba, jamison,kampa ngo	usipa, mlamba, jamison, kampango	Yes	usipa, utaka, jamison	usipa, jamison, mcheni, mbaba	usipa, jamison, mcheni, mbaba	usipa, chambo, utaka, kampango, mlamba, jamison

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	chambo, kambuzi, utaka	kambuzi, utaka, mlamba,	kambuzi, utaka, mlamba	Yes	chambo, mlamba	chambo, mlamba, kambuzi	chambo, mlamba, kambuzi	chambo, kambuzi, chisawasawa, mbaba
EAV	chambo, makumba, kambzi	Mlamba, makumba, kambuzi,fwilili, mbaba	mlamba, makumba, kambuzi	Yes	mlamba, chambo, mbaba	chambo, mlamba, kambuzi, makumba	chambo, mlamba, kambuzi, makumba	makumba, mlamba,fwilili,
River inlets/outlets	sanjika, chambo, mlamba, mpasa, ntchila,, ningwi	sanjika, chambo, mlamba, mpasa, ntchira	sanjika, chambo, mpasa, mlamba, ntchira	Yes	sanjika, mpasa, mlamba, chambo, nkholokolo	mlamba, chambo, makumba, sanjika, ningwi, kadyakoro, mpasa	mlamba, chambo, makumba, sanjika, ningwi, kadyakoro (mbuna), mpasa	chambo, mlamba, sanjika, mpasa,
Deep Areas	usipa, chambo, utaka, kambuzi, mcheni, kampango, chisawasawa, jamison	chambo, utaka, mlamba, usipa	chambo, utaka, mlamba, usipa	Yes	kampango, bombe, sawasawa (chisawasawa), jamison	mcheni, usipa,jamison, mbaba	mcheni,	usipa, utaka, kambuzi, jamison,
Middle Areas	usipa, chambo, utaka, kambuzi, mlamba, jamison, bombe	usipa, mlamba, jamison,kampa ngo	usipa, mlamba, jamison, kampango	Yes	usipa, utaka, jamison	usipa, jamison, mcheni, mbaba	usipa, jamison, mcheni, mbaba	usipa, chambo, utaka, kampango, mlamba, jamison

Kera Community - Threats and Drivers

Table B.3.2. The community of Kera identified threats to their community related to fisheries and explained the reasons behind the threats, how the community responds, and what constitute good practices to counteract these threats.

Threats (Kera)
Illegal Fishing Gear *(nkacha, kandwidwi, mosquito nets, ngongongo, momomo, ogo)Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the threat* ▪ Poverty, people can catch greater quantities of fish, lack of proper laws and regulations, corruption of fisheries officers and the illegal gear owners, and neglect of the fisheries management rules and regulations by both officials and community. *Community's response to threat* ▪ BVCs are not functioning (fisheries officers have not trained them). ▪ Illegal activity is reported – but the fisheries officials take no action. *Perceived Strength and Good Practices* ▪ Locals report what transpires on the lake to the fisheries officials whatever, and they document the reports *Perceived Weaknesses* ▪ Absence of training for BVC. ▪ Lack of resources and absence of handover between old and new BVC. *Perceived Avenues for the Project to Intervene* ▪ Resources are needed (boats, engines, uniforms, IDs); need for boat fuel; and training is needed for the BVC and the forestry management.
Lake Level Changes *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Changes in rainfall patterns, low inflows of water or high levels of water. *Community's response to threat / Perceived Strength and Good Practices* ▪ Reforestation. *Perceived Weaknesses* ▪ Difficulty of areas between lake and mountain (no space or land to plant trees). ▪ The soil is not good for planting. *Perceived Avenues for the Project to Intervene* ▪ Implementation of tree planting, increasing the number of forestry extension workers, ▪ The government should re-introduce lions in the mountain so that people will fear going to cut trees.

Trawlers *(Fishing in areas where they are not supposed to fish)*

Affected Fish Species

- All species and their habitats

Communities Perceptions on the reasons behind the threat

- Lack of authority over trawler who say that they pay high taxes, i.e. they are given access.

Community's response to threat

- Locals always report to fisheries officials but no further action is taken.

Perceived Strength and Good Practices

- Locals report to fisheries officials whatever transpired on the lake to fisheries officials and they document the reports.

Perceived Weaknesses

- No action is taken when they report to the fisheries office.

Perceived Avenues for the Project to Intervene

- Fisheries department can organize regular meetings to create awareness for the locals on trawler the hours that they are legally permitted to trawl within the lake regular meetings can help to empower locals with knowledge on how to stop corrupt practices.

Table B.3.3. The community of Kera identified the drivers to the threats to their community related to fisheries and explained the reasons behind the drivers, how the community responds, and what constitute good practices to counteract the drivers of the threats.

Drivers (Kera)
Population Growth *(Higher birth rates leads to big family sizes)* *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Lack of family planning, children dropping out of school leading to early marriage, ignorance, increased population, overfishing and use of illegal gears to support families. *Community's response to threat / Perceived Strength and Good Practices* ▪ Community members encourage children to go to school, doing family planning. *Perceived Weaknesses* ▪ Locals believe that practicing family planning makes them sick (continuous menstruation for women) and that they also get fat. *Perceived Avenues for the Project to Intervene* ▪ Making people more aware of family planning, collaborating with communities Chief to help in the formation of committees that will enforce child education, and the government to introduce 3 children per family policy.
Climate Change *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Erratic rainfall events. *Community's response to threat* ▪ Community acceptance of environmental conservation. Tree planting efforts along the Dowa river. *Perceived Strength and Good Practices* ▪ They do not cultivate along the river banks, community acceptance of environmental conservation, and tree planting efforts along Dowa river. *Perceived Weaknesses* ▪ Absence of ownership in tree conservation, reduction of land to plant trees, reduced Forest management extensions and the corruption of Forest extension workers. *Perceived Avenues for the Project to Intervene* ▪ Trainings on forest management, reforestation with fast growing varieties of trees, enforcement of laws concerning forest conservation, and the formation of village natural resources conservation committee.

Madothi Community: Data Fish Biodiversity

Table B.4.1. Fish Biodiversity reported in Lake Malawi by the community of Madothi. Around 22 species were reported to be harvested in the last 12 months. The most abundant being: usipa (1st), utaka (2nd), jamison (3rd), chambo (4th), mlamba (5th). The preferred habitat for breeding, nursing and feeding were further refined during the PRA second visit.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	chambo, usipa, utaka, bluefish, dyamphipi, prakadon,	Tsungwa, mpalu, chimbenje, palala, fwilili, ntsungwa, mdyabango, kadyakoro, kanchimanga, gong'ola	prakadon, ngumbo, mlamba, palala, fwilili, mayani, ningwi, chambo, utaka, usipa, mpasa, ngumbo, kadyakoro, chimbenje	Yes	chambo, kambuzi, chimbenje, thondo, prakadon, thilingwi	chambo, prakadon, mayani, kampango, chimbenje	chambo, kambuzi, bombe, mlamba, bluefish, nsese, chimbenje	chambo, kambuzi, bombe, mlamba, bluefish, nsese, fwilili, usipa
EAV	chambo, usipa, , dyamphipi, tsungwa	chambo, usipa, , dyamphipi, tsungwa (all species were more	chambo, usipa, , dyamphipi, tsungwa (all species were more abundant)	No	usipa, mlamba, dyamphipi, chimbenje, bombe, kampango,	usipa, mlamba, dyamphipi, chimbenje, bombe, kampango,	usipa, mlamba, dyamphipi, chimbenje, bombe, kampango,	usipa, mlamba, dyamphipi, chimbenje, bombe, kampango, tsungwa, chambo
River inlets/outlets	ningwi, mphuta, matemba, sanjika, matamba, mpasa	ningwi, mphuta, matemba, sanjika, matamba	ningwi, mphuta, matemba, sanjika, matamba,	Yes	ningwi, mpasa, sanjika, mlamba, fwilili	sanjika, mpasa	chambo, utaka, ningwi, mpasa, fwilili, sanjika	chambo, utaka, fwilili, mpasa, ningwi, sanjika, mlamba
Deep Areas	usipa, utaka, kambuzi, mcheni, mlamba, jamison, chisawasa, bombe, fwilli	usipa, utaka, kambuzi, mcheni, mlamba, jamison, chisawasa, bombe, fwilli	usipa, utaka, kambuzi, mcheni, mlamba, jamison, chisawasa, bombe, fwilli	No	usipa, mcheni, utaka, jamison	bombe, mcheni	bombe, mcheni	mcheni, bombe, kampango
Shallow Areas	mbaba, mlamba, dyamphipi, chimbenje, nsese	mbaba, mlamba, dyamphipi, chimbenje, nsese	mbaba, mlamba, dyamphipi, chimbenje, nsese	No	chambo, usipa, chimbenje	chambo, kambuzi, sanjika, mpasa, ningwi, bluefish, chimbenje	ningwi, mpasa, mlamba, gong'ola	mpasa, ningwi, gong'ola
Rocky Areas	**mbuna**, mayani, bombe, usipa, ningwi, utaka, kampango	**mbuna**, mayani, bombe, usipa, ningwi, utaka, kampango	**mbuna**, mayani, bombe, usipa, ningwi, utaka, kampango	No	Mbuna, kampango, ngunga, chisembele, bombe, samwamowa	Mbuna, kampango, nkunga, chisembele, bombe, samwamowa	Mbuna, kampango, nkunga, chisembele, bombe, samwamowa	Mbuna, kampango, nkunga, chisembele, bombe, samwamowa
Middle of the lake	usipa, utaka, kambuzi, mlamba, jamison	usipa, utaka, kambuzi, mlamba, jamison	usipa, utaka, kambuzi, mlamba, jamison	No	chambo, utaka, kambuzi, mlamba	chambo, utaka, kambuzi, mlamba	kambuzi, bombe, mcheni	kambuzi, mcheni, bombe

Table B.4.2. Threats in Madothi

Threats (Madothi)
Illegal Fish Used *(i.e., trawlers, mosquito nets, ngongongo, katchosa njala)* *Affected Fish Species* ▪ Usipa, chambo, utaka, kambuzi, mlamba, jamison, and mbuna *Communities Perceptions on the reasons behind the threat* ▪ Illegal gears are being used by both local community members and migrants because fish are scarce. There is a lack of fisheries extension officers. No inspections constitutes a threat. *Community's response to threat* ▪ (Not started yet) Bylaws to prohibit the use of under-meshed gears and migrant fishermen. *Perceived Strength and Good Practices* ▪ Chasing away the trawlers and seeing the benefits in the increase in size of the fish they fish. When illegal gear owners left the beach, fish was able to reproduce. *Perceived Weaknesses* ▪ Absence of bylaws. The BVC is not empowered to patrol the lake. ▪ Trawlers communicate with officers at the fisheries head office who retain the trawlers for them. ▪ They are no longer chasing away the trawlers b/c they now think that it's okay for them to be there while in reality the regulations state that the trawlers are not allowed in that area. *Perceived Avenues for the Project to Intervene* ▪ Making the BVC more effective with enforcement (power to revoke licenses when trawlers break the rules). Uniforms, identification, a boat and engine. Doing capacity building on the BVC management, leadership and de-centralization.
Sedimentation *Affected Fish Species* ▪ Chambo, ningwi, sanjika, fwili and mpasa. *Communities Perceptions on the reasons behind the threat* ▪ Deforestation due to high population growth. Cut trees are used to generate money. ▪ Erosion due to heavy rains. *Community's response to threat / Perceived Strength and Good Practices* ▪ Afforestation of bare land; practicing around Salumbidwa mountains). The planting elephant grass in their farm lands and along the Mphani river; and not allowing deforestation along the river banks. *Perceived Weaknesses* ▪ Failure to look after their livestock which destroying the grass. ▪ Lack of proper nurseries and tools to take care of the nurseries (i.e water canes). *Perceived Avenues for the Project to Intervene* ▪ Educating the community on forest management. Need for tools and equipment, tree seeds (nursery). Provision of loans to start small scale business to uplift their lives.

Trawlers

Affected Fish Species

- All species, trawlers destroy breeding grounds.

Communities Perceptions on the reasons behind the threat

- It is believed that cape Maclear area has a lot of fish hence they want to catch as much as possible for high profits.

Community's response to threat / Perceived Strength and Good Practices

- Chasing trawler owners

Perceived Weaknesses

- Absence of ownership in tree conservation; reduction of land to plant trees, reduced Forest management extensions and the corruption of Forest extension workers.
- Lack of bylaws. BVC is not empowered to patrol the lake (too new). Trawlers communicate with officers at the fisheries head office who retain the trawlers to them.

Perceived Avenues for the Project to Intervene

- The BVC could be more effective with enforcement if given uniforms, identification, a boat and engine. There is a need for capacity building on BVC management, leadership and decentralization. Empower them to be revoke licensees when trawler owners break the regulations.

Table B.4.3. Drivers and contributing factors in Madothi.

Drivers (Madothi)
Population Growth *(Higher birth rates leads to big family sizes)* *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Lack of family planning. Belief that contraceptives have bad side effects. ▪ They want many children in case one of them will become rich and support them in future. ▪ Illiteracy. *Community's response to threat / Community Perceived Strength and Good Practices* ▪ They are trying to encourage family planning. *Perceived Weaknesses* ▪ Absence *Perceived Avenues for the Project to Intervene* ▪ Civic education of both men and women to increase awareness of the benefits of family planning.
Climate Change *Affected Fish Species* ▪ Chambo, ningwi, ntchira, kadyakoro, mpasa. ▪ Positive note: Because the strong winds prevent fishers from going fishing, the fish are able to reproduce. *Communities Perceptions on the reasons behind the threat* ▪ Strong winds affect all species (especially the juveniles). Heavy rains and strong winds destroy fish habitat due to erosion. *Community's response to threat* ▪ Advise each other on environmental conservation. Encourage afforestation, avoid deforestation ▪ They started IGAs as substitute to fishing. *Community Perceived Strength and Good Practices* ▪ They are doing small scale irrigation to ease pressure on the fishery. ▪ Advise each other to avoid deforestation and encourage afforestation. ▪ They do not use illegal gears. *Perceived Weaknesses* ▪ Careless cutting down of trees. ▪ Not taking care of livestock, which destroy planted grass in their farm lands and along rivers. *Perceived Avenues for the Project to Intervene* ▪ Assistance to carry forth irrigation schemes and mount water pumps. These are currently being done on a small scale. ▪ Fish farming. Additional loans for small scale businesses and entrepreneurships skills.

Malembo Community: Data Fish Biodiversity

Table B.5.1. Fish Biodiversity reported in Lake Malawi by the community of Malembo. Around 14 species were reported to be harvested in the last 12 months. The most abundant being: usipa (1st), jamison (2nd) kambuzi (3rd), mayani (4th), chambo (5th), utaka (6th), mlamba (7th), mcheni (8th). The preferred habitat for breeding, nursing and feeding were further refined during the PRA second visit.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	chambo, kambuzi, mlamba, fwilili	kambuzi, fwilili, mlamba, chambo, ningwi, tsungwa	chambo, kambuzi, mlamba, fwilili, ningwi, tsungwa, ntchira, mpasa, kadyakoro	Yes	chambo, utaka, kambuzi, mlamba, mcheni, fwilili, tsungwa, nkhalala	chambo, mcheni, fwilili, mlamba, tsungwa	chambo, utaka, kambuzi, mlamba, fwilili, tsungwa	chambo, kambuzi, mlamba,tsungwa, fwilili
EAV	kambuzi, mlamba, fwilili, mphuta, tsungwa, nkhalala	kambuzi, mlamba, fwilili, mphuta, tsungwa, nkhalala	kambuzi, mlamba, fwilili, mphuta, tsungwa, nkhalala	No	fwilili, chambo, utaka, kambuzi, mlamba	chambo, utaka, kambuzi, mlamba, jamison, mpasa, fwilili	chambo, utaka, kambuzi, mlamba, fwilili, tsungwa	chambo, kambuzi, mlamba,tsungwa, fwilili
River inlets/outlets	chambo, mpasa, mlamba, sanjika, matemba, nkholokolo	Mpasa, chambo, ningwi, mlamba	chambo, mlamba, ningwi, sanjika, mphuta	Yes	chambo, sanjika, kambuzi, mlamba, fwilili	chambo, mlamba, mpasa, matemba, sanjika, fwilili	chambo, kambuzi, mlamba, sanjika, fwilili	chambo, kambuzi, mlamba, mpasa
Deep Areas	usipa, chambo, utaka, kambuzi, mlamba, jamison, bombe, kampango,mcheni	usipa, jamison, nkholokolo, utaka, chambo, bombe, kampango, chisawasawa	usipa, mlamba, jamison, bombe, chambo, kampango, bombe	Yes	kampango, jamison	usipa, utaka, fwilili	chambo, kambuzi, usipa, mlamba, jamison, sanjika	chambo, kambuzi, mlamba, utaka, mpasa, tsungwa,
Shallow Areas	chambo, utaka, kambuzi, mlamba, tsungwa, fwilili	kambuzi, mlamba, chambo, nkhalala, fwilili	kambuzi, mlamba, chambo, nkhalala, fwilili	Yes	chambo, utaka, kambuzi, mlamba, jamison, mpasa	chambo, utaka, kambuzi, mlamba, jamison	chambo, kambuzi, mlamba, utaka, jamison	kambuzi, chambo, mlamba, fwilili, ningwi, tsungwa, kamchimanga, kam'mawere, fisi,
Rocky Areas	mbuna, utaka, jamison, bombe, usipa, kampango, nkunga	mbuna, utaka, jamison, bombe, usipa, kampango, nkunga	mbuna, utaka, jamison, bombe, usipa, kampango, nkunga	No	kambuzi, mlamba, mbuna, bombe	utaka, kambuzi, mlamba, jamison, mbuna, usipa, chisawasawa	usipa, chambo, utaka, kambuzi, jamison, chisawasawa	chambo, utaka, kambuzi, mlamba, jamison, bombe, nkholokolo, usipa, kampango, mbuna
Middle of the lake	usipa, chambo, utaka, kambuzi, mlamba, jamison, bombe	usipa, chambo, utaka, kambuzi, mlamba, jamison, bombe	usipa, chambo, utaka, kambuzi, mlamba, jamison, bombe	No	usipa, utaka, kambuzi, utaka, chambo,	usipa, utaka, chambo, kambuzi, mlamba, jamison, chisawasawa	usipa, chambo, utaka, kambuzi, mlamba, jamison, fwilili, chisawasawa	usipa, chambo, utaka, kambuzi, mlamba, jamison, bombe, utaka, mpasa, tsungwa, kampango

Table B.5.2. The community of Malembo identified the threats to their community related to fisheries and explained how the community responds, and what constitute good practices to counteract the threats.

Threats (Malembo)
Illegal Fish Used *(Mosquito Nets, Kandwindwi, nkacha, ngongongo)* *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Chief allow the use of illegal gears and BVC do not have the authority to control/ban the use of these gears. ▪ These gears are used to increase fish catch. People lack of adequate cash leading to fishing as a sole source money. ▪ Political interference. Government leaders change, the rules also change and gears that were previously regarded as illegal are made legal by the new leaders. *Community's response to threat* ▪ Chase trawler owners that are breaking the regulations on their license using their own boats. *Perceived Strength and Good Practices* ▪ Use of recommended gears. They work together with the fisheries extension officer ▪ Gear restriction (have bylaws prohibiting the use of illegal gears), mesh size restriction. *Perceived Weaknesses* ▪ BVC lack authority over fishery especially when dealing with trawler owners. ▪ Instability of fisheries rules and regulations. ▪ Corruption among fishers, chiefs and fisheries officials *Perceived Avenues for the Project to Intervene* ▪ More resources for patrol. The BVC could be more effective with enforcement if given uniforms, identification and torches. BVCs should be fully empowered. They need police to accompany them during patrols. ▪ BVC trainings to be done regularly (capacity building).
Trawlers *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ To catch both juveniles and adult fish due to use of un-recommended (small) mesh size. *Community's response to threat* ▪ Community to check license of trawler owners to make sure they are fishing in the right areas. *Perceived Strength and Good Practices* ▪ Verify license of trawler owners to make sure they are fishing in the right areas. ▪ Chasing law violators away as a group. *Perceived Weaknesses*

- Trawlers do not follow recommended time. They start fishing early and finish very late. Trawlers do not observe their landing areas hence officers cannot check what type of fish and amount has been caught.

Perceived Avenues for the Project to Intervene

- They want the community to be involved in issuing licenses to trawler owners. Trainings together with BVC and trawler owners around their community.
- Need for boat and engine and provision of a detector that will help catch trawlers that are fishing in waters that are not recommended for trawlers.
- BVCs to be involved in making rules and regulations.

Climate Change

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- Hunger and poverty.
- Deforestation to make charcoal for money has led to change of water levels and sedimentation due to careless cutting down of trees.

Community's response to threat

- Community is planting trees in groups along river banks. They are planting trees around Chilale river and on their own farm lands.
- They have started Irrigation to find different sources of income.

Perceived Strength and Good Practices

- Planting trees in groups along river banks, Dowa as an example. Follow up every month to make sure trees are not harvested.
- Not cultivate along the river banks, community acceptance of environmental conservation.

Perceived Weaknesses

- Cutting down of trees carelessly. Poor management of forest.
- Increase in population growth leads to clearing of forests to create new settlement areas. Misconception of democracy (they destroy vegetation in belief that they have the right to do so)

Perceived Avenues for the Project to Intervene

- Training/education on climate change issues and how to adapt.
- Soft loans to start small businesses to avoid cutting down trees for money.
- Equipment to help in management of forest and seedling. Capacity building on democracy, entrepreneurship, forestry management. Need more forest extension workers.

Aquatic Vegetation

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- Cutting of vegetation to use for fencing.
- Sedimentation is choking the vegetation (getting buried). Sedimentation is caused by deforestation. Trawlers are also destroying vegetation.

Community's response to threat

- Reforestation in their lands to reduce soil erosion and sedimentation.
- Planting trees and grass along the Chilale river.

Perceived Strength and Good Practices

- Reforestation. Successful planting of trees and vegetation in their farm lands and along river banks.

Perceived Weaknesses

- Lack of resources i.e tree seeds, water canes. Lack of authority to stop illegal fishing.

Perceived Avenues for the Project to Intervene

- Formation of bylaws to prevent/ban use of illegal gears.
- Need seedling, equipment (water-canes for irrigating nursery).

Table B.5.3. The community of Malembo identified the drivers to the threats to their community related to fisheries and explained the reasons behind the drivers, how the community responds, and what constitute good practices to counteract the drivers of the threats.

Drivers (Malembo)
Population Growth *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Ignoring family planning and having early marriages. ▪ Less activities and entertainment, jobs which leads to high reproduction rate. These lead to high pressure on fishery. ▪ A lot of children venture into fishing at an early stage and the money they get attract girls leading premarital sex and early pregnancies. *Community's response to threat* ▪ Discuss family planning and health. *Perceived Strength and Good Practices* ▪ Forcing children to go to school. They are chasing the children around the lake. ▪ Family planning. *Perceived Weaknesses* ▪ Absence of family planning. ▪ Upgrading of small and legal gears to catch more fish in the middle of the lake to meet there family needs (use small mesh). *Perceived Avenues for the Project to Intervene* ▪ Trainings the community on family planning. Introduction of child quota system (2-3). ▪ Promoting the abolition of early marriages (18-above should be the recommended age).
Climate Change *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Hunger, lack of money, poverty. ▪ Deforestation leads to changes of water level and sedimentation due to careless cutting down of trees. *Community's response to threat* ▪ Planting trees in groups along river banks. Follow up every month to make sure trees are not harvested. Irrigation to find different sources of income. *Perceived Strength and Good Practices* ▪ Reforestation. Follow up every month to make sure trees are not harvested. *Perceived Weaknesses* ▪ Cutting down of trees carelessly. Poor management of forest. ▪ An increase in population growth leads to clearing of forests to create new settlement areas. Misconception of democracy (destroying vegetation believing they have the right

to do so).

Perceived Avenues for the Project to Intervene

- Training/education on climate change issues and how to adapt.
- Soft loans to start small businesses to avoid cutting down trees for money.
- Equipment to help in management of forest and seedling.
- Capacity building on democracy, entrepreneurship, forestry management. They also need more forest extension workers.

Market Forces

Affected Fish Species

- All species

Communities Perceptions on the reasons behind the threat

- High demand of fish due to high population growth. Overfishing to meet the demand.
- Business losses due to difference in prices of purchasing fish and selling fish.

Community's response to threat / Perceived Strength and Good Practices

- Nothing. This is too difficult to tackle.

Perceived Weaknesses

- Business losses

Perceived Avenues for the Project to Intervene

- Need for cold rooms, warehouses dryers for preservation of fish.
- Need training on new preservation of fish and value addition.

Water Hyacinth

Affected Fish Species

- All species

Communities Perceptions on the reasons behind the threat

- Nothing

Community's response to threat / Perceived Strength and Good Practices

- Physical removal of water hyacinth when they are closer to the beach

Perceived Weaknesses

- Water hyacinth harbor crocodiles, hence at times their physical removal is difficult.

Perceived Avenues for the Project to Intervene

- Water hyacinth control program to return. Introduce pest that feed on water hyacinth.

Poor Education / Illiteracy

Affected Fish Species

- All species

Communities Perceptions on the reasons behind the threat

- Children do not go to school. There is lack of school feeding program, this use to motivate them.

Community's response to threat

- Chase children along the gate

Perceived Strength and Good Practices

- The forming of groups that chase children along the lake.

Perceived Weaknesses

- Existing video rooms that attract children and reduce their interest in school.
- Cheap restaurants that children can afford hence if parents try to punish the child(when they don’t go to school) by not feeding them they can easily go out and buy some at the restaurant.
- Absence of adult literacy classes. Child labor (parents give children work to do hence barring them from going to school.

Perceived Avenues for the Project to Intervene

- Introduce adult literacy school. Introduce school feeding program to motivate children to go to school. Strong bylaws on child education. Gear owners should be civic educated on child labor.

Mambo (Ft. Maguire) Community: Data Fish Biodiversity

Table B.6.1. Fish Biodiversity reported in Lake Malawi by the community of Mambo. Around 19 species were reported to be harvested in the last 12 months. The most abundant according to focus group 1 are: usipa (1st), utaka (2nd), jamison(3rd), mcheni (4th), kambuzi (5th), chambo (6th). And focus group 2 listed: usipa (1st), jamison (2nd), utaka (3rd). The preferred habitat for breeding, nursing and feeding were further refined during the PRA second visit.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	chambo, mlamba, fwilili, dondolo	chambo, fwilili, mlamba, dondolo	chambo, fwilili, mlamba, dondolo	No	chambo, mlamba, fwilili	chambo, mlamba, fwilili	chambo, mlamba, fwilili	chambo, mcheni, bombe, kampango
EAV	mlamba, fwilili, dondolo, chambo	fwilili, dondolo, mlamba	fwilili, dondolo, mlamba	No	dondolo, fwilili, chambo, mpasa, mlamba	dondolo, fwilili, chambo, mpasa, mlamba, mbaba	dondolo, fwilili, chambo, mpasa, mlamba	chambo, fwilili, mpasa, mlamba
River inlets/outlets	chambo, gong'o, mpasa, sanjika, nkholokolo, mbunungu	mpasa, sanjika, mbunungu, chambo, ntchira, nkholokolo, matemba, gong'o	mpasa, sanjika, mbunungu, chambo, ntchira, nkholokolo, matemba, gong'o	Yes	chambo, mpasa, sanjika	Ntchira, mpasa, sanjika	fwilili, ntchira, sanjika, mbunungu	mpasa, mbunungu, ntchira
Deep Areas	usipa, jamison, kampango, bombe, mpasa, nkholokolo, mbaba, mcheni	kampango, mpasa, usipa, jamison, bombe, nkholokolo, mcheni	kampango, mpasa, usipa, jamison, bombe, nkholokolo, mcheni	Yes	usipa, kampango, nkholokolo	Usipa, kampango, mbaba, nkholokolo	usipa, utaka, kampango	mcheni, bombe, kampango
Shallow Areas	usipa, utaka, kampango, gong'o, mpasa, kadyakoro	usipa, ntchira, kambuzi, utaka, chambo, gong'o, nkholokolo	usipa, ntchira, kambuzi, utaka, chambo, gong'o, nkholokolo	Yes	Usipa, chambo, utaka, gong'o	usipa, chambo, utaka, gong'o	usipa, chambo, utaka, mbaba, gong'o	mcheni, mpasa, kampango
Rocky Areas	bluefish, kampango, bombe, mcheni, mbuna	kampango, bluefish, bombe, solomon fish, mbunungu, mbuna	kampango, bluefish, bombe, solomon fish, mbunungu, mbuna	Yes	chambo, mbuna, solomon fish, bombe	solomon fish, blue fish, mbuna	mlamba, mbuna, kampango, solomon fish	chambo, solomon fish, bombe, kampango
Middle of the lake	usipa, chambo, utaka, jamison, kampango, bombe, mbaba	utaka, usipa, chambo, mpasa, ntchira.	utaka, usipa, kanjenga, chambo, mpasa, ntchira	Yes	Utaka, mcheni, kampango, bombe	utaka, mbaba, jamison, usipa, kampango,	usipa, chambo, utaka, mbaba, mcheni, nkholokolo	usipa, bombe, mpasa, mbaba

Table B.6.2. Threats Mambo

Threats (Mambo)

Illegal Fish Gear Used *(Nkacha, ngongongo, mosquito net)*

Affected Fish Species

- All species

Communities Perceptions on the reasons behind the threat

- Poverty makes fishing a very good source of income hence use of illegal gears to catch as many fish as possible

Community's response to threat

- Restricting all illegal gear users and confiscating the illegal gears. Punishing anyone caught using illegal gears (although it is difficult to punish migrant fishermen) by the Chief bringing charges against them.

Perceived Strength and Good Practices

- Having restricting the use of illegal gears and punishing anyone caught using illegal gears
- Confiscating illegal gears and punishing the user

Perceived Avenues for the Project to Intervene

- Awareness workshops on the dangers of using illegal gear.
- Collaborate with DoF in establishing rules that will restrict the number of fishermen allowed to operate in one fishery so that entry to the fishery is limited. Loans to pay police officers that will help in chasing illegal gear users and uniforms.

Illegal Fishing practices (*Use of flood lights to catch fish)*

Affected Fish Species

- All species

Communities Perceptions on the reasons behind the threat

- Lack of fish is prompting them to engage in illegal fishing practices to catch more fish. The light attracts the fish, and when the fish congregates and surround the boat they throw the net.

Community's response to threat / Perceived Strength and Good Practices

- None.

Perceived Weaknesses

- The Chief do not know that the use of flood lights is destructive so that he can ban them.

Perceived Avenues for the Project to Intervene

- Train and teach chiefs on illegal gears so that they can be able to ban them.

Lake water level changes *(water level has changed in past 5 years)*

Affected Fish Species

- Chambo, fwilili, mbaba, usipa

Communities Perceptions on the reasons behind the threat

- Climate change; low rainfall due to deforestation

Community's response to threat / Perceived Strength and Good Practices

- Nothing.

Perceived Weaknesses

- Deforestation, lack of coordination among the villagers

Perceived Avenues for the Project to Intervene

- Seedlings and nurseries as well as training on forestry and environmental management

Table B.6.3. Drivers and contributing factors in Mambo

Drivers (Mambo)
Population Growth (*Higher birth rates/family sizes: 5 to 15 children.)* *Affected Fish Species* ▪ All species but mostly usipa because it is the species in highest abundance now. *Communities Perceptions on the reasons behind the threat* ▪ Lack of family planning; lack of entertainment and other activities. ▪ Early marriages, additionally, there was a government program that brought people from other districts to their village *Community's response to threat* ▪ They are advising each other on family planning and now there is a health extension worker teaching them more about family planning (World Vision, government hospital). *Perceived Strength and Good Practices* ▪ They are advising each other on family planning and now have a health extension worker that is teaching them about family planning. *Perceived Weaknesses* ▪ They think family planning reduces libido and causes diseases like cancer. Only women are practicing as men do not use condoms. ▪ Children misunderstand the concept of democracy and think they can do whatever they want which encourages early marriages. *Perceived Avenues for the Project to Intervene* ▪ Teach them more about family planning. Help enforce the laws on early marriages. ▪ Loans to strengthen already existing businesses and act as capital for those that do not have businesses so that they can be occupied and reduce reproduction. Encourage education for both children and adults to help in early marriages as well as creating awareness on democracy.
Climate Change *(Heavy and low rainfall)* *Affected Fish Species* ▪ All species: the fish are migrating to deeper waters. *Communities Perceptions on the reasons behind the threat* ▪ Unusual strong winds that destroy habitats. ▪ Pollution from factories, deforestation contributing to inadequate rains and fish feed. *Community's response to threat* ▪ Afforestation (mostly school children) in homes and schools. ▪ Construction of an irrigation scheme with assistance from the Government. *Perceived Strength and Good Practices* ▪ They do not see individual tree planting as community strength. *Perceived Weaknesses* ▪ Lack of community coordination and extension, high population growth rates leading to greater rates of deforestation, and ignoring the rules that protect the forests. *Perceived Avenues for the Project to Intervene*

- Encourage tree planting program. Establishment of VNRC. Enforcement of rules and regulations.

Market Forces

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- Increase in fish traders so there has been an increase in fishing to meet the demand. Nothing. This is too difficult to tackle.

Community's response to threat

- More intensive fishing to meet demand.

Perceived Strength and Good Practices

- Preservation of fish by drying and smoking (as value addition)

Perceived Weaknesses

- Instability of fish prices at the markets and beaches

Perceived Avenues for the Project to Intervene

- Provision of loans for small scale businesses.
- Need for ice making machine to preserve fish when the prices are low, and then sell it another day for a greater profit.

Lack of Alternative Livelihoods

(Currently only farming maize and cassava to ease pressure on the fishery)

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- High population growth leads to less land for farming.
- Illiteracy also limits alternatives.

Community's response to threat

- The community is engaged in farming (maize and cassava) and doing some small businesses.

Perceived Strength and Good Practices

- Farming and small businesses.

Perceived Weaknesses

- Lack of capital for businesses.

Perceived Avenues for the Project to Intervene

- Loans for businesses and training on entrepreneurship.
- Help in the creation of clear markets so that they can sell and buy fish at a good price.

Namgoma Community: Data Fish Biodiversity

Table B.7.1. Fish Biodiversity reported in Lake Malawi by the community of Namgoma. A total of 13 species were reported to be harvested in the last 12 months. The most abundant according to focus group 1 are: Utaka (1st), usipa (2nd), jamison (3rd) and chambo (4th). The other species harvested were: Kampango, mpasa, kambuzi, nkholokolo, ntchira, mphuta, mababa, matemba, Nkhalala.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	Chambo, silibanga	Chambo, fukufuku, fusili	Chambo, kampango, fukut	Yes	Chambo, kampango, mpasa, mbaba, mlamba	Chambo, utaka, kampango, mlamba, jamison	Chambo, utaka, kampango, mlamba, jamison	Chambo, kampango, mlamba
EAV	Chiyendamwamba , silibanga	Silibanga, kadyba, nkhalala, chiyendamwamba	Silibanga, kadyb, nkhalala	Yes	Chambo, kampango, mbaba, mlamba, gong'o	None	Utaka, kampango, mlamba, jamison	Chambo, kampango, mlamba
River inlets/outlets	Chambo, mpasa, mlamba, ntchila, sanjika	Chambo, mpasa, ntchila, fwili, sanjika, mcheni	Chambo, mpasa, ntchila, sanjika	Yes	Chambo, kampango, mpasa, ntchila, mlamba, sanjika	Chambo, kampango, mpasa, ntchila, mlamba, sanjika	Chambo, kampango, mpasa, mlamba, sanjika	Chambo, kampango, mlamba, jamison
Deep Areas	Chambo, usipa, utaka, mlamba, jamison, chisale, mcheni, bombe	Chambo, usipa, utaka, mpasa, kampango, mlamba, chisale, mcheni, jamison	Kampango, mlamba, bombe, mcheni	Yes	usipa, utaka, kampango, mlamba, jamison	Chambo, usipa, utaka, kampango, mpasa, mlamba, jamison, mbuna	Chambo, usipa, utaka, kampango, mlamba, sanjika, jamison	Chambo, usipa, utaka, kampango, mlamba, jamison
Rocky Areas	Kampango, nkahalala, fukufuku, fwili, Mayani/blue fish, nkholokolo, mlamba	Mbuna, nkholokolo, kampango, mlamba, fukufuku	Utaka, mbuna, mlamba	Yes	usipa, utaka, kampango, mlamba, jamison, mbuna	Utaka, kampango, mlamba, jamison	Mlamba, mbuna	Chambo, kampango, mlamba, mbuna
Shallow Areas	Nkhalala, fukufuku, fwili, matemba, gong'o	Kampango, matemba, gong'o, mlamba, fukufuku, nkhalala	Chambo, usipa, matemba, mlamba, gong'o	Yes	Chambo usipa, utaka, kampango, matemba, mlamba, jamison, mbuna	Usipa, utaka, kampango, mlamba, jamison	Chambo, usipa, utaka, kampango, mlamba, jamison	Chambo, usipa, utaka, kampango, mlamba, jamison
Middle of the lake	Matemba, gong'o	Usipa, gong'o, matemba, nkhalala, gunda	Kampango, matemba, gong'o	Yes	utaka, usipa	Chambo, usipa, utaka, kampango, mlamba, jamison	Chambo, usipa, utaka, kampango, mlamba, jamison	Chambo, usipa, kampango, mlamba, jamison

Table B.7.2. Threats in Namgoma.

Threats (Namgoma)
Illegal gear *(Nkacha, mosquito nets, and ngongongo used by migratory fishermen and local fishers)* *Affected Fish Species* ▪ Chambo, utaka, kampango, mlamba and jamison. *Communities Perceptions on the reasons behind the threat* ▪ Lack of enforcement, no alternative livelihoods, poverty and weak BVCs. *Community's response to threat* ▪ Community tries to ineffectively chase illegal fishers away. *Perceived Strength and Good Practices* ▪ Working together; community has removed water hyacinth to help the matemba stocks recover. They have also engaged in good management practices that have led to fish recovery and they have engaged in fish farming activities. *Perceived Weaknesses* ▪ The community does not comply. *Perceived Avenues for the Project to Intervene* ▪ Need for identity cards, uniforms, boat and engine. ▪ The community believes that closed seasons and gear restrictions (to prevent the use of illegal gear) are the best ways to manage the fishery. They would like assistance in strengthening the BVCs to allow them to work effectively. ▪ The community members would like training in fisheries management and help to work with the Chiefs in order that all migrants report to the BVC. The BVCs should be empowered so that they can inspect trawlers. The Government should make sure that commercial fishers respect fisheries regulations.
Trawlers *Affected Fish Species* ▪ Chambo, utaka, kambuzi, mlamba, jamison, kampango, mcheni, mayani sawasawa, and mbaba. *Communities Perceptions on the reasons behind the threat* ▪ The trawlers are fishing in areas where they are not supposed to fish. They are operating within the shore and outside their allotted fishing times of 5:30 a.m. to 4:30 p.m. They are using under-meshed codends as well as under-meshed nets and are catching small and young fish. ▪ The trawlers feel superior and will not respect the authority of the BVCs. The fisheries trawler Ndunduma is also trawling in non-designated areas and catching very small fish. *Community's response to threat* ▪ The BVCs are trying to check licenses, but the trawl-net owners do not recognize them as they do not have uniforms and IDs. *Perceived Strength and Good Practices / Perceived Weaknesses* ▪ None mentioned. *Perceived Avenues for the Project to Intervene* ▪ They need the Government and/or the Project to provide uniforms, IDs, and help to

empower the BVCs so that the trawlers will respect them. Help enforce the regulations placed on the trawlers.

- Bring the commercial fishers and artisanal fishers together to bridge the gap between the two entities and help them understand what the specific regulations are for each type of fishery.

Table B.7.3. Drivers and contributing factors in Namgoma.

Drivers (Namgoma)
Population Growth *(Higher birth rates and large family sizes)* *Affected Fish Species* ▪ Species not identified. *Communities Perceptions on the reasons behind the threat* ▪ Increased fishing effort. *Community's response to threat* ▪ No response to date. Community *Perceived Strength and Good Practices* ▪ Contraceptives are being used by few women. The people believe that prolonged bleeding and that contraceptives can cause bareness in women *Perceived Weaknesses* ▪ Men do not take part in family planning. *Perceived Avenues for the Project to Intervene* ▪ Civic education on family planning.
Climate Change *Affected Fish Species* ▪ Usipa, chambo, utaka, kampango, mlamba, jamison, mbuna *Communities Perceptions on the reasons behind the threat* ▪ Deforestation, population growth, lack of employment, emissions from factories (e.g., Njereza cement factory). *Community's response to threat* ▪ No response to date. Community *Perceived Strength and Good Practices/ Perceived Weaknesses* ▪ No responses *Perceived Avenues for the Project to Intervene* ▪ Small loans, job creation, provision of drought tolerant crops, seedlings, irrigation farming and training in land resource management.

Njerenje (Makanjira) Community: Data Fish Biodiversity

Table B.8.1. Fish Biodiversity reported in Lake Malawi by the community of Njerenje. Around 18 species were reported to be harvested in the last 12 months. Focus group one mentioned the most abundant being: Chimbenje (1st), utaka (2nd), mankonko (3rd), mbaba (4th), usipa (5th); and the focus group 2 mentioned: usipa (1st), utaka (2nd) and kambuzi (3rd), among the others.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	chambo, utaka, sanjika, mlamba, mpasa, mbaba, mankoko	chambo, utaka, sanjika, mlamba, mpasa, mbaba, mankoko	chambo, utaka, sanjika, mlamba, mpasa, mbaba, mankoko	No	Chambo, mlamba, sanjika, mpasa, makumba, chiyendamwamba, dondolo, chimbulungu	Chambo, mlamba, sanjika, mpasa, makumba, chiyendamwamba, dondolo, chimbulungu	Chambo, mlamba, sanjika, mpasa, makumba, chiyendamwamba, dondolo, chimbulungu	Kampango, bombe, chambo, chimbunungu, kadyakoro
EAV	chambo, mlamba, mpasa, sanjika	mlamba, chambo, mpasa, Mcheni	mlamba, chambo, samwamowa, makumba, sanjika, matemba, mpasa,	Yes	chambo, utaka, kambuzi, jamison	chambo, mlamba, kambuzi, jamison	matemba, utaka, mbaba, mankoko, makumba, dondolo, kambuzi	Kampango, bombe, chambo, chimbunungu
Rocky Areas	usipa, utaka, kambuzi, mbuna, chimbenje, bombe, mcheni, mbaba	utaka, usipa, mbuna, mbaba, kampango, blue fish	utaka, usipa, mbuna, mbaba, kampango, blue fish	Yes	usipa, mlamba, jamison, mcheni, mbuna	kambuzi, mlamba, jamison, mbuna, mcheni	utaka, mlamba, jamison, kampango, mbuna	usipa, chambo, kampango, mbuna
River inlets/outlets	usipa, chambo, utaka, mlamba, jamison, mpasa, sanjika, matemba, makumba	chambo, utaka, jamison, sanjika, matemba, mpasa, mcheni, nkholokolo	chambo, utaka, sanjika, matemba, mpasa	Yes	usipa, chambo, mlamba, mpasa, sanjika, matemba, likudyu	chambo, ntchira, mpasa, sanjika, makumba	usipa, chambo, utaka, mlamba, matemba, ntchira, sanjika, mpasa, makumba, mbaba	Chambo, kampango, mlamba, mpasa, sanjika, chilenje
Deep Areas	usipa, utaka, mlamba, jamison, mpasa, sanjika, matemba, makumba, chimbenje, bombe, mcheni, mlamba, nkholokolo	usipa, utaka, mlamba, jamison, mpasa, sanjika, matemba, makumba, chimbenje, bombe, mcheni, nkholokolo,	usipa, utaka, mlamba, jamison, mpasa, sanjika, matemba, makumba, chimbenje, bombe, mcheni, mlamba, nkholokolo	No	Usipa, jamison, kampango, samwamowa, bombe, chisawasawa	utaka, kambuzi, mlamba, jamison	usipa, chambo, utaka, kampango, mlamba, jamison, bombe, mcheni, nkholokolo	usipa, kampango, bombe, sanjika, nkholokolo
Shallow Areas	usipa, chambo, utaka, mpasa, nkholokolo, makumba	utaka, makumba, matemba, mpasa, usipa, chambo, mbaba	utaka, makumba, matemba, sanjika, mpasa, usipa, chambo, mbaba	Yes	usipa, chambo, mlamba, chimbenji, mbaba	chambo, utaka, mlamba	usipa, chambo, mlamba, matemba, sanjika, mpasa, makumba, mcheni	usipa, bombe, kampango, mlamba,, mcheni, chilenje, dondolo
Middle of the lake	usipa, chambo, kambuzi, mlamba, utaka, mankoko, makumba, mcheni, mbaba	usipa, chambo, kambuzi, mlamba, utaka, mankoko, makumba, mcheni, mbaba, mpasa	usipa, chambo, kambuzi, mlamba, utaka, mankoko, makumba, mcheni, mbaba, mpasa, sanjika	Yes	bombe, nkholokolo, jamison, utaka, chigonthi	Chigonthi, utaka, usipa, bombe, kampango, chambo	usipa, chambo, utaka, kampango, mlamba, jamison, mbuna, matemba	usipa, kampango, bombe, mcheni

Table B.8.2. The community of Njerenje identified the threats to their community related to fisheries and explained how the community responds, and what constitute good practices to counteract the threats.

Threats (Njerenje)
Illegal Gears *(kandwindwi, ngongongo, wogo, and mosquito nets)* *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Poverty. Scarcity of fish. Ability to catch a lot of fish with the illegal gear. ▪ Climate change. *Community's response to threat* ▪ Catching the illegal gear users and taking them to the chief. (Not successful: locals fear for their lives because the illegal gear owners threaten them.) Community *Perceived Strength and Good Practices* ▪ They catch them and are taken to the chief two fines them either 1 goat or more/chickens. ▪ They go out together as a group to confront the illegal gear users *Perceived Weaknesses* ▪ Their BVC is not officially inducted by the DoF. The gear restrictions rules are ineffective and the BVC members fear being hurt or killed when confronting the illegal gear owners about the gear. *Perceived Avenues for the Project to Intervene* ▪ Provision of ID cards, bikes, raincoats, life jackets, gumboots (rain boots), a boat and engine. ▪ Adequate funding to help them improve their enforcement capabilities.
Habitat Destruction (EAVs, SAVs) *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Poverty: they cut EAVs and SAVs to make mats to sell. They also use the vegetation to construct 'hatched' roofs. *Community's response to threat* ▪ Nothing because when they confront anyone who is cutting the aquatic vegetation they are told that they do not have the right to do so because they do not own the aquatic vegetation. ▪ They are also told that if they stop them from cutting the vegetation that the BVC should then provide them with food because the EAVs and SAVs are source of money. Community *Perceived Strength and Good Practices* ▪ No response. *Perceived Weaknesses* ▪ Destruction of vegetation for money and clearing areas for settlement, fear of being hurt. *Perceived Avenues for the Project to Intervene* ▪ Assist in empowering the BVCs and provide awareness on how to protect the aquatic vegetation from further destruction/loss.

Table B.8.3. The community of Njerenje identified the drivers to the threats to their community related to fisheries and explained the reasons behind the drivers, how the community responds, and what constitute good practices to counteract the drivers of the threats.

Drivers (Njerenje)
Population Growth *(Higher birth rates and family sizes)* *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Lack of family planning. ▪ Poverty also plays a role. *Community's response to threat* ▪ Family planning is being practiced by some community members. Community *Perceived Strength and Good Practices* ▪ Some people have started practicing family planning. *Perceived Weaknesses* ▪ None mentioned. *Perceived Avenues for the Project to Intervene* ▪ Awareness program on family planning (promoting the importance on the use of condoms).
Climate Change *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ An increase in population is leading to the clearing of forests to create areas for cultivation. ▪ Strong winds (attributed to climate change) are making things more difficult. *Community's response to threat* ▪ Farming and continuing to try to fish. *Community Perceived Strength and Good Practices* ▪ Protecting the remaining trees that still remain along the Luweza River. ▪ Starting afforestation and planting grass to replace the trees that have been cut. *Perceived Weaknesses* ▪ Lack of seedlings and a nursery. *Perceived Avenues for the Project to Intervene* ▪ The forestry extension workers are inactive and there is a paucity of programs and projects to help support their efforts. ▪ Need for tree seedlings and training on how to plant and take care of the seedlings. ▪ Training on forest and environmental management.

Migration

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- Fishermen coming into their areas without authorization.

Community's response to threat

- They report the migratory fishermen to the chief who chases them away as the chief is the one empowered to deal with them.

Community Perceived Strength and Good Practices

- Chasing migrants away. Acting together as a group.

Perceived Weaknesses

- The chief is the one responsible and BVC members have no say.

Perceived Avenues for the Project to Intervene

- Educating the BVC on the importance of licensing. Project can work with the DoF in making sure that the BVCs are involved in licensing.

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Appendix C – Lake Malombe

Chisumbi Community: Data Fish Biodiversity

Table C.1.1. Fish Biodiversity reported in Lake Malombe by the community of Chisumbi. A total: 10 species were reported to be harvested in the last 12 months. The most abundant according to focus group 1 are: Kampango (1st), usipa (2nd), usiliwa (3rd), mbaba (4th). The other species harvested were: Chambo, utaka, mlamba, silibanga, adondolo, and ntchira.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	Usipa, chambo, kampango, mlamba, silibanga, adondolo, mpasa	Usipa, chambo, kampango, mlamba	Usipa, chambo, kampango, mlamba, silibanga, adondolo	Yes	chambo, mlamba, mpasa, ningwi	chambo, mlamba, matemba	Usipa, chambo, kampango, mlamba, ntchira, ningwi	
EAV	Usipa, chambo, kampango, mlamba	Usipa, chambo, kampango, mlamba, silibanga, adondolo	Usipa, chambo, kampango, mlamba,	Yes	Usipa, chambo, mlamba, matemba	chambo, mlamba, matemba	None	
River inlets/outlets	kampango, mlamba, ntchira, khalara	kampango, mlamba, ntchira, khalara	kampango, mlamba, ntchira, khalara	Yes	chambo, mlamba, ntchira	mlamba	None	Usipa, chambo, kampango, mlamba, silibanga, adondolo, usiliwa, ntchira, mbaba
Deep Areas	Usipa, chambo, kampango, mlamba	Usipa, chambo, kampango, mlamba	Usipa, chambo, kampango, mlamba	No	Usipa, ntchira	None	Kambuzi	
Rocky Areas	None	None	None	None	None	None	Kambuzi	None
Shallow Areas	Chambo, kampango, mlamba, khalara, sapuwa	chambo, kampango, mlamba, khalara, sapuwa	chambo, kampango, mlamba, khalara, sapuwa	No	usipa	Usipa, chambo, mlamba,	chambo, mlamba, matemba, kambuzi	
Middle of the lake	Usipa, chambo, kampango, mlamba, sapuwa	Usipa, chambo, kampango, mlamba, sapuwa	Usipa, chambo, kampango, mlamba, sapuwa	No	none	mlamba, usiwila, ningwi	chambo, kampango, mlamba, ntchira	

Table C.1.2. Threats in Chisumbi.

Threats (Chisumbi)
Non compliance to Fisheries regulations *Affected Fish Species* ▪ Chambo, kambuzi, mlamba, and mbaba. *Communities Perceptions on the reasons behind the threat* ▪ Mesh size limits are not being followed. *Community's response to threat* ▪ Yes [Not described] *Community Perceived Strength and Good Practices* ▪ After noting the depletion of fish species, a few people came together to mobilize themselves and they chased away migrant fishermen. *Perceived Weaknesses* ▪ Lack of collaboration in the past. People tend to be selfish. *Perceived Avenues for the Project to Intervene* ▪ Provision of uniforms, ID cards, whistles, life jackets, and a patrol boat with an engine.
Illegal gear *(i.e., kandwindwi, mosquito nets, nkacha w/small bunt used during the night by members of the local community)* *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat / Perceived Weaknesses* ▪ No response. *Community's response to threat* ▪ Yes [Not described]. *Community Perceived Strength and Good Practices* ▪ They confiscate the gear and place charges on the illegal fishers; then these fishers are tried by the community. ▪ After noting the depletion of fish species, a few people came together to mobilize themselves and they chased away migrant fishermen. *Perceived Avenues for the Project to Intervene* ▪ Training in fishing and allowances for the BVCs. ▪ Creating closed areas, and silent police to help them manage their patrol activities.
Loss of habitat SAV & EAV *Affected Fish Species* ▪ Usipa, chambo, kambuzi and mlamba. *Communities Perceptions on the reasons behind the threat / Community's response to threat* ▪ No response. *Community Perceived Strength and Good Practices/ Perceived Weaknesses* ▪ None described. *Perceived Avenues for the Project to Intervene*

- Training BVCs to be empowered and trained on the additional roles of their members, which includes the protection of SAV and EAV.

Destruction of riverine habitat

Affected Fish Species
- All species.

Communities Perceptions on the reasons behind the threat
- No response.

Community's response to threat
- No response by the community to stop deforestation.

Community Perceived Strength and Good Practices
- A group has been formed for reforestation activities

Perceived Weaknesses
- They tried planning indigenous trees along the rivers in the past, but the program was not successful due to poor management

Perceived Avenues for the Project to Intervene
- Provide seedlings to assist with reforestation efforts

Bad farming practices leading to sedimentation

Affected Fish Species
- All species.

Communities Perceptions on the reasons behind the threat
- The sedimentation destroys SAVs, breeding areas, and areas where juveniles seek shelter

Community's response to threat
- None described.

Community Perceived Strength and Good Practices
- None mentioned.

Perceived Weaknesses
- Lack of skills. Absence of an agriculture extension worker to help them learn good farming practices.

Perceived Avenues for the Project to Intervene
- Training on good farming practices and the provision of seedlings.

Table C.1.3. Drivers and contributing factors in Chisumbi.

Drivers (Chisumbi)
Climate Change *Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the threat* ▪ The species are reduced due to fluctuating and declining lake levels. The change in rainfall patterns has also caused food insecurity. *Community's response to threat* ▪ Yes [nothing outlined]. *Community's Perceived Strength and Good Practices* ▪ Practicing irrigation. *Perceived Weaknesses* ▪ None. *Perceived Avenues for the Project to Intervene* ▪ Help to mechanize their pumping system. Training on the planting and caring of trees.
Lack of alternative livelihoods *Affected Fish Species* ▪ All species. *Community's response to threat* ▪ Engaging in farming. *Community's Perceived Strength and Good Practices* ▪ Adding more value to the fish to earn more money. Engaging in farming and small-scale business. *Perceived Weaknesses* ▪ No response *Perceived Avenues for the Project to Intervene* ▪ Building a good road to connect to the main road (assumption: this will assist w/the fisheries value chain additions).
Poor Governance *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ No response. *Community's response to threat* ▪ No response. *Community's Perceived Strength and Good Practices* ▪ Having an active chairman. *Perceived Weaknesses* ▪ The other BVC members do not participate. They received allowances in the past, now

they complain and do not understand why they should work for the betterment of their community.

Perceived Avenues for the Project to Intervene

- Capacity building of BVC giving them ownership skills.

Likulungwa Community: Data Fish Biodiversity

Table C. 2.1. Fish Biodiversity reported in Lake Malombe by the community of Likulungwa. Around 14 species were reported to be harvested in the last 12 months. Focus group one mentioned the most abundant being: usipa (1st), kambuzi (2nd), mlamba (3rd), matemba (4th), nkholokolo (5th), silibaga (6th); and the focus group 2 mentioned: Usipa (1st), kambuzi (2nd), matemba (3rd), mlamba (4th), nkholokolo (5th), silibaga (6th). The other species harvested include mphuta, nkhalala kampango, chilenje, usiliwa, chambo, mbaba.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	nkhokolo, Mphuta, mlamba, matemba, nkhalala, nkholokolo, kampango, chilenje	chambo, mlamba, usiliwa, kambuzi	chambo, kambuzi, silibanga, mlamba, Utaka (from lake malawi)	Yes	kampango, mlamba	chambo, nkhalala	Kambuzi	nkhokolo, Mphuta, mlamba, matemba, nkhalala, nkholokolo, kampango, chilenje
EAV	Usipa, silibanga, kambuzi, mlamba, kampango, mphuta, usiliwa, nkhalala	Usipa, silibanga, kambuzi, mlamba, kampango, mphuta, usiliwa, nkhalala	chambo, kambuzi, mlamba, ntchira, kampango		kambuzi, mlamba, kampango, chambo, nkhalala, silibanga	kambuzi, mlamba, kampango, chambo, nkhalala, silibanga	kambuzi, mlamba, kampango, chambo, nkhalala, silibanga	Usipa, silibanga, kambuzi, mlamba, kampango, mphuta, usiliwa, nkhalala, makumba, nkholokolo, chambo
River inlets/outlets	kambuzi, mphuta, mlamba, nkhalala	kambuzi, mphuta, mlamba, nkhalara, sanjika, silibanga,	utaka, kambuzi, nkhalala, mlamba	No	mlamba, kampango, chambo	Mlamba	Kambuzi	mlamba,
Deep Areas	chambo, kambuzi, kampango, mbaba, mlamba	ntchira, kambuzi, chambo, mlamba	kambuzi, kampango, chambo, ntchira, mbamba, mlamba	Yes	None (too deep hence feed) gigh velocity can wash away eggs	kampango	Kambuzi, chambo	chambo, kampango, mlamba, kambuzi
Rocky Areas	Not rocky	Not rocky	Not rocky	Not rocky	Not rocky	Not rocky	Not rocky	Not rocky
Shallow Areas	usipa	kampango, mphuta, Nkhalara, matemba, nkholokolo, mlamba	Mphuta, kampango, matemba, nkholokolo, mlamba	yes	chambo, kampango, mlamba, kambuzi	chambo, kampango, mlamba, kambuzi	Kambuzi, mlamba, ntchira, kasawala	mlamba, makumba
Middle of the lake	chambo, kambuzi, kampango, mlamba	chambo, utaka (from lake malawi), kambuzi, kampango, mlamba, mbaba	chambo, utaka (from lake malawi), kambuzi, kampango, ntchira, mbaba, mlamba	yes	none	kampango, mlamba	Kambuzi, kapango, mlamba	kambuzi, kampango, chambo, mbaba

Table C.2.1. Threats in Likulungwa.

Threats (Likulungwa)
Climate Change *Affected Fish Species* ▪ Chambo, kambuzi, mlamba, and mbaba. *Communities Perceptions on the reasons behind the threat* ▪ Change in water level has affected breeding season of fish due to destruction of habitats and breeding grounds. ▪ The water levels have changed due to sedimentation caused by deforestation. Erratic rainfall is also causing change in water levels. *Community's response to threat* ▪ Are doing small scale irrigation to reduce pressure on fishery (they have started). *Community's Perceived Strength and Good Practices* ▪ Irrigation. *Perceived Weaknesses* ▪ They ignore conservation measures. *Perceived Avenues for the Project to Intervene* ▪ Assist in Reforestation is very much (seedlings, tools, i.e water canes, hoes).
Illegal gear *(Kandwidwi, mpelekeza, mosquito net)* *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Poverty, lack of awareness on Fisheries regulations; the use of small meshed gears to catch more fish. BVC does not know their role so they do not educate fishers. Do not have enough land to cultivate so they buy illegal gear (between lake and game reserve). *Community's response to threat* ▪ Licensing, enforcement. The community chases away migrant fishers that use illegal gears *Community's Perceived Strength and Good Practices* ▪ They confiscate the gear. Payments for license. Mesh size restrictions. *Perceived Weaknesses* ▪ Due to poverty, mesh size restriction is not followed so that they can catch more fish and make higher profits *Perceived Avenues for the Project to Intervene* ▪ Training in fishing and allowances for the BVCs. ▪ Need for identity badge, uniform, bicycles to help in lake monitoring.

Table C.2.3. Drivers and contributing factors in Likulungwa.

Drivers (Likulungwa)
Population Growth *Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the threat* ▪ Farm land is scarce due to high population hence rely on fishing and increasing pressure on fishery. Non compliance of family planning. Limited parental care leading to early marriages. Due to large families, children are not monitored and venture into fishing at an early stage *Community's response to threat* ▪ Family planning, some. *Community's Perceived Strength and Good Practices* ▪ Some members of the BVC have started family planning. *Perceived Weaknesses* ▪ Limited parental care that leads to early marriages and high population growth. ▪ Non compliance of family planning. They believe contraceptives have bad side effects. ▪ Men do not want wives to do family planning because they think they will not enjoy sex with a woman doing family planning. *Perceived Avenues for the Project to Intervene* ▪ Trainings of BVC, health center to increase awareness in family planning and its benefits. Need for boreholes for safe drinking water.
Climate Change *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Change in water level has affected breeding season of fish due to destruction of habitats and breeding grounds (the water levels have changed due to sedimentation caused by deforestation). Erratic rainfall is also causing change in water levels. *Community's response to threat* ▪ Some people have started to do small scale irrigation to reduce pressure on fishery. *Community's Perceived Strength and Good Practices* ▪ Irrigation schemes. *Perceived Weaknesses* ▪ People ignore conservation measures. *Perceived Avenues for the Project to Intervene* ▪ Assist in Reforestation is very much (seedlings, tools: water canes, hoes)

Food Insecurity *(i.e., kandwindwi, mosquito nets, nkacha w/small bunt used during the night by members of the local community)*

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- Lack of land for cultivation due high population growth. This leads to deforestation to create new farm lands and leads to soil erosion/Insufficient rainfall

Community's response to threat

- Practicing small scale irrigation and practicing intercropping.

Community's Perceived Strength and Good Practices

- Intercropping and irrigation practices.

Perceived Weaknesses

- They have small farm lands because the village is between a game reserve and the lake hence the population relies mostly on fishing

Perceived Avenues for the Project to Intervene

- Providing early maturity hybrid seeds, small loans to start IGAs.
- Provide food, there is hunger in the village. Provision of fertilizers for farm; and training on good farming practices.

Mwalija Community: Data Fish Biodiversity

Table C. 3.1. Fish Biodiversity reported in Lake Malombe by the community of Mwalija. Around 11 species were reported to be harvested in the last 12 months. Focus group one mentioned the most abundant being kambuzi (1st) chambo (2nd), mlamba (3rd), matemba (4th), usipa (5th); and the focus group 2 mentioned: kambuzi (1st), usipa (2nd), bluefish (3rd), and chambo (4th).

SAV	usipa, chambo, mlamba, usiliwa, bluefish and sanjika	usipa, chambo, mlamba, usiliwa, kampango, mpasa, sanjika	chambo, mlamba, kampango, kadyakoro, solomon fish	yes	solomon fish	chambo, kambuzi, mlamba, mcheni, khalara, solomon fish, sanjika	kambuzi, mlamba	usiliwa, khalara, chibenji
EAV	malamba, chambo (kasawala, makumba) during the rainy season.	Dondolo, usiliwa, sanjika, mlamba during the rainy season, no mpasa during rain season	Dondolo, usiliwa, sanjika, mlamba during the rainy season, no mpasa during rain season	No	chambo, kambuzi, usiliwa	kambuzi, mlamba, mpasa	mlamba	usiliwa
River inlets/outlets	mlamba, sanjika, phuta	mlamba, sanjika, phuta	mlamba, sanjika, phuta	no	mlamba, mpasa, solomon fish, sanjika, phuta	chambo, mlamba, mpasa, khalara, kadyakoro, solomon fish, sanjika	mlamba, mpasa, khalara, kadyakoro, solomon fish, sanjika, chimbenje, dondolo	mpasa, khalara, kadyakoro, sanjika, phuta, chimbenje
Deep Areas	kambuzi, mlamba chambo, kampango Mcheni is also found in the deep areas, but in much smaller numbers	chambo, kambuzi, mlamba, usiliwa, kampango	chambo, kambuzi, mlamba, usiliwa, kampango Nchila	change b/w 5 years ago and 12 months	kambuzi, kampango, mcheni DO NOT breed in the deep areas.	shallow areas, preference for warmer waters, and aquatic vegetation.	usipa, chambo, kambuzi, mlamba, bluefish, kampango, ncheni, solomon fish	usipa, chambo, kambuzi, mlamba, kampango, solomon fish
Shallow Areas	usipa, chambo, phuta, chimbenje, nkhalara, dondolo	chambo, mlamba, kampango, chimbenje, sanjika, dondolo, nkhalara	usipa, chambo, mlamba, kampango, nkhalara	yes	usipa, chambo, kambuzi, mlamba	usipa, chambo, kambuzi, mlamba, usiliwa, mpasa, sanjika, khalala, chibenji, dondolo	usipa, kambuzi, mlamba, usiliwa, mpasa, khalara, kadyakoro, solomon fish, sanjika, chibenji, dondolo	usiliwa, mpasa, khalara, kadyakoro, sanjika, phuta, dondolo
Middle of the lake	usipa, chambo, kambuzi, mlamba, usiliwa, bluefish, mcheni, sanjika	chambo, mlamba, bluefish, kampango, mcheni, sanjika	chambo, mlamba, bluefish, kampango, mcheni, sanjika	Yes	kambuzi, bluefish, kampango	kambuzi, kampango, mcheni	usipa, chambo, kambuzi, mlamba, bluefish, kampango, ncheni, solomon fish	usipa, chambo, kambuzi, mlamba, bluefish, kampango

Table C.3.2. Threats in Mwalija.

Threats (Mwalija)
Illegal gear *(kandwindwi, mosquito nets, and all small-meshed size gear like ngongongo; illegal nets: sine/chibati)* *Affected Fish Species* ▪ All fish, and nursery habitat *Communities Perceptions on the reasons behind the threat* ▪ To target all types of species, catch more and juveniles. *Community's response to threat* ▪ Chase illegal fishers away. Others FG do not do anything because they do not have any fisheries regulations to follow. *Community's Perceived Strength and Good Practices* ▪ Chase illegal fishers away. ▪ From Jan - Oct., they patrol the lake on a monthly basis (i.e., one day per month). From Oct-Dec., it is the closed season. The legal gear used during this time is the 3 inch gill net while all active gears are banned. Makumba is no longer available and only found at Mvera (the outlet of Lake Malombe) b/c it is well protected ▪ The actions that they have taken against the kandwindwi owners, eliminating its use in their area. *Perceived Weaknesses* ▪ There is no power to enforce the law b/c there is no transport for patrolling the lake and they do not have equipment for patrolling. *Perceived Avenues for the Project to Intervene* ▪ This BVC is interested in requiring the migrant fishermen to get transfer letters from the BVC overseeing their own beach in order to ensure that the recommended gears are being used. This has not been implemented yet. In the other FG, they felt that the transfer letters would not be effective. Equipping the community with knowledge on the current bylaws (i.e., those passed by the Government. ▪ Establishment of fisheries bylaws. They are waiting for the Government (DoF) to move first and give them some guidelines. ▪ Assistance w/income generating activities to relieve fishing pressure (i.e., fish farming, winter cropping, poultry, the provision of small loans by a microfinance institution, tree planting, vocational training in painting, carpentry, bricklaying so that the next generation has additional employment options). They suggested that the closed season be extended from Oct-Jan vs. the current period which is Oct-Dec. (i.e., extend it one month further) because the water levels are lowering exposing the EAV/SAV breeding areas.

Loss of Emergent Aquatic Vegetation

Affected Fish Species

- All species, especially during their breeding seasons.

Communities Perceptions on the reasons behind the threat

- The EAV is being cut by the local communities to open up areas for fishing.
- The EAV is also cut to use the material for making mats, fencing, thatching for their roofs as well as for creating new beaches to land their fish.

Community's response to threat

- They cannot do anything b/c there are currently no rules or clear regulations. There is no orientation from the Fisheries Dept. They are waiting for the Dept. of Forestry to come up w/the rules and regulations regarding the cutting of EAV.

Community's Perceived Strength and Good Practices

- No response

Perceived Weaknesses

- No response

Perceived Avenues for the Project to Intervene

- Training on closed areas. The community suggested: Mwalija, Mtenje, Mphwanya, Likala, Changamire for possible closures.

Sedimentation

Affected Fish Species

- All fish species because siltation is decreasing the amount of area available for fish breeding

Communities Perceptions on the reasons behind the threat

- Five years ago, the women were able to make donuts and sell them to the fishermen, but as the fish abundance declined so did the number of fishermen and they were no longer able to sell the donuts. As a result, they started cutting down the trees to sell firewood and charcoal.
- Increased poverty levels.

Community's response to threat

- Reforestation and afforestation by the community members. They have done this activity at Kambera forest (behind the Chiefs home and near the Mountain). It is not productive, however, b/c they need training on forest mgmt. This planting has been done by the BVC, VDC, and Village Nat'l Resources Mgmt Committee (VNRMC). They were encouraged with the provision of foodstuff (e.g., a bag of maize, flour, cooking oil, and livestock) by CADECOM (Catholic Project) and the Forestry Dept. The community commented, however, that they often do not feel ownership over these plots and that they participated only for the food. They would like to be able to ACTIVELY take part in the project activities (I as a person, did x, y, and z being proud of what they did and then being able to tell others that it's not OK to cut down the trees that they planted) vs. being given money or food. They want a role.

Community Perceived Strength and Good Practices

- Reforestation and afforestation of trees and elephant grass (probe for specific locations of these activities). They are planting elephant grass along the rivers w/help from

CADECOM and the Dept. of Forestry. They do feel a sense of ownership over the planted grasses b/c it is measurable and closer to their homes for them to monitor. Their crops are not eaten by the goats when protected by the elephant grass (they are seeing an immediate benefit from the grasses, but not so for the trees). The elephant grasses also help to prevent the erosion of soil (another benefit they perceive quickly). They also sometimes sell the elephant grass to people who have cattle, which allows them to generate some income.

Perceived Weaknesses

- Lack of knowledge in forestry management

Perceived Avenues for the Project to Intervene

- Tree nursery, provide food as a motivational factor for replanting (vs. money).
- Forestry management trainings.

Table C.3.3. Drivers and contributing factors in Mwalija

Drivers (Mwalija)

Climate Change

Affected Fish Species

- Usipa, chambo, kambuzi, mlamba and all other species

Communities Perceptions on the reasons behind the threat

- Decline of fish because the nursery habitats of SAV and EAV are adversely affected by changes in the water levels within the lake and tributaries.
- Migration of fish to other areas.

Community's response to threat

- Tree planting/reforestation and capacity building. The BVC is new and hasn't received any training yet

Community's Perceived Strength and Good Practices

- Tree planting/reforestation
- They are doing winter cropping with irrigation where they are planting maize and vegetables

Perceived Weaknesses

- None mentioned

Perceived Avenues for the Project to Intervene

- Training in forestry, land resource and fisheries management to understand how to protect the plants along the lake b/c these are the areas that the fish come to breed and feed.
- They would also like fences put in to protect their crops from hippos.
- The provision of small-scale loans so that they can start businesses during the closed season.
- Also interested in fish farming ponds.

Food Insecurity

Affected Fish Species

- Chambo, mlamba, kambuzi,

Communities Perceptions on the reasons behind the threat

- High population is causing food insecurity since there is less fish per person.
- Cutting of the trees also increases soil erosion; it lowers the productivity of the farm land. Fertilizers are too expensive so the production is low and they are forced to go fishing.

Community's response to threat

- Implementing winter cropping with irrigation for maize and vegetables for home consumption and to generate income.
- Presently they do irrigation on a small-scale to grow maize, sweet potatoes and tomatoes. The area is usually 1/4-1/2 hectares and the farming is done by both men and women.

Community's Perceived Strength and Good Practices

- Doing irrigation in 1 hectare with water from the Lake.

Perceived Weaknesses

- No response

Perceived Avenues for the Project to Intervene

- Assistance in establishing fish farms. Planning for additional irrigation schemes, fences and electric wiring to prevent the hippos from coming onto their farmland.
- Locals are interested in a water pump that uses solar power, gas or electricity vs. the manual treadle pump.
- Subsidize the fertilizers so that it is more affordable for them.

Poor Education and Low Literacy Levels

Affected Fish Species

- All species

Communities Perceptions on the reasons behind the threat

- Lack of knowledge on how to implement different fisheries management measures
- Most parents do not accept the idea of sending their children to school. The Chief tried to form committees to force the children to go to school, but it was not successful. They prefer to have their sons engage in fishing activities or other types of work. This is influenced by the migrant fishermen and illegal gear users making a lot of money that makes children believe that fishing can be profitable.

Community's response to threat

- Chief has tried to enforce sending the children to school- Unsuccessful to date.

Community's Perceived Strength and Good Practices

- None mentioned.

Perceived Weaknesses

- None mentioned.

Perceived Avenues for the Project to Intervene

- Helping with the establishment of bylaws and the forming of groups that ensures that the children go to school. There should also be meetings b/w the Chiefs policemen, fishermen, and community at large so that everyone understands the importance of sending their children to school.

Nalikolo Community: Data Fish Biodiversity

Table C. 4.1. Fish Biodiversity reported in Lake Malombe by the community of Nalikolo. Around 10 species were reported to be harvested in the last 12 months. Focus group one mentioned the most abundant being kambuzi (1st), usiliwa(2nd), mlamba (3rd); and the focus group 2 mentioned: kambuzi (1st), mbaba (2nd), kampango (3rd), mlamba (4th), matemba (5th).

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	kambuzi, silibanga, mlamba	chambo, silibanga, mlamba	chambo, kambuzi, silibanga, mlamba	Yes	kambuzi, silibanga,mbaba, mlamba	chambo, usipa, kambuzi, mbaba,mlamba	usipa, mphuta, mlamba, nkholokolo	mlamba ,solomon fish,makumba, mlambakambuzi, silibanga
EAV	mlamba,makumba,mayera, mphuta, kambuzi	mphuta, nkhalala, makumba, mlamba, matemba, kambuzi, ntchira, makumba	mphuta, nkhalala, makumba, mlamba, matemba, kambuzi, ntchira, makumba, ntchila		chambo, kampango, mbaba, mlamba, nkholokolo, makumba, mphuta, makumba,sanjika	chambo, matemba, sanjika, silibanga, mbaba	chambo, kampango, mlamba	makumba,chigonthi (samwamowa), mlamba
River inlets/outlets	usipa, kambuzi, matemba, silibanga	silibanga, matemba , mlamba, mphuta, sanjika	silibowa, matemba, mlamba, sanjika	Yes	silibanga, ntchira, matemba, nkhalala,sanjika, makumba,mbaba, mphuta, nkholokolo, mlamba	mphuta, matemba, nkhalala	mphuta, matemba, nkholokolo, nkhalala, mlamba, chambo	mlamba, mbaba, makumba, kambuzi, nkholokolo, matemba
Deep Areas	chambo, kambuzi, kampango, ntchira, usiliwa,mbaba, usipa	usiliwa, kampango,ntchira, chambo	usiliwa, kampango, ntchira, chambo	Yes	No Fish	No Fish	kasawala kambuzi, kampango, mbaba, sanjika	chambo, kambuzi, kampango, mlamba,mbaba
Shallow Areas	usipa, kambuzi, nkholokolo, mphuta	chambo. kambuzi, silibanga,usiliwa	chambo, kambuzi, silibanga, ntchira	Yes	kambuzi, matemba, silibanga, makumba, nkholokolo	kambui, mbaba, makumba, mphuta	usiliwa, kambuzi, mbaba, silibanga	usipa, kambuzi, mbaba, mlamba,makumba
Middle of the lake	kambuzi, kampangp, makumba, usipa, nkholokolo	kambuzi, kampango, mbaba	kambuzi, kampango, mbaba,sanjika, mlamba	No	kampango, mbaba	kambuzi, kampango, mbaba, mlamba	chambo, kambuzi, kampango, mphuta, mlamba, sanjika	kambuzi, usiliwa,makumba, kampango, mbaba

Table C.4.2. Threats in Nalikolo

Threats (Nalikolo)
Illegal gear *(Mosquito Nets, (Kandwindwi) ngongongo)* *Affected Fish Species* ▪ All fish, and nursery habitat *Communities Perceptions on the reasons behind the threat* ▪ Poverty: Illegal gears are cheap e.g. ngongongo and mosquito nets, while kandwindwi is expensive and lack of IGAs sources of money, more accessible. (Use mosquito nets provided by the government). Legal gears are expensive. *Community's response to threat* ▪ Confiscation of illegal gears. But the gear is returned on the lake by the fisheries officers. *Community's Perceived Strength and Good Practices* ▪ Confiscation of illegal gears. Make the community aware of the dangers of using illegal gear ▪ Better resource management, ability to move out illegal fish users; training for the chief went to training for participatory fisheries management. Sharing of problems and solutions with the community and other BVCs nearby. *Perceived Weaknesses* ▪ Gears are returned after a fine is paid. Lack of support from fisheries in terms of equipment, uniform, conflicts between the chief and BVC members on their roles and responsibilities concerning the lake, community resolve to fishing than other IGAs, men depend more on fishing than on farming. *Perceived Avenues for the Project to Intervene* ▪ Provision of small loans to start up business, capacity building on fisheries management.
Loss of Emergent Aquatic Vegetation *Affected Fish Species* ▪ Mmakumba, silibanga, mphuta, kambuzi, mbaba, nkhalala and mlamba. *Communities Perceptions on the reasons behind the threat* ▪ They use them for house thatching, construction of fences and selling. *Community's response to threat* ▪ Doing civic education on the importance of conserving the aquatic vegetation. *Community's Perceived Strength and Good Practices* ▪ Doing civic education on the importance of conserving the aquatic vegetation. ▪ Taking self initiative measures to conserve the aquatic vegetation. *Perceived Weaknesses* ▪ No by-laws for the conservation of AV. No ownership on the fisheries resources. ▪ Men depend on fishing than farming. ▪ Children not going to school but cutting the AV to sale it. *Perceived Avenues for the Project to Intervene* ▪ Help them to formulate by-laws, ▪ Conduct civic education on the need to conserve the AV.

Table C.4.3. Drivers and contributing factors in Nalikolo

Drivers (Nalikolo)
Population Growth *Affected Fish Species* ▪ All fish species. *Communities Perceptions on the reasons behind the threat* ▪ Men discourage women to go for contraceptives. They believe it can reduce libido. ▪ Early marriages, most people they are ignorant about the reproductive health services and are discouraged by contraceptives side effects. *Community's response to threat* ▪ Discuss family planning and health. *Community's Perceived Strength and Good Practices* ▪ Very few people have started Family planning. *Perceived Weaknesses* ▪ Most women fear of using the reproductive health services because they fear losing their husbands. Parents are doing nothing. *Perceived Avenues for the Project to Intervene* ▪ Creating awareness on family planning, social extension worker to be based in the village, policies or laws should be put in place to encourage two children per family. ▪ Provision of soft loans to act as startup capital so as to make them busy vs. being only a child manufacturer company.
Climate Change *Affected Fish Species* ▪ All fish species. *Communities Perceptions on the reasons behind the threat* ▪ Decline of fish, fish migrate to other areas as siltation affects habitat (due to deforestation) ▪ Trees are cut for charcoal making. Fertile soil has been washed away therefore low productivity. *Community's response to threat* ▪ Planting trees in groups along river banks. Follow up every month to make sure trees are not harvested. *Community's Perceived Strength and Good Practices* ▪ Planting trees in groups along river banks. Follow up every month to make sure trees are not harvested. *Perceived Weaknesses* ▪ They need tree seedling to plant and land (?) *Perceived Avenues for the Project to Intervene* ▪ Need for training on forestry management. ▪ Planning for winter cropping. Need for seed supplies and equipment.

- Provision of soft loans for IGAs.

Lack of Savings

Communities Perceptions on the reasons behind the threat

- Lack of coordination between fishers & traders. Inconsistencies in fish pricing between fishers and town market.

Perceived Weaknesses

- Business losses.
- Difference in prices of purchasing fish and selling fish minimizes profits.

Appendix D – Lake Chilwa

Mposa Community: Data Fish Biodiversity

Table D.1.1. Fish Biodiversity reported in Lake Chilwa by the community of Mposa. Around 3 species were reported to be harvested in the last 12 months. Focus group one mentioned the most mlamba (1st), chambo (2nd), matemba (3rd); and focus group 2 mentioned: mlamba (1st), chambo (2nd), matemba (3rd).

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	chambo, matemba, mlamba	chambo, makwale, mphuta, mlamba, matemba	chambo, makwale, mphuta, mlamba, matemba	Yes (but no change b/twn 5 and 10 years ago)	chambo, matemba, mlamba	mlamba, chambo, matemba	mlamba, chambo, matemba	mlamba, chambo, matemba
EAV	chambo, matemba, mlamba	chambo, matemba, mlamba	chambo, matemba, mlamba, mphuta	Yes	chambo, matemba, mlamba	chambo, matemba, mlamba	chambo, matemba, mlamba	chambo, matemba, mlamba
Rocky Areas	chambo, matemba, mlamba	chambo, mphuta, matemba, mlamba	chambo, mphuta, matemba, mlamba	Yes (but no change b/twn 5 and 10 years ago)	chambo, matemba, mlamba	chambo, matemba, mlamba	chambo, matemba, mlamba, mphuta	chambo, mphuta, matemba
River inlets/outlets	chambo, matemba, mlamba	matemba, mlamba	matemba, mlamba, makwale, chambo	yes	chambo, matemba, mlamba	chambo, matemba, mlamba, mphuta	chambo, matemba, mlamba, mphuta	chambo, matemba, mlamba, mphuta
Deep Areas	chambo, matemba, mlamba	makwale, mphuta, mlamba, matemba	makwale, mphuta, mlamba, matemba	Yes	chambo, matemba, mlamba, mphuta	chambo, matemba, mlamba, mphuta	chambo, matemba, mlamba	chambo, matemba, mlamba, mphuta
Shallow Areas	chambo, matemba, mlamba	chambo, makwale, mphuta, mlamba	chambo, makwale, mphuta, mlamba	Yes	Matemba, mlamba	chambo, matemba, mlamba	matemba, mlamba	mlamba
Middle of the lake	chambo, mlamba	makwale, mlamba, chambo, matemba	makwale, mlamba, matemba	Yes	chambo, matemba	Chambo, mphuta, matemba	chambo, matemba, mlamba	chambo, matemba, mlamba, mphuta

Table D.1.2. Threats in Mposa.

Threats (Mposa)
Illegal gear *(mosquito net and khoka)* *Affected Fish Species* ▪ All fish species. *Communities Perceptions on the reasons behind the threat* ▪ The need to catch a lot of fish (and faster), ▪ Weak enforcement, corruption, high fishermen population. Additionally, the gears are easily found at a cheap price. *Community's response to threat* ▪ They chase away illegal gear users (but it not effective) *Community's Perceived Strength and Good Practices* ▪ Observation of closed season and use of proper gears (but some are using illegal gears) ▪ They work as a group to chase away the illegal gear owners *Perceived Weaknesses* ▪ BVC is not empowered. Lack of security because fishermen threaten them. ▪ Illegal gears are mostly used at night (BVC does not monitor at night) *Perceived Avenues for the Project to Intervene* ▪ Intensify civic education on use of legal gears. ▪ Provisions of identification cards, uniforms, bicycles, boat and engine, raincoats for enforcement. ▪ Assistance in formation of a special committee to monitor daily fisheries activities. ▪ Empowering the BVC and village heads. Allowances for BVC when they patrol (K1,800 per person)
Loss of Emergent Aquatic Vegetation *Affected Fish Species* ▪ Chambo and mlamba. *Communities Perceptions on the reasons behind the threat* ▪ Fishermen cut the vegetation because a lot of fish are found around the aquatic vegetation. Fish lack breeding habitats and sanctuaries. The vegetation is used to thatch houses *Community's response to threat* ▪ They try to stop the fishermen from cutting the aquatic vegetation *Community's Perceived Strength and Good Practices* ▪ They try to stop the fishermen from cutting the aquatic vegetation *Perceived Weaknesses* ▪ Bad fishing practices, which destroy the vegetation in order to catch more fish. *Perceived Avenues for the Project to Intervene* ▪ Creating awareness on the importance of aquatic vegetation. ▪ Assisting on the formation of bylaws; fining fishermen that cut aquatic vegetation.

Lake Level Changes

Affected Fish Species

- All fish species, except for mlamba because it is able to survive in muddy habitats.

Communities Perceptions on the reasons behind the threat

- Insufficient rainfall. Soil erosion due to deforestation, which leads to siltation.
- Cultivating around the Chikala Hill leads to added erosion.

Community's response to threat

- Nothing.

Community's Perceived Strength and Good Practices

- Nothing but they think tree planting (Afforestation) might help.

Perceived Weaknesses

- Lack of energy alternatives. Cutting of trees for charcoal and firewood, this results in higher rates of erosion and sedimentation.

Perceived Avenues for the Project to Intervene

- Training on environmental management. Provision of tree seedlings. Demarcation of forest from farming land.

Table D.1.3. Drivers and contributing factors in Mposa

Drivers (Mposa)
Climate Change *(Erratic rainfall pattern)* *Affected Fish Species* ▪ All fish species. *Communities Perceptions on the reasons behind the threat* ▪ Insufficient rainfall leads to drought and then famine due to low harvests. Therefore, there is a high reliance on the fishery during these times. The BVC said heavy rainfalls are good for the fish. *Community's response to threat* ▪ Nothing but they are planning to start afforestation in Chikala forest *Community's Perceived Strength and Good Practices* ▪ None. *Perceived Weaknesses* ▪ They cut a lot of trees for fish drying and smoking, which in turn leads to erosion. ▪ Absence of village natural resource conservation committee. *Perceived Avenues for the Project to Intervene* ▪ Training on fisheries and environmental management. ▪ Provision of new ways for drying and smoking (value addition) other than using firewood. ▪ Locals want a functional village natural resource conservation committee.

Lack of Alternative Livelihoods *(rice farming, small scale enterprises, micro loans)*

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- They rely on the fishery a lot. They do not have the technical preparation to do small scale business.

Community's response to threat

- Practicing rice farming; start small scale businesses

Community's Perceived Strength and Good Practices

- Engaged in rice farming and small scale businesses, and have started VSLs.

Perceived Weaknesses

- Lack of capital to start businesses. Their VSLs are not strong

Perceived Avenues for the Project to Intervene

- Provision of new ways of drying and smoking (value addition) other than using firewood.
- Establishing irrigation systems for farming
- Fish farming (ponds) and they requested loans to further their rice farming and start small scale businesses.

Namanja Community: Data Fish Biodiversity

Table D.2.1. Fish Biodiversity reported in Lake Malawi by the community of Namanja. Around 4 species were reported to be harvested in the last 12 months. Focus group one mentioned the most abundant being mlamba (1st), chambo (2nd), matemba (3rd) and njenjeta (4th); and the focus group 2 mentioned: mlamba (1st), matemba (2nd) and chambo (3rd).

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	chambo, mlamba, matemba	Chambo, matemba, mlamba and makwale	Chambo, matemba, mlamba and makwale	Yes	Mlamba, matemba, chambo	chambo, mlamba, matemba	matemba, makwale	Chambo, matemba, mlamba and makwale
EAV	chambo, mlamba, matemba	Chambo, matemba, mlamba and makwale	Chambo, matemba, mlamba and makwale	Yes	chambo, mlamba, matemba	chambo, mlamba, matemba	chambo, mlamba, matemba	chambo, mlamba, matemba, makwale, nkhalala
Rocky Areas	chambo, mlamba, matemba	chambo, mlamba, matemba	chambo, mlamba, matemba	No	mlamba, chambo, matemba	chambo, mlamba, matemba	chambo, mlamba, matemba	chambo, matemba, makwale
River inlets/outlets	chambo, mlamba, matemba, njenjeta	mlamba, chambo, njenjeta	chambo, mlamba, matemba, nkhalala, njenjeta	Yes	chambo, mlamba, matemba,	chambo, mlamba, matemba, Njenjeta, nkhalala	chambo, mlamba, matemba,	chambo, mlamba, matemba, nkhalala, Njenjeta
Deep Areas	mlamba	mlamba, makwale	Chambo, matemba, mlamba and makwale	Yes	Matemba	mlamba, matemba,	chambo, mlamba, matemba	chambo, mlamba, matemba
Shallow Areas	Mlamba	mlamba, makwale	Chambo, matemba, mlamba and makwale	Yes	chambo, mlamba, matemba, mpale	chambo, mlamba, matemba	chambo, mlamba, matemba	chambo, mlamba, matemba, makwale
Middle of the lake	chambo, mlamba, matemba	Mlamba	matemba, mlamba, matemba	Yes	Chambo	chambo, mlamba	chambo, mlamba, matemba	chambo, mlamba, matemba

Table D.2.1. Threats in Namanja

Threats (Namanja)
Lake Level Changes *Affected Fish Species* ▪ Chambo, matemba and mlamba. *Communities Perceptions on the reasons behind the threat* ▪ Poor farming practices - cultivation along river banks is causing heavy erosion (from bare hills) and sedimentation. Rivers are also drying quickly due to siltation. *Community's response to threat* ▪ Rice Farming and protecting the areas that still have water to protect the few remaining fish species. *Community's Perceived Strength and Good Practices* ▪ Protection of fish species ▪ Fish farming in rice fields at a very small scale (to ease pressure on the fishery) *Perceived Weaknesses* ▪ Heavy deforestation. *Perceived Avenues for the Project to Intervene* ▪ Piped water for clean drinking water (since Lake Chilwa is not a fresh water lake). ▪ Assistance in afforestation to reduce erosion. Clearing rivers so that more water can enter into the lake.
Illegal gear (Gauze wire, mosquito net, dande) *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ Poverty, lack of capacity building to educate fishermen about the danger of using the illegal gears; BVC is not empowered; to catch more fish and make higher profits; no enforcement by the Fisheries Office; inadequate extension workers, especially in the past. *Community's response to threat* ▪ Patrolling and enforcement. They confiscation of the illegal gear and require the offender to pay a fine. *Community's Perceived Strength and Good Practices* ▪ Patrolling and enforcement. The confiscation the illegal gears and fining the offenders to pay a fine (not in practice yet). They have managed to confiscate illegal gear. *Perceived Weaknesses* ▪ No enforcement by Fisheries Office; inadequate extension workers, especially in the past *Perceived Avenues for the Project to Intervene* ▪ Need for more extension workers. There is need to strengthen enforcement. ▪ Need for engine, boat, fuel, raincoats and IDs to assist in patrolling. Security and surety to BVC members in case of harm during enforcement.

Loss of habitat SAV & EAV

Affected Fish Species

- All species. In particular, aquatic vegetation provides breeding and nursery grounds for mlamba and provides protection to makwale chambo and mlamba from predators.

Communities Perceptions on the reasons behind the threat

- Destruction of aquatic vegetation leaves fish vulnerable and reproduction levels are low. The community cuts EAVs to thatch houses. Cultivation along river banks causes erosion and sedimentation, which destroys habitats.

Community's response to threat

- Nothing because they rely a lot on the aquatic vegetation to thatch houses.

Community's Perceived Strength and Good Practices

- They work as group to monitor and confiscate gears when they find anyone cutting aquatic vegetation to fish

Perceived Weaknesses

- They cannot afford iron sheets so they cut EAVs to thatch their houses.

Perceived Avenues for the Project to Intervene

- Conducting awareness campaigns on fisheries resource management.
- Training the BVC on how it should work. Promoting visitations between BVCs so that they can teach each other ways of managing the fishery.

Table D.2.3. Drivers and contributing factors in Namanja

Drivers (Namanja)
Migration *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the threat* ▪ The migrants use illegal gears and increase the total number of fishers on the lake. ▪ High catches and depletion of the fishery. ▪ The boundary with Mozambique is not very clear. *Community's response to threat* ▪ Any migrant caught using illegal gears is caught and fined *Community Perceived Strength and Good Practices* ▪ Fining migrant fishermen (mostly the ones using illegal gears) *Perceived Weaknesses* ▪ Most of the migrants are allowed to fish by the village head hence villagers cannot do anything. Corruption. BVC members are threatened when they confront the migrant fishers. *Perceived Avenues for the Project to Intervene* ▪ BVCs should be paid (allowances); licenses; empower BVC so that they can deal with migrants on their own. Provide IDs and uniforms.

Climate Change (low rainfall)

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- Heavy rainfall causes fish to migrate from the lake to the rivers. When the lake level is low, the water quality lowers and diseases such as cholera become more prevalent.

Community's response to threat

- Lower rainfall levels lead to hunger (poor harvest), a lack of money, a higher incidence of diseases (they cannot go fishing), a scarcity of fish and a change in the lake's level.
- Practicing irrigation, engaging in small businesses and doing piece work to sustain themselves.

Community Perceived Strength and Good Practices

- Practice irrigation, engage in piecework and small businesses

Perceived Weaknesses

- (Note on the community not fully understanding what climate change is)

Perceived Avenues for the Project to Intervene

- Trainings on beach sanitation (to deal with cholera). They requested tree seedlings to plant along the rivers and training in resource (vegetation inclusive) management. Other identified needs include health workers, boreholes, and transportation to quickly take patients to the hospital.

Lack of Savings

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- Poverty (they feel the money they have is not enough to save).

Community's response to threat

- They are using VSLs, but they lack expertise in financial management. Some are banking (very small percentage ~10%)

Community Perceived Strength and Good Practices

- They think using VSLs is a strength

Perceived Weaknesses

- Lack of expertise in financial management. Low profits from fish business hence not enough to save.

Perceived Avenues for the Project to Intervene

- Financial management training.

Market Forces

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the threat

- High demand and profitability of fish encourages overfishing.

Community's response to threat

- Finding alternative sources of income (selling rice, maize). They sell fish at retail price to make more profits.

Community's Perceived Strength and Good Practices

- Small scale businesses and selling of farm produce.

Perceived Weaknesses

- There is no stable price for fish. Lack of coordination between business men/women and fishers.

Perceived Avenues for the Project to Intervene

- Training on value addition and entrepreneurship.

Appendix E – Lake Chiuta

Misala Community: Data Fish Biodiversity

Table E. 1.1. Fish Biodiversity reported in Lake Chiuta by the community of Misala. In the last 12 months a total of 9 species were caught. The most abundant of these species were Chambo (1st), mphuta (2nd), chitondolo (3rd), and matemba (4th). Preferred habitats for various life stages were validated upon secondary field visits.

Habitat Types	Fishing grounds (last 12 months)	Fishing Grounds (5 years ago)	Fishing Grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV		Kampango		Yes	Makumba, nkhalala, chitondolo, tilapia rendalli	Makumba, mlamba		
EAV	Mlamba, matemba, mphuta		Matemba	Yes	Mlamba, matemba	Makumba, mlamba, tilapia rendalli		
Rocky Areas	Chilenje, nkhalala, chitondolo	Makumba, matemba, chitondolo, chilenje	Chambo, matemba	Yes	Mlamba, matemba			
River inlets/outlets		Nkhalala	Mlamba	Yes			Makumba	Makumba, mlamba, chitondolo, chilenje
Deep Areas	Makumba	Ntchila	Chambo, matemba	Yes				Makumba, mlamba, mphuta, ngunga, chitondolo
Shallow Areas			Chambo, matemba	Yes		Nkhalala, tilapia rendalli		Makumba, mlamba, chitondolo
Middle of the lake				No				Makumba, mlamba, chitondolo
Other (EAVs/Rocky areas around Islands)				No		Nkhalala, mphuta, chitondolo, dande	Makumba, johnstonii, nkhalala, dande, chitondolo	Makumba, mlamba, matemba

Table E.1.2. Threats in Misala.

Threats (Misala)
Illegal Fishing Gear Used *(i.e., Mosquito nets, khoka, seines, traps wrapped w/ mosquito nets)* *Affected Fish Species* ▪ Makumba and mlamba. *Communities Perceptions on the reasons behind the threat* ▪ Fishers operate illegal gears to increase catches and subsequently, profits. *Community's response to threat / Perceived Strength and Good Practices* ▪ Illegal gear is confiscated and guilty fishers are fined Mk 35,000. ▪ BVC receives the payment. *Perceived Weaknesses* ▪ Both Malawians and Mozambicans are known to use illegal gears in Lake Chiuta. *Perceived Avenues for the Project to Intervene* ▪ Community members want the project to train them in management and enforcement methods. ▪ Providing fishers with boat engines, IDs to the BVC members, life jackets, uniforms and bicycles will help them with enforcement.
Habitat Destruction *(Loss of submerged and emergent aquatic vegetation)* *Affected Fish Species* ▪ Chambo, Matemba *Communities Perceptions on the reasons behind the threat* ▪ Overfishing in rocky, SAV, and EAV areas is destroying habitat for fish. ▪ Illegal gears are harmful to aquatic vegetation. *Community's response to threat / Perceived Strength and Good Practices* ▪ Confiscation of illegal gears. *Perceived Weaknesses* ▪ Overfishing has not diminished. *Perceived Avenues for the Project to Intervene* ▪ Currently no response from communities.
Lake Level Change *(Fluctuation in lake level due to climate variability)* *Affected Fish Species* ▪ All species and their habitats. *Communities Perceptions on the reasons behind the threat* ▪ Climate Change. *Community's response to threat* ▪ No Response. *Perceived Strength and Good Practices* ▪ None. *Perceived Weaknesses* ▪ Irrigation systems take too much water from the system.

Perceived Avenues for the Project to Intervene ▪ Alternatives to irrigation systems to decrease pressure on the water. supply.

Table E.1.3. Drivers and contributing factors in Misala

Drivers (Misala)
Population Growth *(Higher birth rates lead to bigger family sizes)* *Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the driver* ▪ Failure to follow family planning programs. *Community's response to threat / Perceived Strength and Good Practices* ▪ Family Planning Programs *Perceived Weaknesses* ▪ This increases fishing effort on the system. *Perceived Avenues for the Project to Intervene* ▪ Making people more sensitive to family planning, collaborating with communities Chief to help in the formation of committees that will enforce child education.
Climate Change *Affected Fish Species* ▪ All species. *Communities Perceptions on the reasons behind the driver* ▪ Erratic rainfall events. ▪ Low water levels. *Community's response to threat* ▪ No response. *Perceived Strength and Good Practices* ▪ Fisheries and lake levels have recovered in the past. ▪ God will take care of them. *Perceived Weaknesses* ▪ Low fish catches. *Perceived Avenues for the Project to Intervene* ▪ Trainings on forest management, afforestation with fast growing varieties of trees, enforcement of laws concerning forest conservation, and the formation of village natural resources conservation committee.

Lack of Alternative Livelihoods *(Sources of income outside of fishing)*

Affected Fish Species

- All species and their habitats.

Communities Perceptions on the reasons behind the driver

- Alternative livelihoods are not as profitable.

Community's response to threat

- Farming
- Small businesses
- VSLs

Perceived Strength and Good Practices

- Village Savings and Loans services help families better manage their finances.

Perceived Weaknesses

- VSLs need to be established by BVCs.

Perceived Avenues for the Project to Intervene

- Create VSLs
- Supply loans for small businesses.
- Better farming practices.

Njerwa Community: Data Fish Biodiversity

Table E. 2.1. Fish biodiversity reported in Lake Chiuta by the community of Njerwa. In the last 12 months a total of 6 species was caught. The most abundant of these species were Chambo (1st), mphuta (2nd), and matemba(3rd). Preferred habitats for various life stages were validated upon secondary field visits.

Habitat Types	Fishing grounds (last 12 months)	Fishing grounds (5 years ago)	Fishing grounds (10 years ago)	Change in fishing grounds over time?	Breeding Habitat	Nursery Habitat	Juvenile Habitat	Adult Feeding Habitat
SAV	Chambo, matemba, mlamba			Yes	Chambo, mlamba	Chambo, chilinguni		
EAV	Chambo, matemba, mlamba			Yes				
Rocky Areas	Chambo, matemba, mlamba	Chambo	Chambo	Yes	Chambo, mlamba, dande	Dande	Chambo, matemba, mlamba, dande, chilenje	
River inlets/outlets	Chambo, matemba, mlamba	Mphuta, matemba	Mphuta, matemba	Yes	Chambo, mlamba, chilenje, nkhalala, mphuta	Chambo, mlamba, mphuta, chilunguni	chambo, chilenje	
Deep Areas	Chambo, matemba, mlamba			Yes	mlamba	mlamba	mlamba	chambo, mlamba, matemba, dande, kampango
Shallow Areas	Chambo, matemba, mlamba		mlamba, matemba, chilenje	Yes	Chambo, mlamba, mphuta, nkhalala, chilenje	Chambo, mlamba, mphuta, nkhalala, chilunguni		
Middle of the lake	Chambo, matemba, mlamba			Yes				
Other (EAVs/Rocky areas around islands	Chambo, matemba, mlamba			Yes				Chambo, mlamba, matemba

Table E.2.1. Threats in Njerwa.

Threats (Njerwa)
Illegal Fishing Gear Used *(i.e., Nkacha seines, fish traps wrapped w/ mosquito nets, 2" gill nets)* *Affected Fish Species* ▪ Chambo, Mlamba. *Communities Perceptions on the reasons behind the threat* ▪ Fishers operate illegal gears to increase catches and subsequently, profits. *Community's response to threat / Perceived Strength and Good Practices* ▪ Illegal gear is confiscated and guilty fishers are fined Mk 35,000. ▪ Fishermen also chase away outsiders using nkacha nets. ▪ Since the removal of seine netters, nkhalala have rebounded. *Perceived Weaknesses* ▪ Some Mozambican illegal fishers are well armed, and difficult to chase away. *Perceived Avenues for the Project to Intervene* ▪ Community members want the project to train them in management and enforcement methods. ▪ Providing fishers with boat engines, IDs to the BVC members, life jackets, uniforms and bicycles will help them with enforcement.
Habitat Destruction *(Loss of submerged and emergent aquatic vegetation)* *Affected Fish Species* ▪ All species *Communities Perceptions on the reasons behind the threat* ▪ Overfishing in rocky, SAV, and EAV areas is destroying habitat for fish. ▪ Illegal gears are harmful to aquatic vegetation. *Community's response to threat / Perceived Strength and Good Practices* ▪ None *Perceived Weaknesses* ▪ Destroys shelter for breeding fish. ▪ No alternatives. *Perceived Avenues for the Project to Intervene* ▪ The community would like alternative livelihoods to help offset their dependence on fishing.

Lake Level Change *(Fluctuation in lake level due to climate variability)*

Affected Fish Species

- All species and their habitats

Communities Perceptions on the reasons behind the threat

- Sedimentation
- Abstraction of water from irrigation schemes (not yet implemented)

Community's response to threat

- No Response

Perceived Strength and Good Practices

- None

Perceived Weaknesses

- Irrigation systems take too much water from the system.

Perceived Avenues for the Project to Intervene

- The community would like alternatives to irrigation systems to decrease pressure on the water supply.

Table E.2.3. Drivers and contributing factors in Njerwa

Drivers (Njerwa)

Population Growth *(Higher birth rates lead to bigger family sizes)*

Affected Fish Species

- All species

Communities Perceptions on the reasons behind the driver

- Failure to follow family planning programs.

Community's response to threat / Perceived Strength and Good Practices

- None.

Perceived Weaknesses

- Poverty.
- Loss of vegetation.
- Increased illiteracy.

Perceived Avenues for the Project to Intervene

- Unsure of how to move forward. Unclear how the project could help.

Migration *(From other lake systems/countries)*

Affected Fish Species

- All species.

Communities Perceptions on the reasons behind the driver

- Mozambicans over-exploit the Lake Chiuta fisheries.

Community's response to threat

- Patrolling.
- Chase away migrant fishermen.

Perceived Strength and Good Practices

- History of success when it comes to removal of unwanted fishers.

Perceived Weaknesses

- Increased presence of illegal fishing gear.

Perceived Avenues for the Project to Intervene

- Money for patrol boats, BVC ID cards, uniforms, etc.

Climate Change *(Erratic weather patterns, Climate Variability)*

Affected Fish Species

- All species and their habitats.

Communities Perceptions on the reasons behind the driver

- Sedimentation.
- Deforestation.

Community's response to threat

- Tree planting.

Perceived Strength and Good Practices

- Reforestation.

Perceived Weaknesses

- Low fish catches.
- Lake levels may affect fish breeding.

Perceived Avenues for the Project to Intervene

- Provide seedlings for reforestation projects.
- Provide guidance/funding for climate smart agriculture.