Chapter 7
Aquaculture and Fisheries Extension

A.P. Shoko, Yunus D. Mgaya, S.M. Limbu, and R.B. Hoza

Abstract The dwindling catch from Lake Victoria has caused an insufficient fish supply to the population of the Lake Victoria basin, Tanzania. The decrease in catch rates and demand for fish has created room for fish farming practices at both small and commercial scales in the Lake Basin. This chapter provides a result-oriented status of aquaculture research and development efforts made by the government and Non-Governmental Organizations (NGOs) in the Lake Basin from the colonial era to the present. The chapter also highlights strengths, weaknesses, opportunities and challenges (SWOCs) to aquaculture development in the basin. Results show that the basin has a high potential for fish farming development due to suitable characteristics for fish farming. Fishponds are the common culture system used in fish farming in the basin. The ponds are stocked with either Nile tilapia *Oreochromis niloticus* or African sharptooth catfish, *Clarias gariepinus*, reared in monoculture or polyculture. A system of integrated aquaculture-agriculture (IAA) farming is also practised in some areas of the basin. The yield from the lake basin has increased with time due to improved pond management techniques. However, more room is available for further increase pending the adoption of technology and improved extension services. Fish farming could help to reduce fishing pressure on capture fisheries in the main lake and contribute significantly to the conservation of the lake's biodiversity. Ultimately, fish farming will generate income for the people, which is in line with the government's efforts to alleviate poverty in the country.

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7.1 Introduction

The falling fish catches from Lake Victoria has led to inadequate fish supply for the population within the Lake Victoria Basin, and Tanzania in general. The export trade of fish, especially of Nile perch (*Lates niloticus*), and a decline in its catches contribute to the inadequate supply of fish protein to the riparian communities and other people living outside the basin. Fish production from the main lake has decreased due to the effects of multiple stressors including the increased use of destructive fishing methods, high fishing pressure, the introduction of the Nile perch (*L. niloticus*), environmental destruction, and the disappearance of indigenous fish species (Matsuishi et al. 2006; Hecky et al. 2010). Similarly, the increasing population pressure, industrial development and other socio-economic activities in the lake basin have resulted in changes in water quality, fisheries biodiversity, wetlands and land use (Kitula 2006; see also Chapter 3 of this volume). These changes have consequently resulted into a general decrease of fish stocks and fisheries biodiversity (Balirwa et al. 2003) leading to a limited source of protein. Given the increasing demand for, and the limited supply of fish from natural capture fisheries, there is an urgent need to look for alternative means of producing fish as a cheap source of protein for the inhabitants of the basin and beyond.

The decline in catch rates and high demand for fish have created significant opportunities for fish farming practices at both small and commercial scales (Balirwa 2007). Fish farming has the potential to increase fish supply and bring socio-economic benefits to the riparian communities because the basin meets the criteria for fish farming. Fish farming is considered important in increasing fish production in rural areas and can be productively integrated with crop and animal husbandry. Thus, fish farming practice in the Lake Victoria Basin could increase fish supply to the riparian communities and improve the livelihoods of the poor through increased food supply, employment and income.

Despite the fact that fish farming in the Lake Victoria Basin was introduced during the colonial era (Fisheries Division 1967; Bwathondi and Mahika 1997), the activity has not developed significantly. Since independence, the government of Tanzania has made some efforts to increase fish farming in the basin. Unfortunately, those efforts have not yet resulted in any significant development; fish farming practices have remained at the level of subsistence. Specifically, emphasis on fish farming research and development in the Lake Victoria Basin started in the early 1960s when fish ponds were established at the Malya fish farm in Kwimba District, Mwanza Region (Fisheries Division 1967). However, such emphasis did not lead to substantive production of fish.

Following previous efforts, other initiatives on fish farming started during 1990s when baseline surveys (Bwathondi and Mahika 1997) were conducted to explore its potential. The inception of the Lake Victoria Environment Management Project (LVEMP) in 1997 made deliberate efforts to promote fish farming in the basin. Such efforts included training of fisheries extension staff on fish farming development, training of farmers on pond construction and management, construction of demonstration

fishponds, and the establishment of breeding ponds as a source of fish fingerlings. These activities were carried out at the Tanzania Fisheries Research Institute (TAFIRI) – Mwanza Centre, Nyegezi Freshwater Fisheries Training Institute (NFFTI) in Mwanza and Magoma village in Tarime District, Mara Region.

Apart from attempts led by the government, there have been some efforts by Non-Governmental Organizations (NGOs) and Community Based Organizations (CBOs) in promoting fish farming activities. Such efforts, though uncoordinated, have made a positive impact towards aquaculture development in the basin. By recognizing the efforts made by NGOs and CBOs, the LVEMP established a collaborative mechanism with these organizations in order to promote fish farming practices in the basin. Lake Victoria Research Initiative (VicRes), a Sida/SAREC funded project has also made an important contribution in aquaculture research and development by supporting different researches aimed at improving fish yields and income generation for local communities (Getabu et al. 2007; Shoko et al. 2011a).

Effective extension service is one of the main aspects required for aquaculture development (Brummett and Williams 2000). Fisheries extension services in the Lake basin started during the colonial era. They have been responsible for the dissemination of information on available fish stocks, sustainable fish harvesting practices, improved fish handling and processing methods and proper care and maintenance of fishing gear. Other activities include fishing demonstrations, promotion of fish consumption as food, and serving as a bridge between resource users, managers and researchers. However, fisheries extension services have been ineffective because of inadequate number of trained staffs, budgetary constraints, and poorly coordinated institutional framework. Despite the setbacks, fisheries extension services such as those provided by the government and the LVEMP have largely supported the current knowledge on fish farming activities in the basin. These efforts have collectively resulted into vibrant aquaculture activities in the basin.

The rise and fall in fish farming activities over time have characterized developments in fish culture practices in the Lake Victoria Basin, Tanzania. Reports show that donor supported post-colonial aquaculture initiatives failed because they were top-down arrangements made between the government and donors, which typically alienated the farmer (Bwathondi and Mahika 1997; Bwathondi et al. 1998). The approach by the LVEMP, of enabling farmers to own the activity, deviates significantly from the experience of the past. Under this setup, farmers are provided with technical support such as pond siting, construction, management and simple fish feed formulation techniques by using locally available ingredients. Besides, community-based breeding ponds have been established in collaboration with farmers, which make the supply of fish fingerlings easier. People, including interested farmers, are also encouraged to establish private facilities for producing fish farming inputs such as fish feeds and commercial hatcheries offering fish fingerlings for sale. Such approaches ensure the sustainability and success of fish farming beyond the project phase.

Despite appreciable efforts made by the government and the private sector in fish farming development in Lake Victoria Basin, the available information is scattered and unfocused. In view of the foregoing narrative, the objective of this chapter is to

review the aquaculture research and development efforts made by the government, CBOs and NGOs in the Tanzanian part of the lake basin from the colonial era to the present, including the development attained during the LVEMP I. The chapter also highlights strengths, weaknesses, opportunities and challenges (SWOCs) to aquaculture development in the basin. Recommendations for future research and development of aquaculture are also given.

7.2 Results

7.2.1 Fish Farming Potential

Results from the baseline studies conducted in the Tanzanian part of the Lake Victoria Basin, showed that there is a high potential for fish farming development, which is yet to be fully utilized (Bwathondi et al. 1993, 1998; Bwathondi and Mahika 1997; Mahika et al. 2001; Mbilinyi and Shoko 2002; Shoko et al. 2011b; Salehe et al. 2012; Rothuis et al. 2014). This potential is indicated by favourable conditions for fish farming activities such as suitable soils, and permanent sources of water from rivers and numerous springs throughout the year in certain areas. Other indicators for fish farming potential include suitable temperatures and abundant animal manure, which is an important input for fishpond fertilization in extensive and semi intensive production. There is a reliable market for fish ranging from local markets where most households buy their fish, to hotels and restaurants where fish can be incorporated in menus, and fish butcheries where fish are prepared and sold while fresh or frozen (Salehe et al. 2012; Rothuis et al. 2014). It was further established that fish farming is mostly favoured in the districts of Tarime (Mara Region), Muleba, Bukoba Rural and Urban (Kagera Region).

A study conducted by Shoko and Onyango (2005) reported that Ngara District in Kagera Region is another important potential area for fish farming. The basin also has diverse wetlands, which if wisely utilized, could be used for fish farming development without affecting their primary role. In addition, a large majority of people in the basin prefer fish farming practice as an important economic activity, which is another opportunity that should be tapped to promote fish farming in the Lake Victoria Basin.

7.2.2 Culture Systems Used

In the Lake Victoria Basin, the most important fish farming system is pond culture of Nile tilapia (*Oreochoromis niloticus*) and the African sharptooth catfish (*Clarias gariepinus*) (Shoko et al. 2003a, 2011a; c, 2014, 2016a, b; Imani et al. 2014; Musiba et al. 2014). Cage culture of tilapia has also, been experimented, since the late 1960s

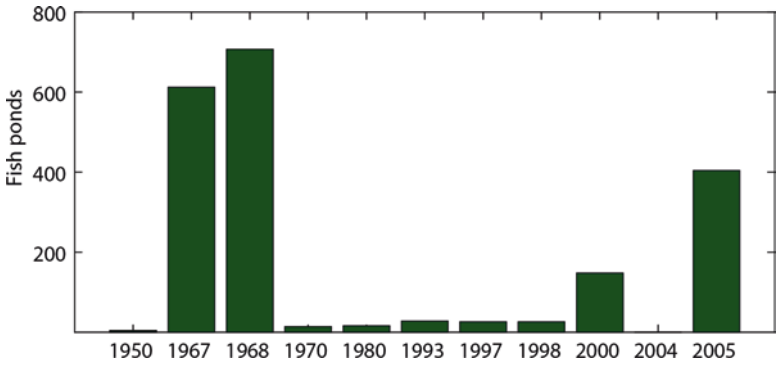


Fig. 7.1 Total number and average yield of fish ponds in the Lake Victoria Basin, Tanzania (Source: Fisheries Division 1967, 1968, 2005; Bwathondi et al. 1993, 1998; Bwathondi and Mahika 1997; Mahika et al. 2001)

to the present, at the NFFTI and TAFIRI Mwanza Centre (NFFTI 1972; Kashindye et al. 2015). Cage culture provides an opportunity for increasing fish supply from aquaculture given the abundance of water from Lake Victoria and many smaller lakes in the basin. Few farmers are practising integrated aquaculture-agriculture systems composed of fish, vegetables and animals. The vegetables used in integration include Kale *Brassica oleracea* (Shoko et al. 2011a) and animals such as chickens.

7.2.3 Number, Size and Yield of Fishponds

Existing records show that fish farming in the Lake Victoria Basin started back in 1950s during the colonial era. The Malya fish farm in Kwimba District, Mwanza Region, was established for promoting fish farming and restocking Lake Victoria (Fig. 7.1) (Fisheries Division 1967, 1968; Bwathondi and Mahika 1997). Furthermore, fish farming was introduced in Kagera and Mara Regions in the 1960s by the Fisheries Department (Fig. 7.1). Available records show that during this period, fish farming practices increased as evidenced by 612 and 707 fishponds in 1967 and 1968, respectively (Fig. 7.1). Fish farming practice in the basin was almost stagnant between the 1970s and the early 1990s as indicated by only 14 to 26 fishponds from 1970 to 1998, respectively.

However, things changed for the better from the late 1990s to 2005 as evidenced by a significant ($p < 0.05$) increase in the number of fishponds from 148 in 2000 to 404 in 2005 (Fig. 7.1). An average fishpond yield of 1,823 kg/ha was reported by Shoko et al. (2011c) from the potential areas (Fig. 7.1). The study however, reported no significant difference ($p > 0.05$) in pond yields between the potential areas of the districts of Muleba and Bukoba in Kagera and Tarime in Mara Regions. Because of

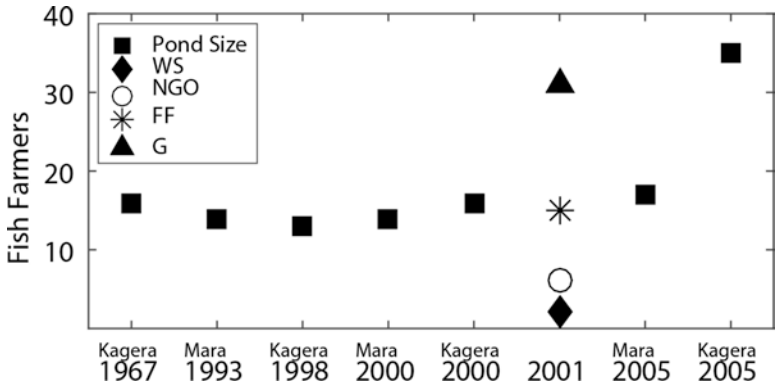


Fig. 7.2 Average size of fishponds and sources of fingerlings in the Lake Victoria Basin, Tanzania. (Source: TAFIRI Unpublished Reports). Key: WS = Wild Sources, FF = Farmer to Farmer, NGO = Non-Governmental Organization, G = Government

the lack of consistent data on fishpond production, the increase in the number of fishponds was not correlated with the yields.

The results indicated a further increase in the average size of fishponds in Mara and Kagera Regions of the Lake Victoria Basin, Tanzania (Fig. 7.2). The sizes of two dams (16,500 m^2 and 30,000 m^2) in Tarime District, which were constructed and stocked in 1967 and 1968 (Fisheries Division 1967) are not included in Fig. 7.2. There is no information on the pond sizes from Mwanza Region. The number of people involved in fish farming activities in the whole basin increased from 60 in 1998 (Bwathondi et al. 1998) to 500 in 2005 (TAFIRI, unpublished data). The available information does not indicate the number of people involved in fish farming before 1998.

7.2.4 Fish Species Farmed

The survey conducted in the basin recorded several fish species that have been cultured in different areas of the basin over the years. Table 7.1 summarizes the types of fish species cultured from 1967 to 2005. Through research, it was established that the Nile tilapia (*O. niloticus*) and the African sharptooth catfish (*C. gariepinus*) are the preferred cultured species, with *O. niloticus* being the most preferred species. Since 1997, emphasis was put on the culture of these two fish species. However, a study by Shoko and Onyango (2005) found that *O. leucostictus* was mistakenly identified as *O. niloticus* and cultured in some fishponds supervised by NGOs and CBOs.

Table 7.1 Type of fish species cultured in Mara, Mwanza and Kagera Regions of Lake Victoria Basin, Tanzania

Year/Region	Mara	Mwanza	Kagera
1967		*Oreochromis esculentus*	
		T. zillii	*Tilapia zillii*
		T. andersoni	*T. melanopleura*
			T. esculentus
			T. machrochir
1993	*O. niloticus*		
	C. gariepinus		
	Oreochromis spp.		
	P. aethiopicus		
	Tilapiines		
1997		*O. niloticus*	
		C. gariepinus	
		Tilapiines	
1998			*Bagrus docmac*
			O. niloticus
			C. gariepinus
			Tilapia spp.
2000	*O. leucostictus*		*O. leucostictus*
	O. niloticus		*O. niloticus*
	Tilapia spp.		*C. alluadi*
	C. gariepinus		*Barbus altianalis*
2005	*O. niloticus*	*O. niloticus*	*O. niloticus*
	C. gariepinus	*C. gariepinus*	*C. gariepinus*
	O. leucostictus	*O. leucostictus*	*O. leucostictus*

7.2.5 Adoption of Technologies

The cage culture technology, which was experimented with at the NFFTI and TAFIRI (NFFTI 1972; Kashindye et al. 2015) is yet to be adopted by fish farmers in the basin. Poor fishpond management has been reported to be responsible for low pond yields over the years (Fisheries Division 1968; Shoko et al. 2011b; Shoko et al. 2014). Pond fertilization techniques of using cribs were recommended and adopted by fish farmers for pond management. Fish farmers adopted the practices of stocking of fish at a low density of two fingerlings per square metre and feeding their fish with diets containing cotton seed cake as the main ingredient twice per day (Shoko et al. 2003a, b; Shoko 2004). However, recent studies show an increase in stocking density of *O. niloticus* and *C. gariepinus* from 2 to 13 fish m^{-2} (Imani et al. 2014; Shoko et al. 2014, 2015, 2016a, b).

However, it was established that, despite the preference for culture of *C. gariepinus*, it is difficult for farmers to obtain the fingerlings of this species (Shoko and

Onyango 2005). This fish species does not reproduce in captivity. Thus, the technology of producing fingerlings of *C. gariepinus* through artificial spawning was introduced and people were adopting it. One farmer had already adopted the technology by 2004 and in 2005, a total of 15 farmers were in the process of acquiring the technology (Shoko and Onyango 2005). A few farmers (two in Kagera Region and five in Mara Region) have adopted an integrated agriculture-aquaculture system (IAA) where aquaculture is incorporated in other farm enterprises such as animal and crop husbandry (Shoko et al. 2011a).

7.2.6 Extension Services

Training of Fish Farmers and Service Providers

The extension officers in collaboration with researchers and NGOs have trained farmers on various aspects of fish farming as indicated in Fig. 7.3. The training covered general fish culture techniques, artificial spawning of *C. gariepinus* and the integration of aquaculture in other farm enterprises such as crop and animal husbandry. The number of people trained in fish farming rose from 82 in 1998 to 355 in 2003, but dropped to 72 in 2005 (Fig. 7.3).

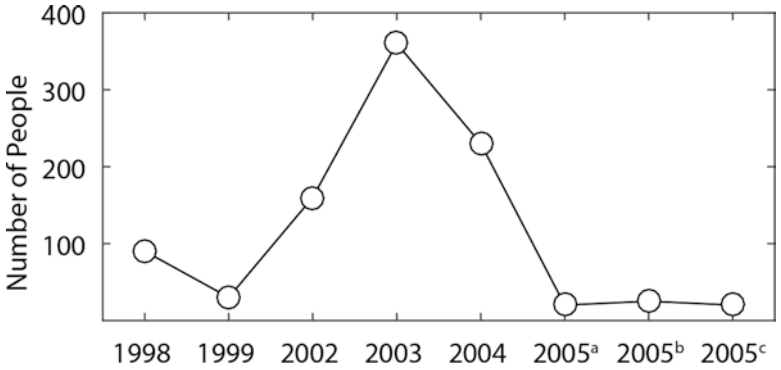


Fig. 7.3 Number of people trained and the type of training offered (See the table below for the type of training offered and source of data)

Year	Type of training	Source
1998	General fish culture techniques	Fisheries Development Division (Shoko AP, personal communication)
1999	Artificial insemination of *C. gariepinus*	Bwathondi et al. (1999)
2002	General fish farming techniques	Mogabiri Agricultural Extension Centre (Shoko AP, personal communication)
2003	General fish farming techniques	Mogabiri Agricultural Extension Centre (Shoko AP, personal communication)
2004	General fish farming techniques	Mogabiri Agricultural Extension Centre (Shoko AP, personal communication)
2005a	Artificial insemination of *C. gariepinus*	Magoma (Shoko AP, personal communication)
2005b	Integrated aquaculture-agriculture (IAA)	Shoko and Onyango (2005)
2005c	General fish farming techniques	Shoko AP. (personal observation)

Non-Governmental Organizations and Community Based Organizations

Findings from several studies have recorded a number of NGOs and CBOs involved in providing fish farming extension services (Bwathondi et al. 1993; Mahika et al. 2001; Shoko and Onyango 2005). These NGOs have been in operation since 1990, which is an average of 15 years. The oldest and youngest organizations are the Tanganyika Christian Refugee Services (TCRS) in Ngara District and the Serengeti District Development Programme (DDP), which have been in operation for 31 years and 1 year, respectively (Shoko and Onyango 2005). Some of the fish farming extension services offered include pond preparation, fertilization and general pond management including harvesting (Shoko and Onyango 2005). A list of these organizations and their areas of operation is summarized in Table 7.2.

Fish Fingerlings Production Centres

During the 1950s and 1960s when fish farming was introduced in the basin, fish fingerlings were obtained from the Malya fish farm and Rwamishenye breeding ponds in Mwanza and Kagera Regions, respectively. Fish fingerlings from Malya fish farm were supplied to areas as far as Kahama and Tabora. Also, Nyalutiti dam which was owned by Rulenge Refugee Camp in Ngara District, Kagera Region was used to supply fingerlings to fish ponds in the Rulenge Camp (Fisheries Division 1968). The Malya fish farm station collapsed after the grant from Food and Agriculture Organization/International Development Agency (FAO/IDA) was stopped; whereas the Rwamishenye breeding ponds collapsed after the government ran short of funds. Thereafter, fish fingerlings were sourced haphazardly.

Table 7.2 NGOs and CBOs offering fish farming extension services

Name of Organization	Organization type	District	Region
Norwegian Peoples AID	NGO	Biharamulo	Kagera
Faiders Group	NGO	Biharamulo	Kagera
Tweyambe Fishing Enterprise	CBO	Muleba	Kagera
Daily Action Development Trust	NGO	Bukoba	Kagera
Tanganyika Christian Refugee Service (TCRS)	NGO	Ngara	Kagera
Relief Development Society (REDESO)	NGO	Ngara	Kagera
Ecovic	NGO	Nyamagana	Mwanza
Heifer Project International (HPI)	NGO	Nyamagana	Mwanza
Community Based Health Program Promotion (CBHPP)	NGO	Serengeti	Mara
Serengeti District Development Program (DDP)	NGO	Serengeti	Mara
Serengeti Farmers Association (SETA)	NGO	Serengeti	Mara
Mogabiri Farmers Extension Centre	NGO	Tarime	Mara
Buhemba Farmers Extension Centre	NGO	Musoma Rural	Mara

Source: Shoko and Onyango (2005)

Efforts to produce fingerlings have been made by some churches such as Mennonite and Lutheran. By the year 2000, quality fish seed production was still a serious problem. Further efforts were made by the NFFTI, Mwanza and the Mennonite Church in collaboration with the Lutheran Church in Arusha to supply fish fingerlings to farmers. According to Mahika et al. (2001) most respondents (62%) obtained fingerlings from NFFTI (Fig. 7.4). Other sources of fish fingerlings included farmer-to-farmer delivery and wild sources (Fig. 7.4). In 2000, the types of fingerlings stocked in ponds showed that the targeted fish species were *O. niloticus* and *C. gariepinus* at 23% and 11%, respectively. Although the above institutions supplied fish fingerlings to farmers, the fingerlings were of poor quality.

In 1997, the LVEMP Project took deliberate measures to produce quality fish fingerlings of *O. niloticus* by establishing four and ten fish breeding ponds at NFFTI and TAFIRI, Mwanza respectively. Breeding ponds established at Nyegezi (NFFTI) and TAFIRI were used as sources of fingerlings for fish farmers. A total of four (4) breeding ponds were also established in Magoma village in Tarime District with the aim of bringing fish fingerlings production centres closer to the community. In addition, fingerlings produced from farmers' ponds have been used by other farmers due to an inadequate supply of fingerlings from NFFTI and TAFIRI.

A fairly modern hatchery was built at TAFIRI Centre, Mwanza in addition to the fish breeding ponds existing at the Centre. The hatchery has two circular concrete and 18 polyethylene ('Polytex') experimental tanks. The facilities in the hatchery were used for conducting fish farming research on the nutrition and

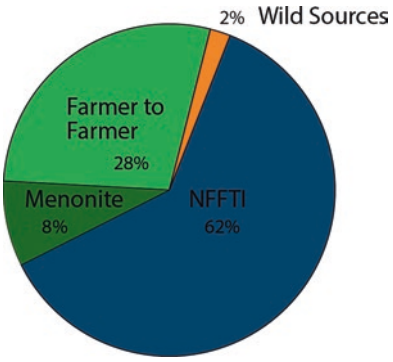


Fig. 7.4 Sources of fish fingerlings in the Lake Victoria Basin in the year 2000

artificial spawning of *C. gariepinus* and for training of farmers. All these activities were aimed at developing appropriate fish farming technologies in order to enhance fish production and alleviate poverty in the three riparian regions.

Following the LVEMP intervention, the Fisheries Management component in collaboration with TAFIRI, supplied a total of 21,743 *O. niloticus* fingerlings to fish farmers in the Lake Victoria Basin from 1999 to 2005. The Kagera Region received the highest number of fingerlings (11,670) followed by Mara Region (6,068) and Mwanza Region (3,930). Apart from the Lake Victoria Basin, some fingerlings were supplied to Morogoro Region (700) and Tabora Region (1,740). Additionally, a total of 2,800 *C. gariepinus* fingerlings were produced by TAFIRI Mwanza researchers in collaboration with the Heifer Project International (HPI), an international NGO based in the Lake Victoria Zone. The fingerlings were supplied to fish farmers in Misungwi District, Mwanza. However, there are no records on the number of fingerlings distributed in the basin before 1999.

Development of a Fish Farming Strategic Plan

Efforts to develop aquaculture in the Lake Victoria Basin started during the colonial era and continued after independence in 1961. However, aquaculture development was not supported by any strategic development plan until 2005 when a draft plan was developed. The strategy was geared towards implementing the National Fisheries Sector Policy and Strategy Statement of 1997. The strengths, weaknesses, opportunities and challenges (SWOCs) for aquaculture development in the basin were identified following a thorough review of the external and internal situations (Table 7.3). The SWOCs formed the basis for identifying the strategic issues to be addressed in a five-year strategic plan from 2005/06 to 2009/10.

Table 7.3 Strengths, weaknesses, opportunities and challenges (SWOCs) analysis

Strengths	Weaknesses
Existing National Fisheries Policy and Act	Inadequate awareness on fish farming practice to potential fish farmers
Suitable soils for fish pond construction	
Reliable sources of water	Inadequate fish farming extension services
	Lack of quality fingerlings
Reliable sources of brood stock	Inadequate facilities for fish farming
Adequate interested fish farmers	
Adequate fish farming expertise and leadership structure	Lack of transport facilities for extension workers
Availability of fertilizers for pond fertilization	Inadequate legal framework for ownership of land for aquaculture
	Poor fish pond management
	Lack of demonstration fish ponds closer to fish farmers
Adequate fish farming experience in the basin	Low fish yields amidst high expectations
	Lack of credit schemes for fish farmers
Availability of supplementary feeds	Low priority accorded to fish farming activities by fish farmers and local authorities.
Adequate knowledge of conservation of fish farming environment	
Availability of labour	Lack of quality fish feed
Availability of equipment for pond construction	
Existence of aquaculture Fisheries Training and Research Institutes	Stunted growth of cultured fish especially tilapias
	Difficulties in accessing credits from financial institutions to support aquaculture
	Inadequate capacity to promote fish farming
	Inadequate research information
	Inadequate support to research and training institutes
	Lack of gender balance in fish farming practice
	Inadequate knowledge on markets for farmed fish
Opportunities	Challenges
Favourable legal and policy environment	Unexpected changes in weather such as El-Nino floods
Availability of markets for farmed fish	Changes in government development priority due to change of government policies

(continued)

Table 7.3 (continued)

Strengths	Weaknesses
Employment for youths	Existence of fish predators and competitors such as otters, snakes, frogs, etc.
Reduction of malnutrition	
Emerging credit schemes with less stringent conditions	Theft of fish from fish ponds
	Outbreak of fish diseases
Existence of Non-Governmental Organizations and Community-based Organizations that can contribute to awareness raising on fish farming	Resource (e.g., water) conflicts between fish farmers and peasants and pastoralists
	Conflict of interest among stakeholders on water uses
Existence of government research and training institutes	Unexpected prolonged droughts
Availability of renewable sources of energy for aquaculture (windmill and solar energy)	
Increased costs of fishing	
Existence of high demand for *C. gariepinus* fingerlings for bait	
Existence of numerous small water bodies that can support aquaculture	
Existence and ability to use internet facilities by fish farmers	
Declining catches from capture fisheries and increase in human population	

7.2.7 Stocking of Small Water Bodies

A substantial number of small water bodies, referred to as public reservoirs, were constructed and stocked with different fish species in the Lake Victoria Basin during the 1950s and 1960s (Fisheries Division 1967, 1968). According to Bailey (1968) fish fingerlings were distributed to public reservoirs. Existing records only mention Malya dam in Kwimba District, Mwanza Region, which was constructed and stocked with fish during the colonial era. Kyarano dam in Butiama village, Bunda District in Mara Region was constructed in 1985 and stocked with tilapiines in 1994 by the Fisheries Development Division (E. Kilosa, pers. comm.).

Several dams in the Lake Victoria Basin were reported to have been "self-stocked" (i.e. fish entered the dams from rivers without deliberate attempts by man) by tilapiines and catfishes (Bwathondi et al. 1993, 1998; Bwathondi and Mahika 1997). Such dams include 45 dams in Mara Region, 25 in Mwanza and one dam in Kagera Region. On the other hand, deliberate efforts were made by TAFIRI to stock two dams in 1997, three dams in 2003 and 2005 all in Mara Region. Generally, there had been no deliberate efforts by the Government to put sufficient emphasis on fish farming in small water bodies, in the basin and in Tanzania as a whole.

7.3 Discussion

7.3.1 Fish Farming Potential

The results have shown that Lake Victoria Basin has the potential of increasing farmed fish production, but this potential has not been fully tapped for food production. Deliberate efforts need to be made to tap this potential through the use of improved technologies, urging the private sector to invest in aquaculture and sensitizing the farmers in the Lake Victoria Basin to practise fish farming. With an estimated 70% of Africans being both farmers and consumers of agricultural products, it has been indicated that Africa has the potential for expansion of aquaculture, which could increase production levels due to the existence of suitable climatic and physical characteristics (Brummett et al. 2008). Furthermore, about 37% of sub-Saharan Africa is suitable for small-scale aquaculture and 23% for commercial aquaculture (Brummett et al. 2008); however, less than 5% is utilized for the purpose (Kapetsky 1994; Aguilar-Manjarrez and Nath 1998).

Several factors are behind poor development in fish farming activities/business in the Lake Victoria Basin, Tanzania. These include lack of expertise due to inadequate extension services, lack of quality fish fingerings and feeds; lack of financial backing by financial institutions; and the reliance of the government on external support (Bwathondi et al. 1993; Bwathondi and Mahika 1997; Bwathondi et al. 1998; Mahika et al. 2001; Mbilinyi and Shoko 2002). In addition, most fish farmers lack self-initiative in developing fish farming while others regard it as a hobby or part-time activity (Shoko et al. 2011c).

The potential of fish farming as a source of protein and income can only be realized through proper planning, management and correction of setbacks. Fish farming practised in the basin is mostly for subsistence, which may not contribute significantly to the welfare of the people. Fish farmers should be inspired to consider fish farming as an important activity not only for protein provision, but more importantly for income generation. The Government must consider the aspect of financial and institutional arrangements for small-scale operators to benefit from this subsector of the economy. It has been suggested that for increased fish production from aquaculture, government policy should be geared towards the promotion of commercial investments, which can lead to future growth (Ridler and Hishamunda 2001; Hishamunda and Manning 2002; Hishamunda and Ridler 2002).

7.3.2 Culture Systems Used

From the results, it is clear that pond culture is the main culture system used for fish farming in the Tanzanian part of Lake Victoria Basin. The pond culture system is mainly semi-intensive and is practised by subsistence farmers in static earthen ponds (Shoko et al. 2011c, 2015, 2016a, b). The development of fish farming is not

only measured by the number of culture systems practised but rather by the yields obtained from a particular system. Freshwater pond culture has shown great potential in East and Central Africa despite the fact that the fish yield is still low (Shoko et al. 2011c). Fish yields from ponds can only be realized through proper pond management. Shoko et al. (2011c) reported poor fishpond management in Lake Victoria Basin where most fishponds were not fertilized, and fish were not properly fed. Some fishponds were choked with grass and were completely abandoned. However, fishpond culture has proved successful in other parts of the world such as Asia (de Silva and Davy 2010).

Fishpond management can be enhanced through the integration of fish culture with other farm enterprises, particularly crop and animal husbandry (Shoko et al. 2011c). The common practice for fish farming development in Africa has been that of fishponds as a stand-alone enterprise. Fishponds have been promoted almost exclusively as a source of fish production. This has made fish farming to be considered a part-time activity, with more time being devoted to other activities, thereby seriously reducing time for tending fish. Efforts to link fish culture with other livestock production activities such as poultry and vegetables by small-scale farmers have been initiated recently in Tanzania (Shoko et al. 2011c; Limbu et al. 2016b). Fish yields have usually been poor because most of the farms were nutrient-starved, which led to the abandonment of thousands of fishponds.

The creation of awareness for fish farming communities around the Lake Victoria Basin, Tanzania, to integrate fish farming in the overall farm enterprises through integrated aquaculture-agriculture should be encouraged. Under such integration, a fishpond, which is in most cases a newly introduced enterprise, can be integrated into the on-going farm activities, relying largely on farm residues as pond inputs, especially feeds and/or fertilizers, to increase fish production. In such systems, a fishpond can have a pivotal role in supporting other activities, e.g. dry-season vegetable gardening using fertile water from the ponds, and increased crop production using pond mud to fertilize nutrient-depleted fields. Maximum fish farming production for income generation and poverty alleviation will be realized through this kind of integration.

7.3.3 Number, Size and Yield of Fishponds

The results indicated an increase in the number of fishponds in the 1960s, but the activity almost collapsed between 1970s and 1990s, and picked up again from the late 1990s to 2005 (Fig. 7.1). This trend can be explained in part by the post-colonial donor support initiatives, which failed because of top-down arrangements made between the Government and donors, typically alienating the farmers (Bwathondi and Mahika 1997; Bwathondi et al. 1998). Those initiatives collapsed after the funds were exhausted. Furthermore, during the 1970s to 1980s, low priority was given to aquaculture activities, as more emphasis was given to other sectors of the

economy such as agriculture, wildlife, human settlements, and education, among others (United Republic of Tanzania 1982).

The advent of the LVEMP in 1997 made deliberate initiatives on fish farming practice. The project deviates significantly from the experience of the past, and farmers were provided with technical support and left to develop spontaneously. Since fish fingerlings were provided to fish farmers free of charge in the pilot districts, people became interested and soon the activities spilled over to other areas. This is evidenced by a significant increase in the number of ponds during this period.

Results from various studies show an increase in the yield from cultured fish over time. A study by Shoko et al. (2011c) reported a yield of 1,823 kg/ha from fishpond yields in the basin. A gross yield ranging from 2,624 ± 242 to 14,575 ± 1,658 kg/ha was obtained by Shoko et al. (2016b) for *O. niloticus* cultured in monoculture at stocking densities of three and six fish per square metre respectively. For *C. gariepinus* cultured in monoculture at stocking densities of three, six and nine fish per square metre, gross yields of 8,014 ± 75, 14,022 ± 28 and 17,175 ± 1,389 kg/ha were obtained by Shoko et al. (2016a), respectively. Such results are comparatively higher than pond yields reported elsewhere in the tropics. Bardach et al. (1972) reported that where monoculture of tilapiines such as *O. niloticus* is practiced with fertilization and supplementary feeding, yields of between 1,000 kg/ha and 2,500 kg/ha could be achieved. Mafwenga (1994) reported an average fishpond yield of 1,400 kg/ha and 1,900 kg/ha respectively from Mbeya, Iringa, Arusha and Ruvuma regions in Tanzania. The yields for the three fish per square metre stocking density are relatively comparable to gross yields of 3,649 ± 910 kg/ha for *O. niloticus* and 2,746 ± 527 kg/ha for *C. gariepinus* fed on mixed ingredients obtained by Limbu et al. (2016a) in Morogoro region, Tanzania.

Increased yields are related to improved pond management and increased stocking densities. The yield could be more improved by adopting a polyculture system of the two commonly cultured species in Tanzania (Shoko et al. 2016b). The fact that fishpond yields of the 1990s differ from the yields of the 2000s indicates that deliberate efforts should be made to improve fishpond management in the Lake Victoria basin. However, there was no correlation between the increase in the number of fishponds and the yields due to lack of data.

The size of fishponds is an important aspect in attaining maximum fishpond yields. Despite the fact that fish farming in the basin started during the colonial era (Fisheries Division 1967, 1968) yet most of the ponds were small (less than 100 m^2) which resulted in low fish yields. In their study, Shoko et al. (2011c) reported that 96% of the ponds sampled had an average area of 166 m^2, which is an improvement from the colonial era. Fish farming experience has shown that in semi-intensive farming systems, very small ponds have a negative impact on the welfare of fish.

With the current level of pond management, it is recommended that fish farmers should not construct ponds of less than 200 m^2; and the stocking density should be >3 ind./m^2, depending on the management regimes, in order to attain maximum fish yields. The ponds should be constructed in a manner that allows sunlight and heat reception in order to promote natural primary and secondary productivity. There is a slight increase in pond size over time as indicated in Fig. 7.2. Although this

increase may not be significant, it is nevertheless a sign that fish farmers are shifting from small size fishponds to bigger ones.

7.3.4 Farmed Fish Species

Results have shown that both indigenous and exotic fish species have been cultured in the basin. Probably the culture of indigenous fish species in the basin was caused by the fact that Lake Victoria was dominated by those species prior to the 1980s. Indigenous fish species from Lake Victoria are a delicacy to the people of the basin, which may dictate for their preference in aquaculture (Bwathondi et al. 1998). According to FAO (1994), many indigenous fish species are preferred by consumers but have not yet been fully tested as candidate species for aquaculture.

The NFFTI conducted cage and pond culture experiments of *O. esculentus* and found it to have a positive growth. In another experiment, *T. zillii* showed positive growth under pond culture (NFFTI 1972). Moreover, *O. variabilis* showed a better growth performance when fed on cotton seed cake containing a diet other than the soya bean meal, and a feed mixed with cotton seed cake and soya beans, referred to as a composite diet (Shoko 2002). Results from studies like these, should be adopted and practised by researchers, managers and interested fish farmers. Research results could be tested in the pilot areas to assess their performance before being introduced to farmers upon success.

Studies have also showed that people from Kagera Region prefer to culture "Mbofu" *Bagrus docmac* (Bwathondi et al. 1998) whereas those from Luo land in Rorya district of Mara Region prefer "Kamongo" *Protopterus aethiopicus* (Bwathondi et al. 1993). Such fish species could be more accepted for culture by people living in those areas than any other species once their culture technologies are established. The Nile tilapia (*O. niloticus*), though exotic to Lake Victoria, is the most preferred fish species in aquaculture in the basin due to its proven high nutritive qualities. In addition, most of its culture technologies are well known. Efforts should be made to promote the culture of this species while developing culture technologies for other preferred fish species such as those mentioned above.

Presently, the African sharptooth catfish (*C. gariepinus*) is also cultured in monoculture or polyculture with *O. niloticus* (Shoko et al. 2015, 2016a, b). Moreover, its fingerlings are preferred as bait in the Nile perch fishery. The species is sourced from small water bodies such as dams and rivers. Unfortunately, *C. gariepinus* is one of the threatened fish species, which has just started to reappear in these water bodies, acting as refugia (Mkumbo and Mlaponi 2007). The culture of *C. gariepinus* will serve as a source of high quality protein and income generation for the communities through the sale of fingerlings for bait in the Nile perch fishery and fish for food.

Despite the efforts made by the LVEMP to establish fish breeding ponds for fingerlings production, the demand for the same could not be met because more people became attracted to the aquaculture venture. The government and the private sector

should make efforts to establish more hatcheries, particularly of *O. niloticus* and *C. gariepinus*, in the districts where fish farming is practiced. This will reduce the costs involved in transporting fingerlings and reducing unnecessary mortality.

7.3.5 Adoption of New Technologies

Results have shown that most experimental works do not go beyond the experimental stages. Once a study is completed there are no initiatives to make sure that the results of the work are extended for adoption by farmers. Fish farming development in the Lake Victoria Basin and Tanzania in general will only be achieved through the development of simple technologies suitable to local conditions (Limbu et al. 2016a). The rapid aquaculture development in countries like China, for example, was strongly backed by development in research and technology (Hishamunda and Subasinghe 2003); Tanzania ought to do the same.

7.3.6 Extension Services

Despite the efforts made by the Government and private sector to provide extension services to farmers, general knowledge on fish farming and its management is still inadequate. Results have shown that the Government and NGOs conducted little training. A study by Mahika et al. (2001) reported a number of NGOs, which did a commendable job in fish farming extension services although their activities were uncoordinated. Shoko and Onyango (2005) report the existence of 14 NGOs, which provided fish farming extension services in the basin (Table 7.2).

Some of these organizations are so deeply rooted in the communities that it has become difficult for other fisheries extension officers to access the farmers and train them without passing through the respective NGOs. It was reported that these NGOs are playing an important role despite some observed weaknesses, which need to be corrected (Shoko and Onyango 2005). Experience has shown that a partnership that involves scientists, extension officers and most importantly, the farmers, has proven successful in fish farming development (Pullin and Prein 1995). In this partnership, farmers are given an opportunity to study, discuss and learn from each other, and then develop strategies for improvement together.

The biggest obstacle to fisheries development is inadequacy of effective fisheries extension services. In order to accelerate socio-economic development in the fishing communities, an extension programme on how to use modern methods and techniques is essential. Fortunately, the National Fisheries Policy of 1997 recognizes the importance of effective fisheries extension services and for that matter has policy statements on education, aquaculture development, community participation, and fisheries information management, among others (United Republic of Tanzania 1997).

The Fisheries Development Division started to provide effective fisheries extension services when fishers were trained at the NFFTI. The training was on engine repair and maintenance, fish handling and processing using improved methods, gillnetting, long lining and fish farming among others. This training programme was terminated in 1966 (Fisheries Division 1967). Generally, the fishers who were trained admitted that the training was useful to them. Proper training and especially the demonstration of improved fishing methods, fish handling and processing will improve efficiency and increase income for the riparian communities.

7.3.7 Stocking of Small Water Bodies

Fisheries in small water bodies usually operate at a basic level and could provide opportunities to supplement the diets of poor people/families. Results have shown that there were some efforts to stock smaller water bodies, referred to as public reservoirs, during the 1960s. Although reports do not show the exact number of these reservoirs, the available information show that fish yields and income were generated from these waters (Fisheries Division 1967, 1968).

Observations have shown that there are several dams in the Lake Victoria Basin, which can be used for aquaculture under simple management techniques. The same can be done for temporary dams, where fish would be harvested before the commencement of the dry season. The communities should be taught how to properly protect these dams for the sustainable management of the fishery resources within them. Such efforts can provide fish and income to the riparian communities.

7.4 Conclusion

All things considered, it is clear from the available data, that the fish stocks of the three commercial fish species, namely *L. niloticus*, *O. niloticus* and *Rastrineobola argentea* are heavily exploited, primarily due to high demand in both domestic and foreign markets. This situation, coupled with the high levels of poverty in the Lake Victoria Basin, has only served to highlight the importance of fish farming as an alternative source of protein and income for the riparian communities. Fish farming can help to reduce fishing pressure on capture fisheries and contribute significantly to the conservation of the lake's biodiversity. Ultimately, fish farming will generate income for the people, which is in line with the government's efforts to alleviate poverty in the country.

The Lake Victoria Basin has great potential for fish farming development, which unfortunately, has not been tapped for food production. Fish farming in Lake Victoria Basin has not developed significantly because the constraints that have been reported since the 1960s have not been fully addressed. Currently fish farming

is carried out mostly for subsistence, which cannot contribute adequately to the welfare of the people.

7.5 Recommendations

Based on this review, the following recommendations are made:

- Data on fish farming activities should be gathered and submitted to the Fisheries Headquarters by district fisheries officers every 3 months. Specifically, the data should be on the following: (a) the number and size of stocked fishponds; (b) fishpond yields and the income generated; (c) the number of men and women participating in fish farming; and (d) the types and amount of fertilizer and fish feeds used.
- Detailed basin-wide surveys/inventories on fish farming activities should be conducted every year.
- Fish farmers should be encouraged to keep records of inputs and the outputs of their farms for ease of monitoring and planning.
- There should be close government supervision (provision of technical support) through frequent visits to farmers.
- More community-based fish breeding hatcheries should be established in potential districts for the provision of fish fingerlings to farmers. Such fingerlings should be sold to farmers at affordable prices.
- Emphasis should be directed towards an IAA in order to raise overall farm yields (i.e. fish, crops and/or tame animals).
- Joint researches should be conducted by institutions, NGOs and fish farmers.
- The farming of *C. gariepinus* should be promoted in order to produce live bait for Nile perch fishery and to produce food for the people. The production of *C. gariepinus* will also reduce the exploitation of wild stocks.
- In collaboration with the Department of Aquatic Sciences and Fisheries Technology of the University of Dar es Salaam (UDSM), Department of Animal, Aquaculture and Range Sciences, Sokoine University of Agriculture, and TAFIRI, the government should establish a national modern hatchery for aquaculture research and development. Fish farming stakeholders such as local government authorities, universities, NGOs and CBOs should internalize the Fish Farming Strategic and Development Plan so that it can be successfully implemented. On its part, the government should use this plan to promote fish farming in the country.
- The government also needs to accept the fact that science and technology are the most important drivers of the economy and provide funds for the development of aquaculture technology that is suitable to the Tanzanian environment. Besides, the government should regard the small water bodies in the country as potential areas for aquaculture. All the dams should be stocked with fish for consumption

and income generation by the people living around or near them, and should be managed using simple management methods. Finally, an assessment of the impact of the decrease in water levels in Lake Victoria on aquaculture should be conducted.

- Efforts on extension services should be continued in order to reduce the loss of income due to poor fish handling and processing methods, inadequate dissemination of information, absence of fishers' associations and inadequate market information, among others.

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