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ASSESSMENT OF THE IMPACT OF INTRODUCTION OF CULTURE BASED FISHERIES ON FISH PRODUCTION IN WATER BODIES OF ETHIOPIA

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Abstract

In Ethiopia, the implementation of comprehensive water resources development program, particularly irrigation and hydro power generation could be additional opportunity to increase farm productivity through integration of culture based fishery and water resources uses. The role of fishery and aquaculture in reducing poverty and alleviating food insecurity at household level is enormous. The main objective of the study was to assess the overall activities of fish stocking programs and their impacts on enhancing the fish production and contribution to food security in six regions of the country: Tigray, Oromia, Amhara, Southern Nations, Nationalities and people (SNNP), Afar and Somali Regional States. Both secondary and primary data were used for the assessment. The first fish introduction and stocking program in Ethiopia was started in 1925. Fish harvested in the reservoirs and natural water bodies enhanced by stocking contribute up to 15% of the annual fish production of the country. The development strategy for culture based fishery must rely on scientific evidence and stocking density should be based on the trophic status of the reservoir, desired market sizes of fish, and projected yields.

Key Words: *Carp, Culture based fishery, Fish introduction, Food security, Reservoirs, Tilapia*

Introduction

According to FAO (1994), culture based fisheries are stock enhancement practices in water bodies that are generally incapable of supporting sustainable fisheries through self-recruiting fish populations, and where the stock is managed and owned either individually and or collectively. Accordingly, culture-based fisheries practices fall within the realm of aquaculture, which is often conducted in reservoirs and small water bodies, perennial or seasonal, that retain water at least for six to eight months of the year. Culture based fisheries are essentially direct stock and recapture strategies that result in significantly higher fish yields than otherwise would have been possible through natural recruitment. Culture based fisheries are relatively low cost activities, environmentally acceptable practice, with the main external input being seed stock, most developing country governments regard culture based fisheries to be relevant to and an integrated part of rural development (De Silva, 2003).

Culture-based fishery practices are essentially non-consumptive practices of primary resources, in particular water, in

contrast to the more conventional aquaculture practices such as pond culture. Moreover, culture-based fisheries often do not involve external inputs, such as feed, and therefore are environmentally less disturbing than traditional aquaculture practices. The major reasons for fish introduction and stocking in the world are food and income, restoration, biomanipulation, conservation, mitigation and restoration (FAO, 1999). Globally, reservoirs and lakes (manmade impoundments, natural lakes, floodplain depressions, oxbow lakes, lagoons etc.) are most commonly stocked (FAO, 1999). The primary purpose of stocking these water bodies in developing countries is to increase the food fish supplies, whereas in developed countries it is to enhance recreational fisheries and for conservation purposes (Welcomme and Bartley, 1998).

Worldwide evaluation studies are indicating that currently culture based fisheries and other forms of aquaculture is contributing to an increasing share of the world's food supply. Figures provided by the Food and Agriculture Organization of the United Nations (FAO) shows that aquaculture has increased in importance, with a global growth rate of outstripping that of livestock meat production by a factor of two to four (FAO, 2014). According to the newly released FAO, 2014 statistics, the world aquaculture production in 2012 was 90.43 million ton, including 66.63 million ton of food fish, 23.78 million ton of aquatic algae (mostly marine macro algae / seaweeds) and 22.4 thousand ton of non-food products (pearls and shells, etc.).

The practice of aquaculture in Ethiopia has not really taken off, it is more a potential than an actual practice. The country is gifted with different agro ecologies and huge water resources suitable for development and production of aquaculture. The predominant type of aquaculture activity in the country is the culture based fishery which is a form of extensive aquaculture conducted in reservoirs. Currently implementing comprehensive water resources development program of the country, particularly irrigation and hydro power generation could be additional opportunity to increase farm productivity through integration of culture based fishery and water resources uses. The fish introduction program in the country based for rural farmers and the technology is simple, low cost operation, with selection of appropriate species based on rough estimation of environment suitability (basic analysis of water quality, like water temperature measurements and simple Physico-chemical tests) and fish availability. Only knowledge-based stocking programs gives the opportunity to achieve target goals of stocking with limited environmental impact (Welcomme, 1988). This paper attempt to record and review the major stocking programs with native and non-native fish species that took place in all parts of Ethiopia.

Materials and Methods

The study assessed six regions of the country: Tigray, Oromia, Amhara, Afar, Somali and Southern Nations, Nationalities and people Regional States. Two sources of data primary and secondary were used for the study. The primary data was collected using a participatory approach that covers all the key players that includes fishers, resource person, development agents, as well as traders involved in fish business. Data was collected through questionnaire administration, interviews, discussions,

and personal observation in the field. Secondary data collected from research reports and publications, fishery sector review papers, development plans, project documents, previous surveys and related unpublished documents.

Results and Discussion

The first fish stocking program in Ethiopia was carried out around 1925 when *Oreochromis niloticus* (L.) from Lake Metehara was introduced into Lake Bishoftu and other crater lakes (Lake Arenguade, Lake Babogaya, Lake Hora, Lake Kilole) around Debre Zeit (Bazzi, 1955; Prosser *et al.*, 1968). Shibru and Fisseha (1981) indicated that the first attempt to introduce non-native fish species to the country was made in 1938 by "Establishmento Ittiogenico di Roma" which introduced the pike *Esox lucius L.*, and the gambusia, *Gambusia holbrooki* Girard into Lake Tana. This has been followed by introduction of common carp, *Cyprinus carpio L.,* and crucian carp*, Carassius carassius*. Fish stocking is the primary source of fish in culture based fisheries, in which fish are released into water bodies, where there was no fish originally, to increase the supply of fish as food in rural areas, as well as providing additional income to rural farmers, thereby contributing to poverty alleviation (Table 1).

In general the stocking programs were limited to few fish species (*Oreochromis niloticus*, *Tilapia zilli, Clarias gariepinus* and non-native *Cyprinus carpio* and *Carassius carassius*) and fishless water bodies of natural or man-made origin. The fish used for stocking were typically fast growing species that feed lower in the food chain along with other determining factors including the availability of suitably sized, good quality seed stock and prevailing consumer preferences. Most of the fishery stocking programs are low cost operation, with selection of appropriate species based on rough estimation of environment suitability (basic analysis of water quality, like water temperature measurements and simple Physico-chemical tests) and fish availability. Due to lack of fish breeding stations the majority of stocking has to be carried as translocation of young fish collected from nearest inhabited lake or river. However, the contribution from such stocking programs might be very significant, like that obtained from fish landed from the reservoirs Fincha and Amerti in Oromia region, lakes Haik and Ardibo in Amhara region and Hashengie in Tigray region. Thus the results from the stocking program encourage a more deep study of a development of fish stocking and culture at a wider scale.

The main reason for deliberate fish introductions and stocking of fish, most usually decided by fishery experts were for enhancement, restoration, creation of new fisheries, biological control of aquatic plants and vector disease control. The species combinations in introduction and the proportion of each species used differ from water body to water body and region to region. These were determined through water temperature and seed availability. In Lake Ziway accidental introduction of African catfish, *Clarias gariepinus* led to decline of indigenous species *O. niloticus*. Introduced species quickly colonized all parts of the lake territory (Yared, 2003). According to Ali (1990), faster growth rate, larger size and greater aggressiveness of the African catfish has given this species great advantage in competition with native species. Fish harvested in the reservoirs and natural water bodies like Koka, Fincha and Amerti in Oromia

region, lakes Haik and Ardibo in Amhara region, Tendaho in Afar region, Hashengie in Tigray region, carp and cat fish fishery from lake Ziway, carp fishery from Lake Langano and tilapia fisheries from Debrezeyet creator lakes enhanced by stocking contribute up to 15% of the annual fish production of the country. Introduction and stocking of fish into different water bodies of the country were mainly carried out in the 1970s and 1990s to improve fish production and enhance fish stocks (NFLARRC, 2002 and 2006). *Cyprinus carpi*o and *Carassius carassius* were introduced to feed on macrophytes not utilized by any other commercially important fish species while *Tilapia zilli* were introduced to enhance fish stocks. The growing of fish farming has led to introduction and transfer of Tilapia and Carp species to different corners of the country. The National Fishery and Other Living Aquatic life Research Centre (NFLARRC), former Fish Culture Station did great endeavour in stock enhancement program since the end of seventies through its hatchery and collecting fish from wild and introducing into the reservoirs and natural water bodies .

In the water bodies where fish stocking are practiced are managed by communities living beside the water bodies or downstream crop cultivators. The management processes involve gear number and mesh size control, maintaining vigilance to illegal fishing and taking care of the stock in general. As fish stocking are mostly carried out in reservoirs, which tend to be rurally located, the primary beneficiaries are those communities that live in the vicinity of the water bodies, and who have traditionally enjoyed the use of the water resource for their wellbeing. Even though the whole community (all households) may not be directly involved in fishery, the water body used is a communal property and as such all households benefit, even though to different degrees depending on the extent of involvement in the fisheries practice. In general stocking activities in the country are not governed by regulations and legislation, to ensure that stocking is conducted in a responsible and ecologically sustainable manner. Culture-based fisheries are an attractive development strategy as it mobilizes farming communities (irrigation farmers) to use existing water bodies for the secondary purpose of food fish production. The fish stocking program took place not only on reservoirs and small water bodies but also on natural water bodies for different reasons like, to enhance fish production by filling a vacant niche of the water bodies, establish fishery and mosquito control (Table 2).

Table 1: Fish stocked to manmade reservoirs to establish fishery (Getnet *et al*., 2013 NFLARRC, 2002; TBoARD, 2008; OBoARD, 2002; FRDMP, 2003; NFLARRC, 2006; Shibru and Fisseha, 1981; SNNPBoARD, 2008; Yared *et al*., 2009,)

Region	Water body	Lake/ Reservoir surface (km^2)	Stocked species		Year of stocking	Current status
			Native	Non-native		
Tigray	Enda Medhanialm reservoir	2.5	*O. niloticus* and *T. zilli*	*Cyprinus carpio* and *Carassius carassius*	1995	well established
Tigray	Korire reservoir	1.8	*O. niloticus* and *T. zilli*		1995	Well established
Tigray	Serinka reservoir	1	*O. niloticus* and *T. zilli*		1995	Well established
Tigray	Sesela reservoir	1.5	*O. niloticus* and *T. zilli*		1996	Well established
Tigray	Debella reservoir	3	*O. niloticus* and *T. zilli*		1995	Dried
Tigray	Maishut reservoir	3	*O. niloticus* and *T. zilli,*	*Cyprinus carpio* and *Carassius carassius*	1996	Dried
Tigray	Midmar reservoir	6	*O. niloticus*		2000 and 2001	Well established
Tigray	Maingus reservoir	4	*O. niloticus* and *T. zilli*		2001	Well established
Tigray	Dureanbesa		*O. niloticus* and *T. zilli*		2001	Well established
Tigray	Lahlai Wukro	8	*O. niloticus* and *T. zilli*		2001	Well established
Tigray	Derequa reservoir	3	*T. zilli*		2005	Well established
Tigray	Meila reservoir	4	*T. zilli*		2005	Well established
Tigray	Shilanat reservoir	3	*O. niloticus* and *T. zilli*		2002	Well established
Tigray	Meskebet reservoir	5	*O. niloticus* and *T. zilli*		2002	Dried
Tigray	Gerebemehese	3	*O. niloticus* and *T. zilli*		2002	Well established
Tigray	Gerebebeati	3	*O. niloticus* and *T. zilli*		2002	Well established
Tigray	Rubafelege		*O. niloticus*	*Cyprinus carpio* and *Carassius carassius*	2002	Well established
Tigray	Degeme		*O. niloticus*	*Cyprinus carpio* and *Carassius carassius*	2002	Well established
Oromia	Fincha and Amerti reservoir	350	*O. niloticus*	*Cyprinus carpio* and *Ctenopharyngodon idella*	1972	Well established
Oromia	Melka Wakena reservoir	82	*O. niloticus*	*Cyprinus carpio* and *Carassius carassius*	1989	Well established
Oromia	Koka reservoir	250	*O. niloticus*	*Cyprinus carpio* and *Carassius carassius*	1976-78	Well established

Oromia	Borta reservoir	12	*O. niloticus* and *T. zilli*	*Cyprinus carpio* and *Carassius carassius*	1990	Well established
Oromia	Into (Boji) reservoir	4	*O. niloticus* and *T. zilli*		2000	Well established
Oromia	Gomi reservoir	3	*O. niloticus*	*Cyprinus carpio* and *Carassius carassius*	1995	Well established
Oromia	Sorga reservoir	12	*O. niloticus* and *T. zilli*	*Cyprinus carpio* and *Carassius carassius*	1994	Well established
Oromia	Belbela reservoir	5	*O. niloticus* and *T. zilli*		1999	Well established
Oromia	Gumaro	7	*O. niloticus*	*Cyprinus carpio*	1990	Well established
Oromia	Yayo reservoir	5	*O. niloticus*	*Cyprinus carpio*	1996	Well established
Oromia	Badale reservoir	6	*O. niloticus*	*Cyprinus carpio*	1996	Well established
Oromia	Gebete reservoir	8	*O. niloticus* and *T. zilli*		1996	Well established
Oromia	Wedecha reservoir	10	*O. niloticus* and *T. zilli*		1994	Well established
Oromia	Shakso reservoir	4	*O. niloticus* and *T. zilli*		1996	Well established
Amhara	Ango-mesk reservoir	2	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	2005	Well established
Amhara	Washa reservoir	1	*O. niloticus* and *T. zilli*	*Cyprinus carpio* and *Carassius carassius*	1988	Well established
SNNP	Dembi reservoir	3	*O. niloticus* and *T. zilli*		1993	Well established
SNNP	Chencha kure reservoir	1		*Cyprinus carpio*	1992	Well established
SNNP	Cile chefe reservoir	1.5	*O. niloticus* and *T. zilli*		1993	Well established
SNNP	Areket reservoir	5	*O. niloticus* and *T. zilli*		1993	Well established
SNNP	Yeboba reservoir	2		*Cyprinus carpio*	1995	Well established
SNNP	Damte reservoir	1	*O. niloticus* and *T. zilli*		1999	Well established
Afar	Tendaho reservoir	170	*O. niloticus*		2013	Well established
Somali	EL Bayeh	10	*O. niloticus*		2009	Well established

Table 2. Fish stocked to natural water bodies to enhance fish production by filling a vacant niche and mosquito control (NFLARRC, 2002; TBoARD, 2008; OBoARD, 2002; FRDMP, 2003; NFLARRC, 2006; Shibru and Fisseha, 1981; SNNPBoARD, 2008; Yared *et al*., 2009)

Region	Water body	Lake/ Reservoir surface (km^2)	Stocked species		Year of stocking	Current status
			Native	Non-native		
Tigray	Lake Hashengie	21	*O. niloticus*	*Cyprinus carpio* and *Carassius carassius*	1982, 83 and 2001	Well established
Oromia	Lake Ziway	442		*Cyprinus carpio, Carassius carassius and Cl. gariepinus*	In seventies	Well established
Oromia	Lake Langano	240		*Cyprinus carpio* and *Carassius carassius*	In seventies	Well established
Oromia	Lake Wonchi	5.5		*Cyprinus carpio, Carassius carassius and Oncorhynchus mykiss*)	In eighties	Not established
Oromia	Lake Dandi	72		*Cyprinus carpio, Carassius carassius and Oncorhynchus mykiss*)	In eighties	Not established
Oromia	Creatorlakes around Debrezeyt	5.1 altogether	*O. niloticus* and *T. zilli*		In seventies	Well established
Amhara	Lake Tana			*Esox lucius L., Gambusia holbrooki*	In thirties	Not established
Amhara	Lake Haik	25	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	1982-83	Well established
Amhara	Lake Ardibo	21	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	1982-83	Well established
Amhara	Lake Golbo	3	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	1985-86	Well established
Amhara	Lake Maibar	2	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	1985-86	Well established
Amhara	Lake Terba	3	*O. niloticus*			Well established
Amhara	Lake Zengana	1	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	1987-88	Well established
Amhara	Lake Bahire Giorgis	2	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	1987-1988	Water recedes
Amhara	Lake Lai Bahir	2	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	1987-88	Water recedes
Amhara	Lake Tachi Bahir	2	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	1990	Water recedes
Amhara	Geray reservoir	1.5	*O. niloticus* and *T. zilli*	*Cyprinus carpio*	1990	Well established
SNNP	Lake Small Abaya	12	*O. niloticus* and *T. zilli*		1992-1993	Well established

In Ethiopia alternative sources of animal protein, such as beef and poultry can be afforded only by rich people. Culture-based fisheries is an environmentally friendly practice being an effective secondary use of existing water resources for food fish production in which the only external input is seed stock. Fish introduction has become a popular method of enhancing Ethiopian fisheries, and stocking has been a high priority on fisheries development agendas for several decades. Therefore the development of capture fishery through fish stocking programs could create a good opportunity to increase food supply and provide supplementary income for the people who are living in the rural areas. The experience of other countries have shown that success of stocking programs are depending upon by a number of variables, including but not limited to stocking density and ecological carrying capacity of the receiving environment, age and size of fish at stocking, condition and health of fish, genetic factors, presence and amount of suitable habitat, food, competitors and predators at release sites, timing of stocking relative to above factors and release methods (Wahl et al. 1995; Li 1999; Brown and Day 2002).

In Ethiopia most of the diets are dominated by carbohydrates derived from cereals, which have low protein content. Supply diet with fish can help eliminate the protein deficiency diseases that presently common. The socioeconomic importance of small scale fisheries in reducing malnutrition by supplying high quality animal protein and generating cash income for the rural communities are recently well recognized and attempts are being made to promote and develop the subsector both at farmers and commercial levels. Ethiopia has already adopted and implementing the strategy of Agricultural Development Led Industrialization (EFDR, 2002). In line with this, the development of fish culture in the country receives higher priority for the purpose of achieving food security and it will be seen as an integrated element for dam and reservoir construction for agriculture and hydro power programs.

One of the major issues for the development of capture fisheries is related with the establishment of impoundments like dams and reservoirs. The potential for construction of dams and reservoirs in Ethiopia is enormous. Ethiopia is gifted with diversified and abundant water resources suitable for development of fisheries and aquaculture. The total surface water resources of the country's 12 river basins, are estimated to be in the order of 122 billion cubic meters per year. With regard to ground water resources, the true is not yet known, however it is widely reported that Ethiopia possesses a ground water potential of approximately 2.6 billion cubic meters (Solomon, 2006). In addition there are few native fish species such as Nile tilapia (*Oreochromis niloticus*), Tilapia *zilli* and African catfish (*Clarias gariepinus*) which are common in the country and already widely used for fish farming and can be used for fishery enhancement stocking programs.

In spite of the popularity of stocking activities in Ethiopia till now there hasn't been any systematic approach adopted to assess its ecological impact. Evaluation of stocking and introductions was made only in terms of the inventory of the activity (i.e. place and year of stocking). Welcomme (1984) suggested that the environment can be of great significance for introduced fish species even when hydrological and climatic conditions appear suitable. In many cases fish

stocking worldwide appears more as a political tool whereby user groups are reassured that action is being taken on their behalf rather than as a mechanism for rational action (Welcomme, 1984). Globally stocking of fish is done for a variety of reasons and its success may evaluate different groups using, diversified number of criteria. Despite the ecological and genetic outcomes of fish introductions, increased water productivity, benefits across Africa (Richard and Hecky, 1991). Therefore the development of culture based capture fishery through fish stocking programs could create a good opportunity to increase food supply and provide supplementary income for the people who are living in the rural areas.

There should be considerable concerns about the impacts of stocking and introduction programs on the genetic composition and habitat alteration of the indigenous stocks. Research programs should be urgently devised to document better the consequences of fish introductions and stockings. Policy makers and local administrators should also realize that the lack of regulation and control makes it difficult to avoid possible major ecological threats in the future.

Major constraints for the development of culture based capture fishery

Despite the arising opportunities related with the development of capture based fishery in the country there are some constraints that hinders its prospects in the future. Current and perceived constraints in the sub-sector may broadly identified as follows:

- During construction of Reservoirs fisheries did not receive adequate technical considerations. Consequently tree stumps, and other submerged obstacles and huge rocks remains in reservoir bottoms
- Availability and access to stocking materials / quality seed, feed and gear.
- Lack of fish farming tradition and knowledge limitation in aquaculture.
- Insufficient market outlets for stock water bodies located in remote areas
- Insufficient cooperation between authorities responsible for fisheries and other water management practices, like designing and construction of dams and reservoirs.
- Weak institutional supports of human resource development, research and extension services.
- Limited private sector involvement

Recommendations

- Fish barriers should be in place at any in or outflow area of the reservoir to prevent fish escaping or entry of unwanted fish. This stocking density was not based on the trophic status of the reservoirs.
- Establishment of fish breeding centres (hatcheries)
- Stocking should be based on strict decision process considering both probability of stocking success and environmental issues.
- Promotion of fish farming development, fish harvesting, handling, processing and preserving techniques supported by training.
- Creation of support funding mechanisms available for all segments of the fisheries

production chain and provision of basic marketing infrastructures, such as road and communication channels in remote areas.

- Establishment of regular institutional coordination mechanism for consultation and cooperation among different institutions involved in water resources developments.
- Initiation and support of establishment of local fishing gear producers from locally available materials and strengthening of the institutional supports of human resource development, research and extension services.
- Reservoirs should store enough water to safely raise fish to market size each year. Because reservoirs often have multiple users, water consumption by the infrastructure of the associated community should be estimated to ensure adequate water for the stocked fish.
- Development of fishery monitoring services and research aimed at harvested species, environmental constraints, fishing efforts and selectivity of the fishing gears
- Increasing fish production and fisher men productivity by improving technological standards.
- Promoting appropriate fish harvesting, handling, processing and preserving techniques and prohibition of destructive fishing gears and methods.

Conclusion

In the future, the development strategy for culture based fishery must rely on scientific evidence and stocking density should be based on the trophic status of the reservoir, desired market sizes of fish, and projected yields. Development of culture based fishery in natural water bodies and reservoirs should include technical considerations on ecological, socio-economic, and institutional aspects. From the ecological perspective, the water body should have good water quality for fish life, high natural food resources or high potential fish yield, and the water volume available throughout the year or at least eight months until the fish could grow to table size. Seed stocks should be available and procured easily and be species of economic value, preferred by the communities, and feed low in the trophic chain, can utilize natural food resources, and non-invasive or not negatively impact on native fish species. It should be stressed that government policy makers and planners should be aware of the importance of the fisheries in the overall development schemes, and therefore of the need to incorporate fisheries considerations starting from the earliest stages of water development project planning and development. This is particularly essential where new reservoirs are planned.

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