Impact of introduction of culture-based fisheries on fish production in perennial reservoirs of Sri Lanka

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Abstract: Sri Lanka is blessed with a large number (>12,000) of irrigation reservoirs. Depending on their hydrological regimes, they are broadly categorised into perennial and seasonal reservoirs and are secondarily used for inland fisheries. Culture-based fisheries (CBF) in seasonal reservoirs was initiated in the 1980's and it is well documented. The Government of Sri Lanka has recognised CBF as an effective way of increasing fish supplies in rural areas, at affordable prices, while also providing employment and additional income to rural farmers and thereby contributing towards alleviation of poverty. There are around 200,000 ha of perennial reservoirs in Sri Lanka. These reservoirs are divided into three broad size categories, minor (<200 ha), medium (200 – 800 ha) and major (>800 ha). In this paper the impact of introduction of CBF on fish production in minor, medium and major perennial reservoirs are assessed using the fish production data from eight minor, seven medium and two large reservoirs. In all three categories of reservoirs post CBF resulted in very significant increases in fish production, such as for example increases of 206 and 319 % average annual fish production in minor and medium sized reservoirs, respectively.

Available provisions under the *Fisheries and Aquatic Resources Act No. 02 (1996)* to ensure ownership of the fish harvest to the fisher community, a crucial element in the success of CBF, are also highlighted. Further, the role of fisher community based organisations and fisheries management measures introduced for effecting successful CBF practices are also discussed.

Key words: *Nile tilapia, Indian major carps, Macrobrachium rosenbergii, stocking, fish yields, fisheries co-management.*

Introduction

Sri Lanka is blessed with a large number of irrigation reservoirs. In Sri Lanka, reservoir construction and use have always been an integral part of human activity, with some major reservoirs more than 2000 years old. Most of these reservoirs are concentrated in the dry zone (1250 – 1900 mm annual rainfall) of the country. The total reservoir extent is about 300,000 ha. On average size of these reservoirs range from a few ha to 8000 ha and depending on their hydrological regimes they are either, perennial or seasonal. These reservoirs with a few exceptions are irrigation reservoirs and are very diverse in size, age, hydrology and catchment features (Amarasinghe et al. 2004). Perennial reservoirs (around 200,000 ha) are divided into three broad categories; large, (> 800 ha), medium (200 – 800 ha) and small (< 200 ha) based on the water spread at full supply level.

These irrigation reservoirs have been secondarily used for inland fisheries. Development of inland fisheries in Sri Lanka commenced with the introduction of the exotic tilapia, *Oreochromis mossambicus*, in 1952. Fisheries in reservoirs yielded around 55,020 tonnes in 2013, contributing 82% to the total inland fish production.

The Government of Sri Lanka has recognised culture-based fisheries (CBF) as an effective way of increasing fish supplies in rural areas at affordable prices. CBF provide employment opportunities and additional income to rural communities and thereby contributing towards alleviating poverty.

CBF in seasonal reservoirs of Sri Lanka initiated in early 1980's and its development was well documented (Thayaparan, 1982; Chakrabarty and Samaranayake, 1983; Chandrasoma, 1986; Chandrasoma and Kumarasiri, 1986; De Silva et al. 2006). CBF in perennial reservoirs in Sri Lanka is a recent development. Introduction of CBF into minor perennial reservoirs commenced in 2004 and gradually expanded to cover the other two size categories of perennial reservoirs, medium and large reservoirs.

This paper evaluates the impact of introducing CBF on fish production in three size categories of perennial reservoirs of Sri Lanka. Results of introduction of CBF in eight minor, seven medium and two major perennial reservoirs are used in the evaluation. Further contributions of stocked fish species to the catch are also discussed. The role of community based organisations

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on the introduction of CBF and facilitation of CBF, based on the provisions provided in the *Fisheries and Aquatic Resources Act*, are also discussed.

Materials and methods

Fish production from eight minor, seven medium and two major perennial reservoirs were used to evaluate the impact of introduction of CBF. Locations and water spread at full supply level of the reservoirs selected for this study are shown in Figure 1. Selection of these water bodies was on the availability of long time reliable data with at least a minimum of five years data after the introduction of CBF. Further, these were closely monitored by the Extension Officers of the National Aquaculture Development Authority (NAQDA), thereby enabling further authentication of the information provided. Fish yields and species composition of fish catches in these reservoirs during pre-CBF periods were compared with that from after introduction of CBF.

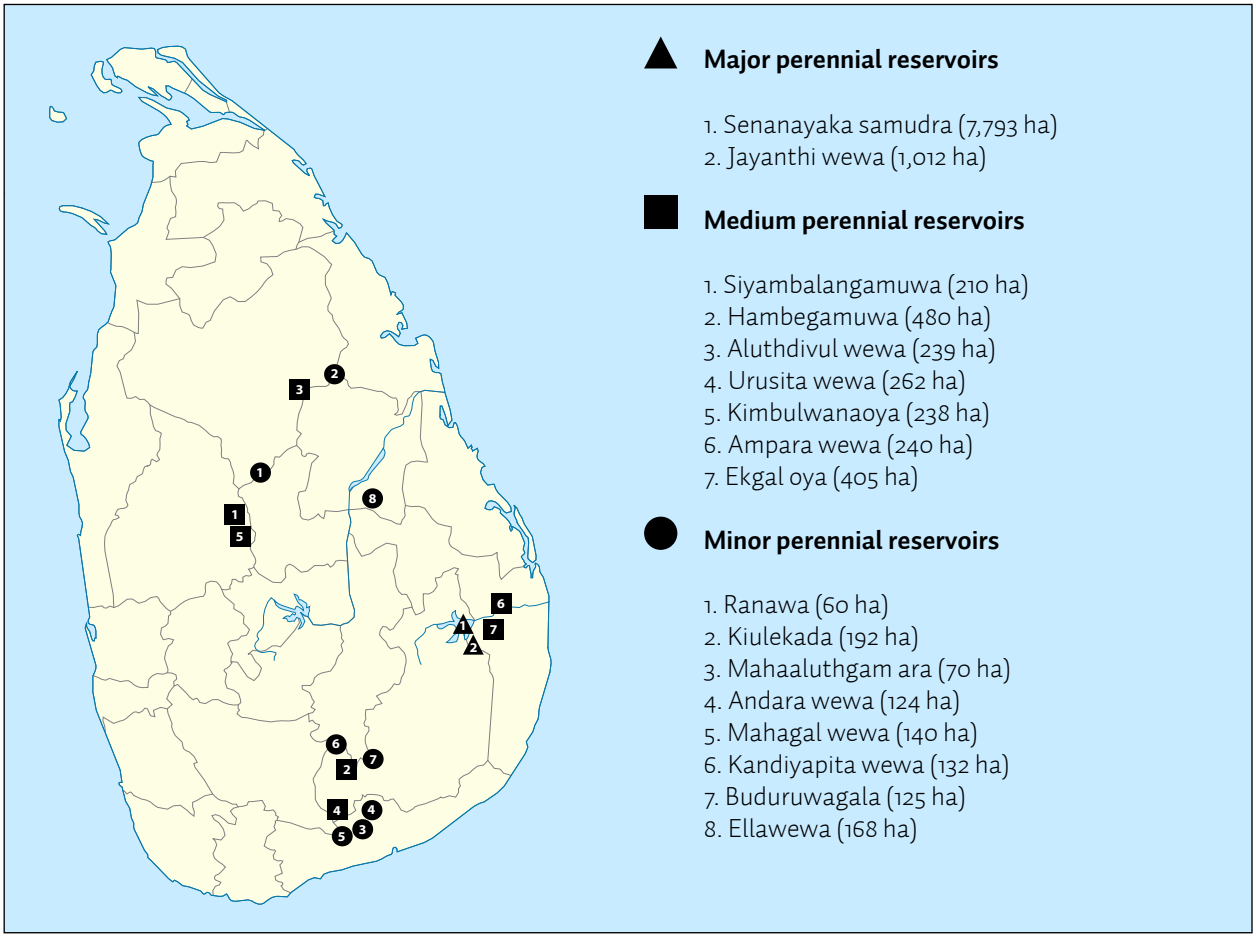
Fisher community based organisations

As a pre-requisite to undertake CBF, fisher community based organisations (CBOs) were formed or reorganised, where applicable, with the participation of fishers and would be fishers in each reservoir. Members of the fisher CBOs of each reservoir were given training in basic aspects of CBF. Further, they were provided with training in community based organisation management, leadership, simple accounting, book keeping etc.

Stocking

Stocking has been a continuous activity with the introduction of CBF with hatchery produced Nile tilapia (GIFT strain of *Oreochromis niloticus*); the Indian major carps catla, *Catla catla*, rohu, *Labeo rohita* and mrigal, *Cirrhinus mirigala*; and freshwater prawn, *Macrobrachium rosenbergii*. The average annual stocking rate was 1,037 individuals/ha/yr (range 251 – 1,940) and 1,023 individuals/ha/yr (range 533 – 2,315) for minor and medium reservoirs, respectively. The average annual

Figure 1. Locations and water spread at full supply level of 8 minor, 7 medium and 2 major perennial reservoirs referred to in this study.



Base map outline by Uwe Dedering (Creative Commons Attribution-Share Alike 3.0 Unported license).

stocking was 192 individuals/ha/yr and 804 individuals/ha/yr, respectively, in Senanayake Samudra and Jayanthi wewa, the two large reservoirs used in the study. Fish species to be stocked, stocked numbers, time of stocking, source of fish seed etc. were determined by the fisher CBOs. In taking decisions on the species to be stocked, CBOs gave due consideration to consumer preference and availability of fish seed. The species for stocking and the stocking numbers revised in subsequent years, depending on the stocking outcome.

Fisheries management measures

Fisher CBOs were actively involved in implementation of fisheries management measures. Regulations of the *Fisheries and Aquatic Resources Act* (FAR Act) of 1996 were strictly adhered to and only gill nets were used for catching. Although minimum mesh size of gill nets allowed is 85 mm, CBO members in most reservoirs collectively agreed and used gill nets with mesh size of 115 mm and above. A fixed time period for fishing operations and the use of one landing site for fishing crafts for each reservoir are two other important fisheries management measures adopted by fisher CBOs, all measures that facilitate monitoring.

Harvesting

Harvesting of fish is a year round activity. Non-mechanised fiber glass, dug out, outrigger canoes (4m in length) are used for fishing. Fishing gear are gill nets with stretched mesh sizes ranging from 85 mm to 200 mm. In general, each boat is operated by two fishers, who place their nets in the evening and haul them in the next morning.

Data collection

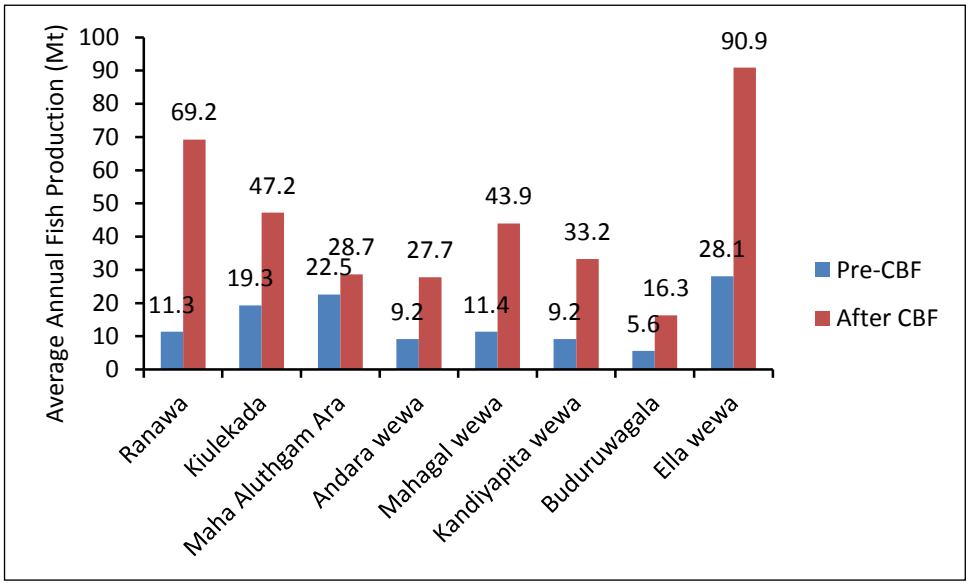
Species wise catch data were collected by the respective CBOs on a daily basis and maintained in a log book or in a computerised data base.

Results

Fish production

Average annual fish production of the reservoirs considered under this study in the minor, medium and major categories, during the pre-CBF period and after introduction of CBF are shown in Figures 2, 3 and 4, respectively. Figure 5 gives the details of annual fish production in two major reservoirs considered in this paper. In all the reservoirs introduction of CBF resulted in significant increases in fish production. Percent overall increase in average annual fish production in minor reservoirs increased after the introduction of CBF by 206.5% ranging from 144.8% in Kiulekada to 510.0% in Ranawa. Similarly, overall annual fish production in medium reservoirs increased by 318.5% ranging from 49.0% in Urusita wewa to 668.5% in Aluth Divul wewa. In Senanayake Samudra and Jayanthi wewa the two reservoirs in the major category percent increase in average annual fish production was 184.7% and 266.9%.

Figure 2. Average annual fish production of minor perennial reservoirs during pre-CBF period and after the introduction of CBF.



Fish production per unit area

Average fish production per unit area in respect of reservoirs of minor, medium and major categories are given in Figures 6, 7 and 8. Significant increases in unit area fish production were observed in all three categories of reservoirs. Average fish production per unit area increased to 353.3 kg/ha/yr from 131.5 kg/ha/yr and to 310.1 kg/ha/yr from 71.1 kg/ha/yr in minor and medium reservoirs, respectively. In Senanayake Samudra and Jayanthi wewa unit area production increased from 14.3 and 31.6 kg/ha/yr to 40.8 and 116.8 kg/ha/yr, respectively.

Species composition

Nile tilapia was the dominant fish species, contributing 80-90% to the total fish catch in all three categories of perennial reservoirs prior to the introduction of CBF. Species composition of the catches of all three categories of reservoirs after the introduction of CBF are given in Figures 9 (a), (b), (c) and (d). Contribution of Nile tilapia decreased to 57.6% (ranging from 53.1% in Mahaaluthgamara to 72.1% in Andara wewa) and 59.3% (ranging from 8.3% in Ekgal Oya to 91.6% in Ampara wewa) in minor and medium reservoirs, respectively,

Figure 3. Average annual fish production of medium perennial reservoirs during pre-CBF period and after the introduction of CBF.

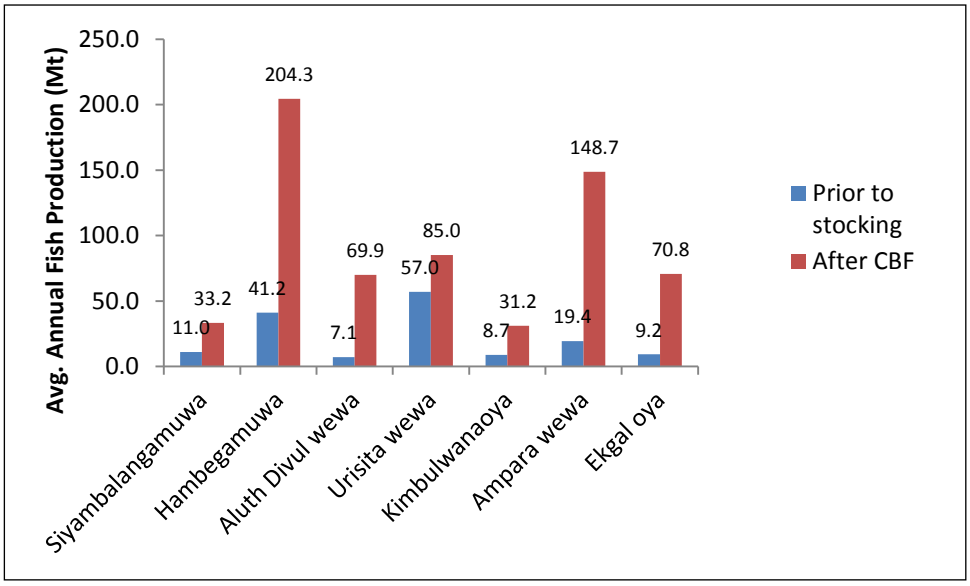
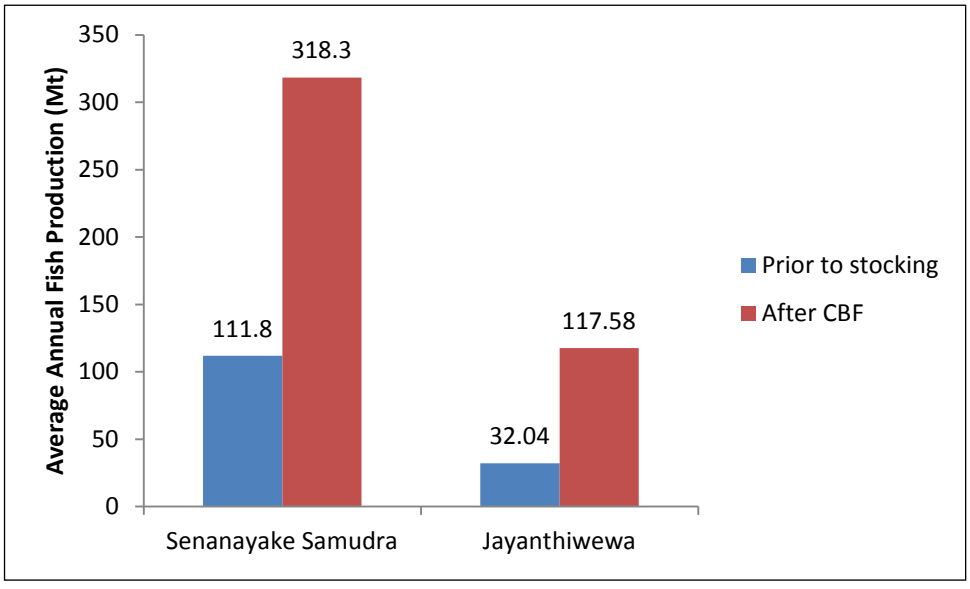


Figure 4. Average annual fish production of major perennial reservoirs during pre-CBF period and after the introduction of CBF.



and similar trends were observed in the two major reservoirs under consideration. Contribution of Nile tilapia decreased to 64.6% and 57.1% in Senanayake Samudra and Jayanthi wewa, respectively,. Although there had been a decrease in the present contribution of Nile tilapia to the total fish catch, tilapia harvest increased significantly in all the categories of reservoirs, for example landings increased by 158.0%, 183.8%, 74.7% and 287.5% in minor perennials, medium perennials, Senanayake Samudra and Jayanthi wewa, respectively. Other significant contributors to the fish catch were stocked exotic carp varieties, with contribution of 41.9%, 39.5%, 29.1% and 38.0% in minor perennials, medium perennials, Senanayake Samudra and Jayanthi wewa, respectively. Catla was the dominant species among the carps in fish catches followed by rohu in all categories of reservoirs. Contribution of freshwater prawn to catches was 1.6%, 0.5%, 0.4% and 1.0% in minor perennials, medium perennials, Senanayake Samudra and Jayanthi wewa, respectively.

Discussion

Development of CBF in perennial reservoirs is a relatively recent development in Sri Lanka, although there were attempts to develop CBF almost three to four decades ago (e.g. Mendis 1967). Details of well managed CBF

Figure 5. Annual fish production in Senanayake Samudra and Jayanthi wewa after introduction of CBF.

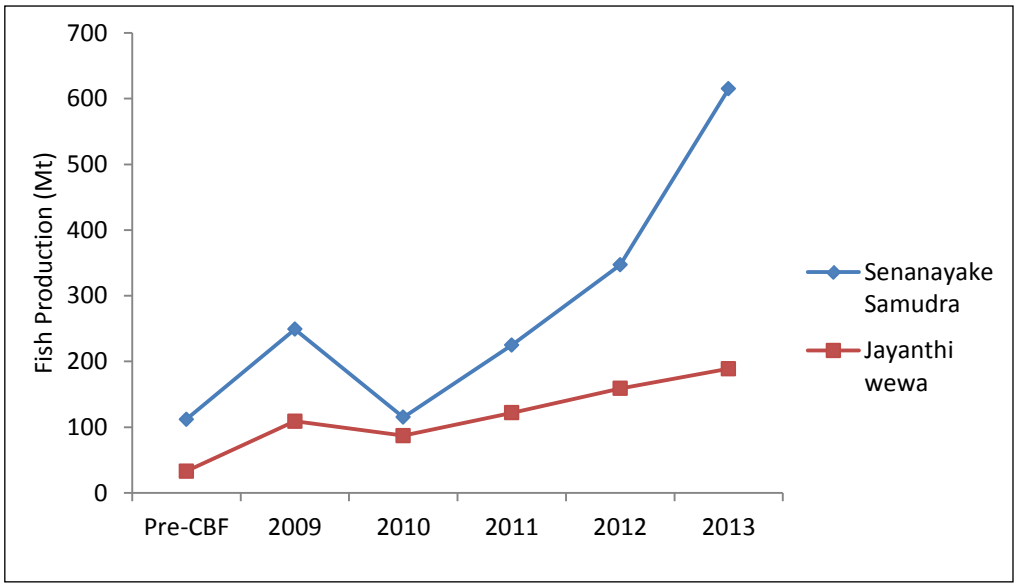
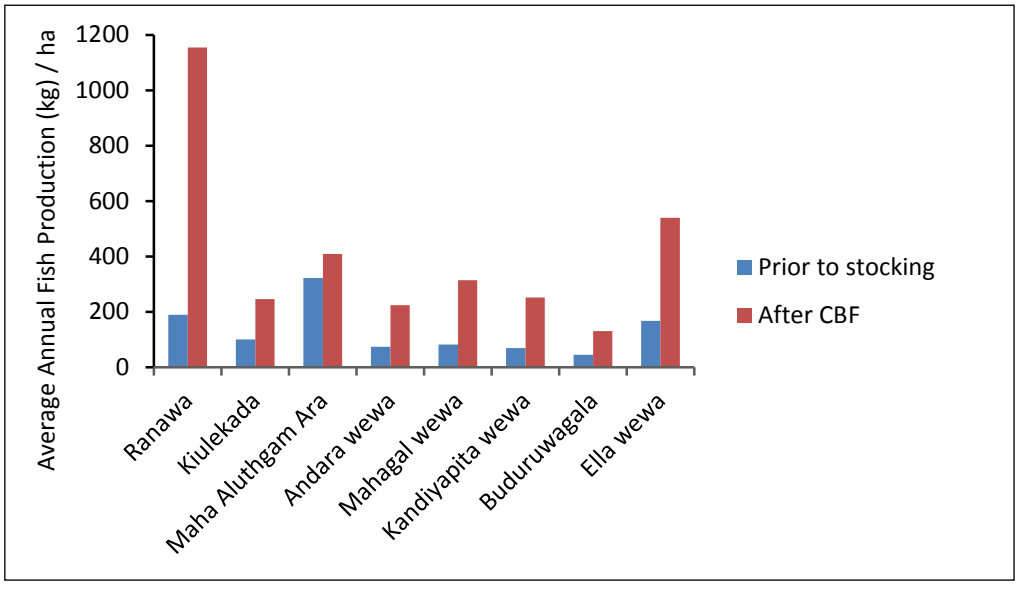


Figure 6. Average fish production per unit area in minor perennial reservoir during pre- and post-CBF.



in Chinese perennial reservoirs have been reported by Li (1987) and Xu (1987). Stocking, coupled with proper management in all three categories of perennial reservoirs, has resulted in significant increases in fish production. Pushpalatha and Chandrasoma (2009) reported an overall production increase of 263% (range 42.8% to 1344%) after the introduction of CBF in 15 minor perennial reservoirs, which is comparable to the fish production increase of 206.5% reported for minor perennial reservoirs under this study. Similarly, production increases observed for medium perennial reservoirs (318.5%), Senanayake Samudra (184.7%) and Jayanthi wewa (266.9%) shows the potential of these reservoirs for enhanced fish production through stocking and introduction of management measures. Fish yields observed under the present study were 353.3 (minor), 310.1 (medium), 31.6 (Senanayake Samudra) and 116.8 (Jayanthi wewa) kg/ha/yr. Although above fish yields are the average fish yield after the introduction of CBF, by 2013 fish yields of Senanayake Samudra and Jayanthi wewa had risen to 78.9 and 187.0 kg/ha/yr. Li (1987) reported fish yields of 75 – 675 kg/ha/yr in five reservoirs (in China) ranging in size from 160 to 40,000 ha. It is interesting to note the increasing trend in annual fish production indicating that full potential is yet to be realised in two major reservoirs.

Figure 7. Average fish production per unit area in medium perennial reservoir during pre- and post- CBF.

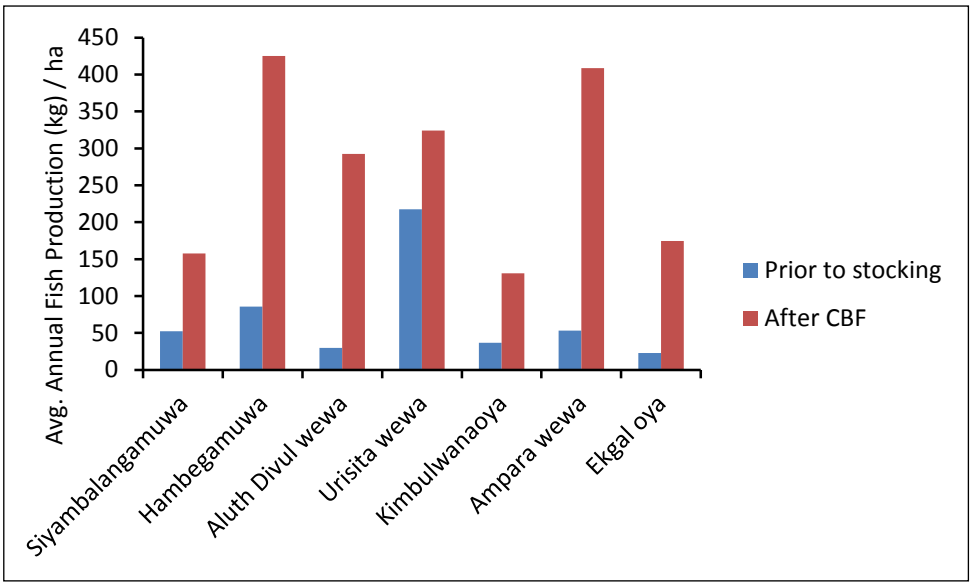
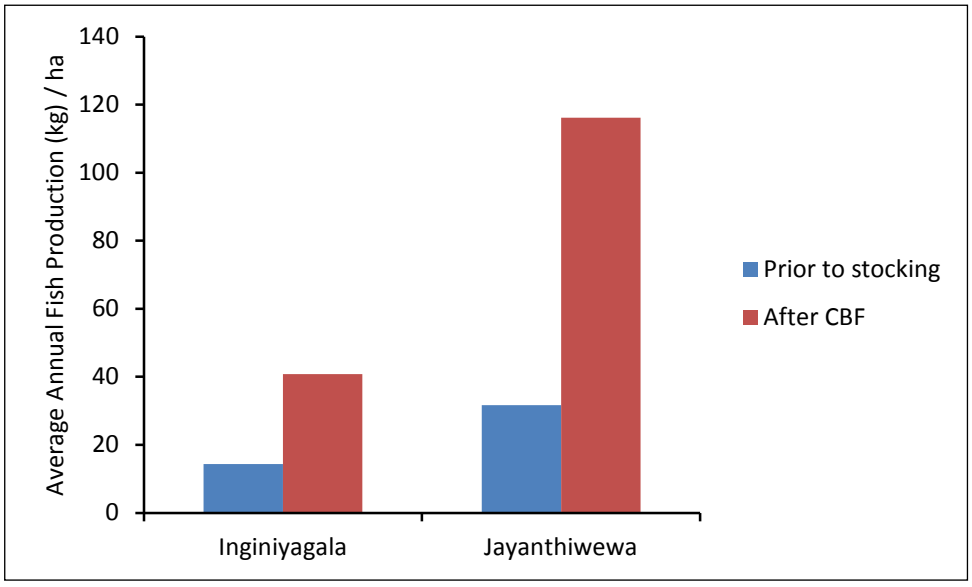


Figure 8. Average fish production per unit area in major perennial reservoir during pre- and post-CBF.

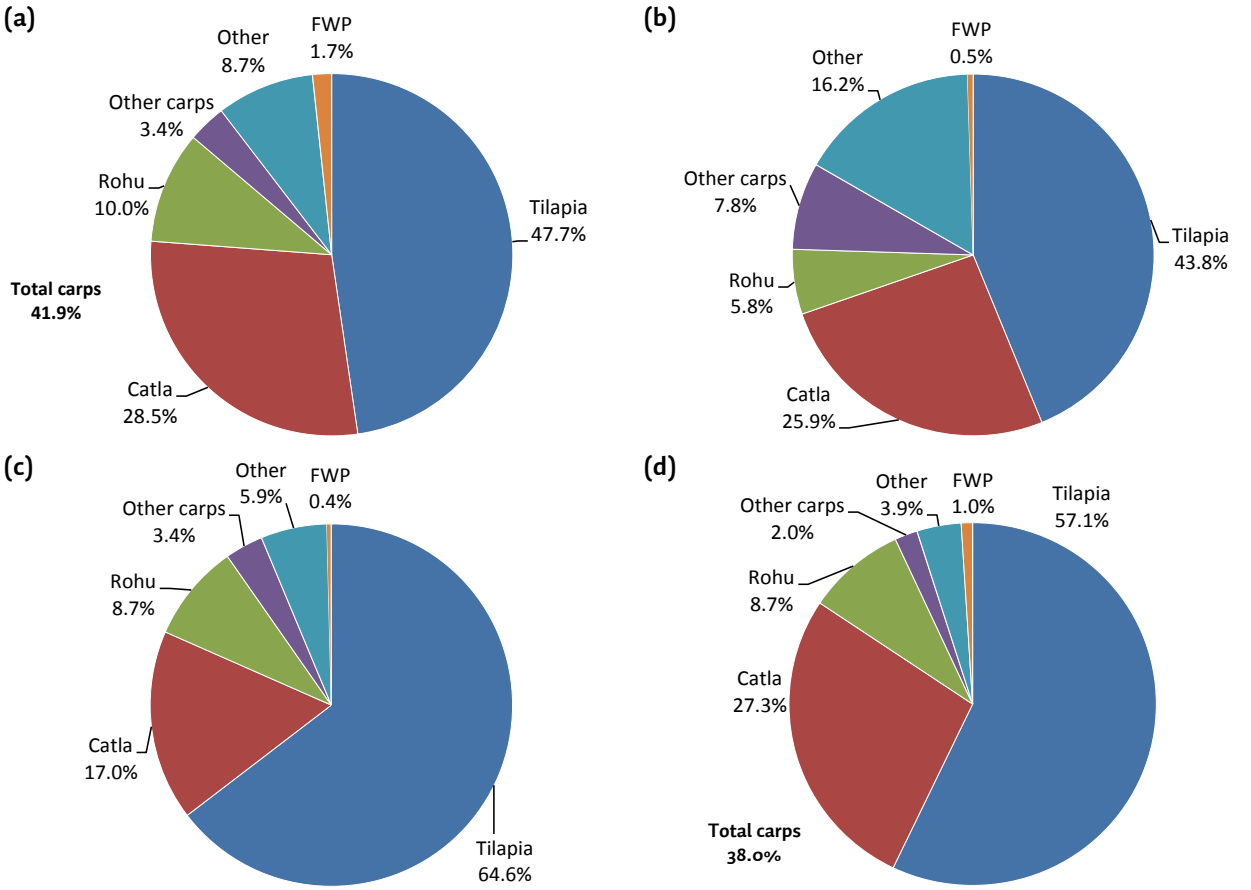


All categories of reservoirs had Nile tilapia as the dominant species in the catches, contributing 80 – 90% prior to introduction of CBF. Although the percent contribution of Nile tilapia to fish catches of all three categories of reservoir has decreased, it is interesting to note a significant increase in landings of Nile tilapia after introduction of CBF. This probably indicates an inadequacy of natural recruitment of Nile tilapia. Stocking of Indian carp species, in particularly catla and rohu, has resulted in a significant contribution of these species to the landings in all three categories of reservoirs indicating availability of suitable conditions for these species including food. It is interesting to observe that mrigal, which was stocked in these reservoirs in late 2013, have started to appear in fish catches in significant numbers in some reservoirs (personnel observations of the first author) and it is anticipated this will further facilitate increases in fish production and contribution of carps to fish catches. Although the contribution of freshwater prawn in fish catches is low, stocking of freshwater prawn has become attractive to fishers as this commodity fetches a higher price and is economically feasible. Fishing gear used in these reservoirs is gill nets and it is not efficient fishing gear for catching freshwater prawn. Introduction of new fishing gear, such as traps may facilitate an increase in landings of freshwater prawns.

The legal framework existing under the *Fisheries and Aquatic Resources Act* of 1996 facilitated the implementation of activities related to CBF. These provisions included registration of fishing crafts, need for a license to engage in fishing operations and use of gillnets with mesh size above 85 mm etc. The requirement for obtaining a license for fishing operations prevents open access to fishing and ensures the ownership of the fish catch to a group of fishers, who has organised into a CBO. In addition, there are provisions to limit the number of licenses issued in each reservoir and also to limit the number of units of fishing gear (gill nets) that can be used by a fisher in a reservoir. Accordingly, the above provisions ensure that CBF as practised in Sri Lankan reservoirs, irrespective of the size of the water body, fall within the realm of aquaculture as per the definition of the FAO (FAO 1994).

Continued and adequate stocking, and the presence of an active CBO, are important for successful implementation of CBF. Fisher CBOs were involved in decision

Figure 9. Species composition of fish catches of (a) minor perennial reservoirs, (b) medium perennial reservoirs, (c) Senanayake Samudra and (d) Jayanthi wewa.



making in all aspects of CBF and actively involved in management of CBF. CBF members not only refrain from using illegal fishing gear but also prevent any unauthorised fishing in reservoirs through close surveillance. It was interesting to note that CBO members in most reservoirs collectively agreed and used gill nets with mesh size of 115 mm and above. The results of this change is yet to be fully realised and or assessed, but does indicate the active and ongoing involvement of CBOs in the overall management strategy of CBF.

The fixed time period for fishing operations and the use of one landing site are two other important management measures, which facilitated prevention of use of illegal fishing gear and unauthorised fishing. Further these measures facilitated data collection of landings. Funds required for stocking was generated by levying a fee for every kilogram of fish landed. Involvement of CBOs in collection and maintenance of stocking and catch data has resulted in availability of very accurate data, which are useful for the CBO as well as for fisheries authorities for planning and further development of CBF. The management of the fisheries in these reservoirs has all the ingredients of a co-management system (Amarasinghe and De Silva 1999). The fisheries community users were actively involved in decision making through their fisher CBOs. Tasks have been allocated to primary stakeholders and implementation of tasks were satisfactory. There has been very close cooperation between relevant Government Authorities and fishers.

The introduction of CBF in these reservoirs has resulted in significant increases in fish production, in turn enhancing income of fishers, availability of fresh fish for rural communities and livelihood opportunities. Adequate stocking of reservoirs with suitable fish species, involvement of active CBOs, their involvement in decision making and legal framework for ensuring ownership of the harvested fish and the implementation of sustainable management measures are the key factors for successful introduction and implementation of CBF.

CBF are essentially a form of extensive aquaculture, or a farming practice conducted in small water bodies (generally less than 100 ha) (De Silva et al. 2006). Experiences in China and Sri Lanka show that CBF could be practised in larger water bodies. Perhaps CBF is a strategy that needs to be adopted by most developing countries to increase the food fish supplies to rural communities, and also increase the overall contribution from inland fisheries to global food fish production (Beard et al. 2011).

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