

Farming of Seabass (*Lates calcarifer*) in net cages in Negombo Lagoon, Sri Lanka: Culture practices, fish production and profitability

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ABSTRACT

Shrimp farming is the main coastal aquaculture activity and sea bass cage farming also recently started in Sri Lanka. Information pertaining to culture practices, fish production, financial returns and costs involved in respect of seabass cage farms operate in the Negombo lagoon were collected through administering a questionnaire. The survey covered 13 farms of varying sizes. The number of cages operated by an individual farmer or a family ranged from 2 – 13. Almost all the farmers in the lagoon used floating net cages, except for very few farmers, who use stationary cages. Net cages used by all the farmers found to be of uniform in size (3m x 3m x 2m) and stocking densities adapted in cages are also similar. Production of fish ranged between 300 to 400 Kg per grow-out cage. All seabass farmers in the Negombo lagoon entirely depend on fish waste/trash fish available in the Negombo fish market to feed the fish. Availability of these fish waste/trash fish at no cost to the farmers has made small scale seabass farming financially very attractive.

Increase of cage farms in the Negombo lagoon has led to conflicts between seabass farmers and other resource users and need of taking adequate precautionary measures to avoid potential conflicts are stressed. The main constraints for the development, sustainability and expansion of seabass farming in Sri Lanka are unavailability of low cost effective diets and irregular and inadequate supply of seabass seeds. Recommendations made include importance of determination of optimum number of fish cages, that can be established in a water body based on carrying capacity assessments to prevent uncontrollable increase of cage farms.

Keywords: seabass farming; farming in cages; culture practices; carrying capacity assessments

INTRODUCTION

Aquaculture is an age old practice in many countries of the world in particularly in the Asian region. Many millennia after terrestrial food production shifted from hunter- gathered activities to agriculture, aquatic food production has transitioned from being primarily based on capture of wild fish to culture of increasing number of farmed species. A milestone was reached in 2014, when aquaculture sector's contribution to the supply of fish for human consumption in the world overtook that of wild caught – fish for the first time (SOFIA, 2016). Sri Lanka has no tradition of fish farming. Among aquaculture activities, Culture-Based Fisheries(CBF) is practiced in man-made lakes in Sri Lanka and it has contributed significantly for enhancing freshwater fish production and for the provision of livelihoods for

rural communities (De Silva et al.2006; Pushpalatha and Chandrasoma, 2009; Chandrasoma et al.,2015). Tilapia farming in ponds in both freshwater and brackish water environments is a recent development (Pushpalatha et al.2016). Shrimp farming in ponds is the main coastal aquaculture activity, which is practiced at present in Sri Lanka. In 2015, 2164 ha were under shrimp farming and produced around 5150 tons of shrimps (www.naqda.gov.lk).

Ministry of fisheries and Aquatic Resources of Sri Lanka made efforts in recent years to promote other coastal aquaculture activities involving seabass, seaweed, sea cucumber etc. with the objective of promoting exports and also to provide livelihoods for coastal communities. First attempt at introducing seabass farming in the country has been made in 2006 under the Asian

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Development Bank assisted Coastal Resources Management Project (CRMP) implemented by the Ministry of Fisheries and Aquatic Resources. The main objective for introducing seabass cage farming by the CRMP was to provide alternative livelihood for fishers in the Negombo Lagoon. Under this CRMP supported Pilot Project a few fishermen (around 10) have been assisted to undertake farming of seabass in cages installed in the lagoon. CRMP provided netting and other materials required for the installation of cages. A private sector aquaculture entrepreneur provided seabass seeds, technical knowhow and purchased the product. Since then there had been various attempts by non-government organizations, donor funded projects, Provincial councils and the Central government to promote seabass farming in few other locations in Sri Lanka. Government of Sri Lanka through Ministry of Economic Development implemented an island-wide multi sector *Divineguma Programme* during 2011-2014, involving rural households with the objective of enhancing nutrition and also for providing supplementary income and livelihoods. People living around lagoons and estuaries including Negombo lagoon were also assisted to commence or expand seabass farming in cages under this programme and financial assistance has been provided to cover part of costs related to establishment of seabass cages. At present 62 seabass cage farms of varying sizes operate in the Negombo Lagoon.

This paper discusses the culture practices adopted by farmers and examines economic aspects including fish production, related costs and profitability of seabass farming in cages in the Negombo Lagoon. Further problems of the farmers and constraints related to seabass farming are discussed and recommendations are made to ensure sustainability and for the further expansion of seabass farming with special reference to culture practices, inputs and the role of the government.

MATERIALS AND METHODS

Negombo lagoon

Negombo lagoon is a shallow basin estuary of approximately 3164ha in extent, located between latitude 7° 4'– 7° 12'N and longitude 79° 47' – 79° 5' E in west coast of Sri Lanka. It is connected to the sea by a single narrow opening at its northern end, which is open year-round. Negombo estuary extends 12.5km in length and 3.5km in width at its widest point

(Jayakody,1994). It has a shoreline of 24km and a mean depth of 0.65m and holds about 22.5 million cubic meters of water (DFAR,2012; Hettiarachchi and Samarawickrama,2003). The exchange of water in the lagoon is influenced by the tides from the ocean and the freshwater supply from the inland. The lagoon receives fresh water from the Attanagalu-oya, which empties as Ja-ela and Dandugam-oya at its southern end (Gammanpila,2010).

Most of the hydrographic features of the Negombo lagoon have been fairly established by various studies (Samarakoon and Van Zon,1991; Silva,1996). Salinity of the Negombo lagoon varies from almost zero to near-oceanic salinity showing a rainfall bound bimodal pattern. The surface salinity ranged from 4.5 – 34.8ppt at the sea entrance, whereas was 1.4 – 24.0ppt and 0 -15.2ppt for the mid-lagoon and at the freshwater outfall respectively (Silva et al., 2013).

The Negombo lagoon is a highly productive eco-system and its productivity has been estimated to range from 73 – 150kg/ha/yr and the estimated annual fish yield was 1385.6mt in 1997 (EAIP, 1998). In 2010, of the 3310 fishers involved in fisheries in the lagoon 2586 has been full time fishers and the rest part time (DFAR,2012). There are around 62 fish farmers operate seabass cages in the lagoon.

Collection of information

Information pertaining to floating net cage farms established for the farming of seabass in the Negombo lagoon were collected during June – September 2016 through administering a questionnaire. The survey covered 13 net cage farms.

RESULTS

Floating net cages

There are two types of net cages used for seabass farming in the Negombo Lagoon; floating and stationary net cages. Almost all the fish farmers use floating net cages except for a few farmers, who operate stationary cages. In general, stationary cages are used in shallow areas of the lagoon, whereas floating cages are used in deeper areas. Stationary cages consist of net cages tied to wooden poles driven and fixed into the lagoon bed.

The floating net cage system consist of net cage proper and the frame to support net cages. The frame is kept afloat by plastic drums. It was

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observed that net cages used by all seabass farmers are of uniform in size (3m x 3m x 2m). Although the height of the net cage is 2m, only around 1.5m immersed in the water, making an effective water volume of 13.5m³. Plastic netting material is used to make net cages. It was observed that net cages used by seabass farmers are of three mesh sizes; ¼ inches (6mm), 1 inches (25mm) and 2 inches (51mm).

The frame used for supporting net cages are constructed of wooden beams. Eight wooden beams of mango (*Magnifera indica*) measuring 4 inches x 2 inches in cross section and 13 feet in length are used to construct the frame for each net cage. The beams are joined by bolts and nuts. Wooden planks (1 inch (15mm) x 4 inches (102 mm) x 18 inches (408 mm)) are used to provide a platform or walkway for easy operation and feeding of fish in cages (Fig.1). Six plastic drums are used as floats for each cage unit. For supporting more net cages, several of the above-described raft units are joined together. These floating net cages are anchored using ropes tied to concrete blocks / metal structures or to a tree on the nearby shore.



Fig1. Floating cages at Negombo lagoon

Source of fish seed

Fish fingerlings of Asian seabass obtained from the Bethsida Hatchery in Ambakandawila, Chilaw are being used for stocking in cages by all the farmers. At present Bethsida hatchery is the only hatchery in Sri Lanka, which involves in production of seabass fish seed. This hatchery was involved in production of *Penaeus monodon* for several years and commenced production of seabass fish seed in 2012 under a Public – Private Partnership with the National Aquaculture Development Authority of Sri Lanka (NAQDA). The main objective of this partnership was to facilitate transfer of seabass seed production technology to Sri Lanka.

Private sector partner provided the hatchery facilities, support staff and funds to cover costs related to operational activities. NAQDA provided the services of a Technical Officer and this officer has been provided with a training in one of the leading aquaculture related institutes in Asia on technical aspects of the seabass seed production and hatchery management with the support of FAO funded Southern Aquaculture Development Project, Sri Lanka. Further NAQDA provided brood fish required for the hatchery. In addition FAO funded Project, provided certain material inputs required for smooth functioning of the hatchery. At present private sector entrepreneur continue to produce seabass fish seed to meet the fish fingerlings requirements of seabass farmers.

Stocking related practices

It was observed that number of net cages operated by an individual farmer ranged from 2 – 13, among farmers covered under the survey. Farmers use 6mm meshed net cages for fingerling rearing phase, while 25mm and 50mm meshed net cages are used for grow-out phase. Fish fingerlings of 2.0 – 2.5g in weight received from the hatchery are stocked in 6mm meshed net cages and reared for about 8 – 10 weeks up to juvenile stage (around 100g). Stocking densities adapted during fingerling rearing phase in small meshed net cages found to be uniform among all farmers (400 fish fingerlings per cage or around 30 fingerlings per m³ of water). When the fish reached a weight of around 100g, they are transferred to a net cage with larger mesh for the grow-out phase. In general around 10% mortalities have been observed by farmers during fingerling rearing phase.

It was common to observe that farms with two cages have a 6mm meshed net cage and a 25mm meshed net cage. A farm with nine cages consisted of four 6mm meshed net cages, three 25mm meshed net cages and two 50 mm meshed net cages. Fish densities in grow-out phase is around 360 fish per cage (27 fish/m³).

Feed and feeding

Seabass farmers of the Negombo lagoon use fish waste /trash fish to feed the fish from fingerling stage to market size. They obtain their requirements of fish waste /trash fish from the main Negombo fish market. Fish vendors provide fish waste to fish farmers at no cost. Hence the only cost that can be attributed to feeding of fish is the costs related to transport of fish waste from the

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market to farm sites. It was observed that one farmer out of 13 farmers covered under the survey used imported extruded fish feeds to feed the fish fingerlings for about 2 – 4 weeks prior to feeding the fish with fish waste. Fish in cages are fed twice daily at around 10 – 11 a.m. and 4 – 5 p.m. in the afternoon. Fish is fed to satiation. In general feeding and other routine activities are carried out by fish farmers with the assistance of family members. As fish farmers do not maintain records on the amount of fish waste used to feed fish, Feed Conversion Ratio (FCR) for feeding of fish waste could not be estimated.

Cleaning and maintenance

The net cages are regularly inspected to observe any damages and if noticed immediate action is taken to repair damages. Cleaning of the cages to remove fouling organisms such as bi-valves and algae, which obstruct exchange of water between the net cage and the lagoon environment is carried out once a month.

Harvesting and marketing of fish

Size of fish at harvesting varied from 0.75 – 1.3Kg. Total weight of fish obtained from a grow-out cage per culture cycle ranged from 300 – 400Kg. All the fish farmers covered under the survey supplied their fish harvest to fish exporters. In most cases complete harvesting of cages carried out at once. According to the

farmers, there had been few instances, where partial harvesting is carried out depending on the requirement of the buyer and the minimum requirement to carry out a partial harvest is 100Kg. Farmgate price for farmed seabass prevailed during 2015 and 2016 ranged from Rs.550 – 650 per Kg of fish.

Fish production and Profitability

Average fish yield per culture cycle from grow-out cages was around 350Kg/cage (around 30Kg/m³). Details of costs and returns for a cage farm consisting of four fingerling rearing net cages and four grow-out net cages and for a cage farm consisting of a fingerling rearing net cage and a grow-out net cage, for a culture cycle of 8 months, computed based on the information on relevant costs and returns collected during the survey is given in Table 1. Computation of economic results showed that seabass farming in cages in the Negombo lagoon is very profitable. The operational cost per Kg of fish produced ranged from Rs.76.92 – 82.30. Net profit over operational cost per Kg of fish ranged between Rs.517.69 and 523.07. Net profit over both operational and capital costs per Kg of fish ranged from Rs.453.73 – 459.12. Net profit over both capital and operational cost for a culture cycle for a farm with 8 cages is Rs.589,855.00, while the same for a farm with two cages is Rs.149214.00.

Table1. Cost and return from seabass farming in a net cage farm consisting of eight cages (four fingerling rearing cages and four grow out cages) and net cage farm consisting of two cages (one fingerling rearing cages and one grow out cages).

Item	Cage farm with eight cages	Cage farm with two cages
Return		
Production (kg)	1300kg	325kg
Value (Rs)	780000.00	195000.00
Operational cost		
Fish fingerlings	40000.00	10000.00
Fish fingerlings transport	2000.00	1000.00
Fish waste/trash fish	0.00	0.00
Transport of fish waste	60000.00	12000.00
Miscellaneous	5000.00	2000.00
Total operational cost (Rs)	107000	25000
Net profit over operational cost (Rs)	67300.00	17000.00
Net profit over capital operational cost(Rs)	589855.00	149214.00
Operational cost/ kg of fish (Rs)	82.30	76.92
Net profit over operational cost/ kg of fish(Rs)	517.69	523.07
Net profit over capital operational cost/ kg of fish(Rs)	453.73	459.12

- Avg sellig price of fish – Rs. 600 per kg

Avg cost of construction of complete cage structure consisting eight cages – Rs. 374150.00; Avg cost of construction of complete cage structure consisting two cages – Rs. 93538.00; Period of depreciation-3years; culture cycle – 8 months; depreciated capital cost per culture cycle for a farm with eight cages – Rs. 83145.00; depreciated capital cost per culture cycle for a farm with two cages – Rs. 20786.00.

DISCUSSION

Inland aquaculture and marine/ coastal aquaculture contributed 47.1 and 26.7 million tons (mt) respectively towards world total of 73.8 mt of aquaculture production available for human consumption in 2014. Fin fish is the main commodity farmed in inland (43.5mt) and marine/brackish waters (6.3 mt) contributing 49.8 mt to the total aquaculture production in 2014.

Although farming of marine fin fish is a recent development in Sri Lanka, it is an established and popular aquaculture activity adapted in considerable number of developed and developing countries in the world. Total production of cultured marine and brackish water fish species in the Asia and the Pacific Region in 2012 was around 2.6 mt (APFIC, 2014). Most of the fish species farmed in marine and brackish waters are species requiring high feed inputs, except for milkfish, which is a herbivorous species, produced mainly in the Phillipines. Among carnivorous fish species farmed in Asia and Pacific region, Japanese seabass, Asian seabass, seabreams, halibuts, turbot, groupers, salmonids, cobias and snappers contribute significantly to farmed marine and brackish water fish production. The Japanese seabass (*Lateolabrax japonicus*) and Asian seabass (*Lates calcarifer*) are two important carnivorous marine/brackishwater fin fish cultured in Asia and Pacific region, with a total production of 185073 mt in 2012 (APFIC, 2014).

Introduction of cage farming of seabass in the Negombo lagoon was the first attempt at introduction of cage farming of fin fish in marine/brackish waters of Sri Lanka. Since the introduction of seabass farming, farmers in the Negombo Lagoon use fish waste/trash fish to feed the fish. This practice is adopted in other small scale seabass farming sites in the other areas of the country. Imported extruded diets are used to feed the fish in the large scale marine cage farm established in the sea of Trincomalee in the Eastern Province of Sri Lanka.

Average fish production from seabass cages in the Negombo lagoon is around 26.0 Kg/m³. Gammanpila and Singappuli (2012) reported a production of 22.1 Kg/m³ from farming of seabass in cages installed in Nandativu, Kinniya in the eastern coast of Sri Lanka. Economic results show that small scale farming of seabass in the Negombo lagoon is highly profitable, mainly due to the fact that fish waste is available at no cost to the farmers. Number of farmers engaged in seabass

cage culture is increasing and it was reported that few large scale piggery owners too have commenced collection of fish waste to feed their animals, competing with fish farmers. Very few farmers have experienced difficulties in obtaining their requirements of fish waste during certain days to feed fish, in particularly during lean fish production season. Imported formulated seabass feeds available in the market costs around Rs.300 per Kg of feed. If seabass farming is carried out using these imported seabass diets (assuming that FCR is 1.5 and the fish production is the same as when feeding with fish waste) estimated operational cost per Kg of fish will be around Rs. 482.00. Estimated net profit over operational cost and net profit over both the operational and capital costs per Kg of fish will be around Rs.118.00 and Rs.54.00 respectively.

One of the main challenges with production of marine and brackish water fish species is the high cost associated with feed and there are several on-going initiatives working to reduce the dependency on low-value fish from capture fisheries and for example, use fish waste from processing plants and/or alternative sources of protein (Asia-Pacific Fishery Commission, 2014). Sustainability and expansion of small scale seabass farming or farming of any other carnivorous fish species in Sri Lanka depend heavily on the availability of suitable economical diets. Fish meal is the most important as well as most costly ingredient used in formulated fish feed, in particularly for carnivorous fish species. At present price of fish meal is very high and Sri Lanka's animal feed industry obtained their requirements of fish meal through imports. It is a positive sign to observe that few local entrepreneurs have commenced production of fish meal of good quality (>60% Protein) in recent years using fish waste and surplus of low value fish available during high fishing season. These locally produced fish meal is available at reasonably low price, when compared to the price of imported fish meal available in the market. National Aquatic Resources Research & Development Agency (NARA) at present, is implementing a Project with the support of Food and Agriculture Organization (FAO) to develop cost effective fish feeds for seabass using locally available fish meal and other plant base ingredients.

During discussions with seabass farmers and other resource users of the Negombo lagoon, it was revealed that the increase of number of cage farms in recent years have given rise to conflict

situations among seabass farmers and the other resource users. There had been few instances, where other resource users have damaged fish cages. There are 3310 fishers including 2586 full-time fishers and 724 part-time fishers in the and 866 out-rigger canoes (oru) and log-raft (Teppams) operated in the Negombo lagoon in 2010 (DFAR, 2012). A variety of fishing gears and methods numbering over 30 have been reported (DFAR, 2012). These include traditional fishing methods such as cast net, stake net, katta, brush pile, kaduppidela, angling, crab pots, scoop net, karakgediya, iratta, fish krall, kemana and dip net. Other more modern methods include the drive-in net, hand trawl, drift gill net, trammel net and lagoon seine. Most of the fishing methods are used in the basin segment of the lagoon. There is high competition for space among various resource users of the lagoon and increase in number of cage farms in recent years have aggravated the situation. At present there are around 50 authorized seabass cage farms and 12 un-authorized farms operate in the Negombo lagoon. As the farming of seabass in the Negombo lagoon is highly profitable, there is a tendency for increased number of people living around the Negombo lagoon to involve in seabass farming. Uncontrollable increase of number of cage farms can negatively affect sustainability of the system. This is evident in the case of Cirata and Sanguling reservoirs (Abery et al., 2005) in Indonesia, where the number of cages has far exceeded the estimated carrying capacities of the two reservoirs. It is vital that fisheries authorities consider undertaking carrying capacity assessments to determine optimal number of cages that can be operated in the lagoon and take action to control proliferation of cage farms without hindering traditional fishery activities of the lagoon. Provisions are available under Fisheries and Aquatic Resources Act. of 1996 to enforce such a control. This recommendation is applicable not only to Negombo lagoon, but also to other lagoons of the country, where potential sites for cage farming is available. It is important to study other fishery related activities in respective lagoons and identify areas/zones of lagoons suitable for cage fish farming. It was observed that considerable number of marine fishers living around the lagoon anchor their sea going motorized boats in the lagoon. Cage fish farmers very often complain about the damages caused to cage structures due to waves created by high speeding sea going boats. The rather simple cage designs utilized in the current practices, make it imperative that fish cages are sited in sheltered areas from the effect

of waves created by motorized boats. Poaching of fish from cages is a major problem faced by some of the farmers. This has prompted most of the farmers to install their cages in sites close to their residences.

Bethsida hatchery in Chilaw is the only hatchery in Sri Lanka which involves inbreeding and supply of seabass seed. Small scale seabass farmers depend on this hatchery to obtain their seed requirements and these farmers very often experience difficulties in obtaining their requirement of seed due to inconsistency and inadequacy of supply. Further several seabass farmers expressed their concerns about the inferior quality of seabass seed, which results in low growth rates. A large scale seabass cage farm operate in the sea around Trincomalee, import their requirements of seed from an Asian country. Government has given priority for expansion of seabass farming in Sri Lanka under presently implemented aquaculture development program and few more hatcheries are required to meet the growing demand for seabass seed.

In summary two main constraints for the development and expansion of seabass farming in the country are unavailability of reasonably priced effective diets and inadequate and inconsistent supply of good quality seabass seed. Suitable sites for cage culture of seabass should be identified based on proper scientific evaluations and social and environment studies and optimum number of cages that can be operated in each selected site need to be determined based on carrying capacity assessments. Further adequate measures should be taken to avoid potential conflicts with other resource users.

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REFERENCES

- [1] Abery, N.W., Sukadi, F., Budhiman, A.A., Kartaminhardja, E.S., Koeshendrajana, S., Buddhiman & S.S.De Silva 2005. Fisheries and cage culture of three reservoirs in West Jawa, Indonesia: A case study of ambitious developments and resulting interactions. *Fish Manage. Ecol.*, 12; 315 – 330.
- [2] Asia-Pacific Fishery Commission 2014. Regional overview of aquaculture trends in the Asia-Pacific Region 2014. RAP Publication 2014/26, 45p.
- [3] Chandrasoma, J., Pushpalatha, K.B.C. & W.A.J.R. Fernando 2015, Impact of introduction of culture-

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- based fisheries on fish production in perennial reservoirs of Sri Lanka. 83-90 pp. In: De Silva, S.S., B.A. Ingram, S.Wilkinson (eds), Perspectives of culture-based fisheries development in Asia. Network of AquacultureCentres in Asia-Pacific, Bangkok, Thailand.
- [4] De Silva, S.S., U.S.Amarasinghe & T.T.T.Nguyen 2006. Better practice approaches for culture based fisheries development in Asia. ACIAR Monograph No. 120, pp 96.
- [5] DFAR 2012. Fisheries development and management plan of Negombo Lagoon. Regional fisheries livelihoods programme for South and Southeast Asia. Department of Fisheries and Aquatic Resources, Sri Lanka. (www.fao.org/3/a-bm051e.pdf).
- [6] EAIP 1998. Study on the Economic- Environment Linkages of lagoon and near shore coastal fishing. Study conducted under the Environment Action 1 Project (EAIP). Ministry of forestry and Environment and world bank (unpublished).
- [7] Gammanpila, M. 2010. Hydrography, nutrients and abundance and distribution of zooplankton in Negombo lagoon, Sri Lanka. Sri Lanka J. Aquat. Sci.,15(2010): 13-24.
- [8] Gammanpila, M. & M.S.Singappuli 2012. Economic viability of Asian seabass (*Lates calcarifer*) and Tilapia (*Oreochromis niloticus*) small scale aquaculture systems in Sri Lanka. Sri Lanka J. Aquat. Sci., 17 (2012): 47-57.
- [9] Hettiarachchi, S.S.L and S.P. Samarawickrama 2003. Towards improved environment management of Negombo lagoon. COPEDEC vi, Colombo, Sri Lanka.
- [10] Jayakody, D.S. 1994. Traditional lagoon fisheries in Negombo. In: Morris, M.J., M. Hotta & A.R.Atapattu (eds). Development of community based fisheries management. Bay of Bengal Programme for fisheries management. BOBP/REP/72: pp98.
- [11] Pushpalatha, K.B.C. & J.Chandrasoma 2009. Culture-based fisheries in minor perennial reservoirs in Sri Lanka: Variability in production, stocked species and yield implication. Journal of Applied Ichthyology 26: 98-103.
- [12] Pushpalatha, K.B.C., J. Chandrasoma, H.S.W.A.Liyanage, W.A.J.R.Fernando & J.M.Jayabahu 2016. Farming of Nile tilapia (*Oreochromis niloticus*) in backyard ponds in Sri Lanka: Culture practices, fish production and profitability. Sri Lanka J.Aquat. Sci. 21(1) (2016): 27 – 34.
- [13] Samarakoon, J.I. & J.C.J. Van Zon (eds) 1991. Environment profile of Muthurajawela and Negombo lagoon. Colombo. Euro Consult/ Greater Colombo Economic Commission.
- [14] Silva, E.I.L., J. Katupotha., O.Amarasinghe., H. Manthritilake& H. Ariyaratne 2013. Lagoons of Sri Lanka: from the origins to the present. Colombo, Sri Lanka: International Water Management Institute (IWMI). 122p. doi: 10.5337/2013.215
- [15] Silva, E.I.L., 1996. Water quality of Sri Lanka – A review of twelve water bodies. Kandy: Institute of Fundamental studies.
- [16] SOFIA, 2016.The state of world fisheries and aquaculture: contributing to food security and nutrition for all. Food and Agriculture Organization of the United Nations. pp189.