Application of a community-based management approach for sustainable governance of kraal (Ja-kotu) fisheries in Sri Lanka

Menake Gammanpila

National Aquatic Resources Research and Development Agency, Crow Island, Mattakkuliya, Colombo 15, Sri Lanka.

*Corresponding author: menakegammanpila@gmail.com

ORCID ID: https://orcid.org//0000-0001-5123-8172

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Abstract The institutional robustness of the community-based management systems of the kraal (Ja-kotu) fisheries in Madu ganga, Bolgoda lake, and Jaffna lagoon in Sri Lanka were assessed for compliance with Ostrom's modified design principles through the utilization of their knowledge in resource management. Out of the total number of 38, 8, and 3,000 fishers from Madu ganga, Bolgoda lake, and Jaffna lagoon respectively, a semi-structured questionnaire was used to interview 90%, 88%, and 10% of the fishers, and focus group discussions (n = 10) were conducted over a period of one year. The socio-demographic profiles of Ja-kotu fishers in the three places indicated that most of the fishers were in the >40 years of age group, respectively, with at least 41% of fishers in the three places having over 20 years of experience in fishing. In Bolgoda lake, many fishers (57%) have sufficient formal education (up to GCE: Ordinary Level). Almost all the fishers interviewed, 94%, 71%, and 98% of fishers in Madu ganga, Bolgoda lake, and Jaffna lagoon, stated that the ownership of the Ja-kotu fishery was passed down from generation to generation. Individual fishers voluntarily monitored fishing activities and resources, and there were strong mechanisms to share the cost among fishers in three places proportionally. Though there is no proper legislation to define user boundaries for Ja-kotu fishers in all places, the multi-layer institutional structure of Ja-kotu fishers in the Jaffna lagoon was comparatively strong enough to support their decision-making process. After declaring Madu ganga as a Ramsar wetland site, the traditional community rights and institutional structures of Ja-kotu fishers are not supported by responsible fishery management mechanisms. The customary institutions unveil the general weakness of key interactions with organizations, suggesting that a community needs strong institutional support to face socioeconomic, political, and institutional challenges to govern common pool resources.

Keywords: Local ecological knowledge, Ostrom's design principles, community-based management, fisheries management.

INTRODUCTION

Small-scale coastal fisheries (SSF) are an important source of income, food security and nutritional needs for a large population in many parts of the world, particularly in developing countries. FAO (2020) reported that 120 million people are dependent on SSF for their livelihood, and almost 97% of whom are in developing countries. SSF employ over 90% of the world's capture fisheries and provides livelihoods and food security for many millions of individuals around the globe (Berkes *et al*., 2001). The long-term economic prospects of a country largely depend upon the sustainable use of its unique natural resources (Hossain *et al*., 2004), including SSF which, increasingly become part of globalized food systems (Arthur *et al*., 2022). Many SSF in the world are in crisis today due to the over-exploitation of resources, the inequity of allocation of access to the resources and failures to enforce sustainable management options. Low excludability and high subtractability result in over-exploitation and are the common challenges of managing SSF unless common pool resources are effectively governed (Feeny *et al*., 1990). Top-down management in fisheries management always ignores local participation in the management process (Berkes *et al*., 1989) and especially in the

SSF, often the socio-economic aspects. In this context, the importance of participatory approaches in fishery resource management, an alternative to conventional centralized resource management, especially in labour-intensive, small-scale fisheries, in many parts of the world has been increasingly acknowledged (Johannes *et al*., 2000; Halls *et al*., 2017; Bavinck & Vivekanandan, 2017., Berkes, 2018., Halls *et al*., 2017). Theorists and policymakers increasingly recognize the right of small-scale fishers to participate in governance and management processes (Schultz, 2017) and to have equitable access to, and benefits from those resources. Bavinck *et al*. (2013) emphasized the importance of fisheries governance by state and non-state institutions in Sri Lanka. In fact, in fisheries management, attention has been directed towards the active involvement of local communities in managing near-shore coastal resources (Richmond & Levine, 2012; Rivera *et al*., 2017). Fishers have a wealth of knowledge and long experience developed in a socio-cultural and geographical context including ecosystem-based and resources management, fishing practices, and governance of fisher livelihoods, which provide valuable information for resource management of small-scale fisheries in developing countries (Fisher *et al*., 2015). Traditional ecological knowledge (TEK) or indigenous knowledge (IK) is the transmission of regular and persistent interactions between individuals and the biophysical environment from one generation to the next (Faii *et al*., 2018) or horizontally through socialization (Ruddle, 1994) by a particular group of people. TEK is widely recognized as one of the vital components in the community-based fisheries management of SSF in many developing countries in the tropics (Pomeroy *et al*., 1997). It provides an appropriate source of information that can supplement fishery information collected from conventional methods (Saenz-Arroyo *et al*., 2005). Analysis of TEK can help share knowledge, facilitate dialogue among resource managers, scientists and fishermen (Paolisso, 2002) and wide range of cost-effective sources of information on fish migration patterns, that support environmental impact assessment, fisheries management, and conservation priorities (Nunes *et al*., 2019). TEK is also useful for examining changes in resource abundance including the size of fish and catch, spawning behaviour, habitat and information on management practices and is used for resource extraction of small-scale fisheries (Fisher *et al*., 2015).

The Nobel Prize-winning economist, Elinor Ostrom (Ostrom, 1990) introduced a common-pool resource theory based on a set of eight core design principles that local communities could develop more robust institutions for managing common pool resources rather than through regulations by external organizations. She strongly believed in the power of local communities and suggested that resource users could be organized to collectively solve problems and take responsibility for monitoring common resources. Later Cox *et al*. (2010) expanded these eight design principles to 11 principles.

The well-being of the fishing community depends on a combination of social, economic and environmental conditions (Bavinck & Vivekanandan, 2017). Integrating fishermen's traditional knowledge of ecological processes gained by a series of observations and trial and error, into management decisions has not been a large concern in Sri Lanka and resulted in a mismatch between management approaches and ecosystem dynamics. A few locally organized informal fisheries management systems and institutional arrangements of several traditional coastal fisheries are reported from Sri Lanka, including stake net fishery in Negombo estuary (Amarasinghe *et al*., 1997; Iwasaki, 2014), kraal (Ja-kotu) fisheries in the Madu ganga estuary (Atapattu, 1987), and Rekawa lagoon (Maitipe & De Silva, 1986), in southern Sri Lanka, beach seine fisheries in the north-western and southern provinces (Deepananda *et al*., 2015, 2016a; Gunawardena & Amarasinghe, 2016; Gunawardena *et al*., 2016), stilt fishing in southern Sri Lanka (Deepananda *et al*., 2016b), culture-based fisheries in perennial reservoirs of Sri Lanka (Pushpalatha *et al*., 2020), brush park fisheries in Negombo lagoon, Sri Lanka (Gammanpila *et al*., 2019) and state and community institutions governing of fisheries in southern Sri Lanka (Wickramasinghe & Bavinck, 2015). However, most of the community-based fisheries management strategies have gradually begun to fail due to the mechanization of world fisheries and fisher communities are challenged to preserve their traditions, fish resources and livelihoods. Many SSF in the world are increasingly affected by external factors and pressures that jeopardize their traditional practices, food security and livelihoods (Kittinger *et al*., 2013). In addition,

small-scale fishermen are left increasingly vulnerable to the shocks and uncertainties associated with economic, political and environmental change (Frawley *et al*., 2019). The management strategies initiated by the government with a centralized top-down control approach are aimed at managing the declining fishery resources, but they too are largely unsuccessful in many parts of the world (Barkes *et al*., 1989). However, local knowledge of fishers can be effectively used in the conversation between fishers and resource managers for the sharing of power and responsibility between the central government and local resource users (Berkes, 2009).

The Ja-kotu or kraal fishing method is the most abundant static and passive fishing gear targeting shrimp and prawn species in a few lagoons, including Madu ganga, Bolgoda lake, and Jaffna lagoon in Sri Lanka. A fish kraal has a long vertical wall of netting or bamboo strips held up by a line of strong wooden poles sticking upwards from the beach, running perpendicular to the shoreline, around fifty meters long, that is intended to interrupt the natural swimming pattern of the fish and other species and direct them along it away from the shore and into a series of traps. Being traditional fishing practices, kraal fishers are expected to possess mechanisms, which utilize their TEK for resource management. Such TEK and customary management practices of community-based management techniques offer great promise for improving the condition of the coastal environment and management of fisheries. However, these traditional management strategies are, in most situations, not on record, and existing information does not give a complete overview of the structure and functioning of fisheries. The present study was designed to evaluate the effectiveness of the TEK in empowering communities to manage their own resources of kraal (Ja-kotu) fisheries in Madu ganga estuary, Bolgoda lake and Jaffna lagoon, and empirically verify with Ostrom's modified design principles to provide possible recommendation for sustainable management of the fisheries.

MATERIALS AND METHODS

The study was conducted to assess community-based management practices adopted by Kraal (Ja-kotu) fishers in Bolgoda lake, Madu ganga and Jaffna lagoon in Sri Lanka (Fig.1). The Jaffna lagoon is the largest lagoon (extent 450 km^2) in Sri Lanka, situated between 9° 50' N and 79° 50' E to 9°20' N and 80° 30' E and covering the Jaffna and Kilinochchi districts of the Northern province (Ragavan *et al.*, 2021). The lagoon is a semi-enclosed brackish water body, which opens into the northeastern part of Palk Bay as well as to the sea. The Madu ganga estuary is a relatively shallow brackish coastal aquatic system located in the Galle district, Sri Lanka. The estuary is spread over 9.00 km^2 of which 7.70 km^2 are covered with water and 64 islands having 15 islands of larger landmasses. Bolgoda lake is located in the Southwest of Sri Lanka, around 19 km east of Colombo. The lake covers 374 km^2 of partly fresh and brackish water. It consists of two main bodies of water, a Northern and a Southern portion, connected by a waterway called Bolgoda river.

The information was gathered primarily based on the available literature, key informant interviews and additional secondary source documents including peer-reviewed journals, government documents and other legislative documents. A detailed semi-structured questionnaire was used by the author to interview stakeholders in all aspects of the traditional management processes. There were 38 kraal fishers in the Madu ganga estuary, 8 in Bolgoda lake and 3000 in Jaffna lagoon. The different structures of kraal installed in three different lagoons are shown in Figure 2. Of these, 34 fishers (90%) in the Madu ganga estuary, 7 (88%) from Bolgoda lake and 300 (10%) from Jaffna lagoon were interviewed from January to December 2020 to collect information about the broad range of existing traditional fisheries management systems and socio-demographic information of fishers. The key informants including the presidents of the fisheries cooperative societies, community members, fisheries inspectors and the assistant directors of fisheries in the regions were also interviewed. The questionnaire administered to interview fishers was focused on preliminary demographic information of their fishers including age, educational level, number of years of experience, indigenous knowledge in the fishing operation, factors that affect shrimp harvest including salinity, depth and distance from the sea, fish and shrimp species found, phases of the lunar cycle and appreciation of fishing rights for equity sharing of the resource. In addition to the

questionnaire survey, a series of group discussions (N=10), visual observations and fish identification were made following the fish identification guide (De Bruin et al., 1995) during fishing practices. The questionnaire also contained statements to gather information relevant to institutional robustness for averting the common pool resources (CPR) dilemma in the fishery (Table 1).

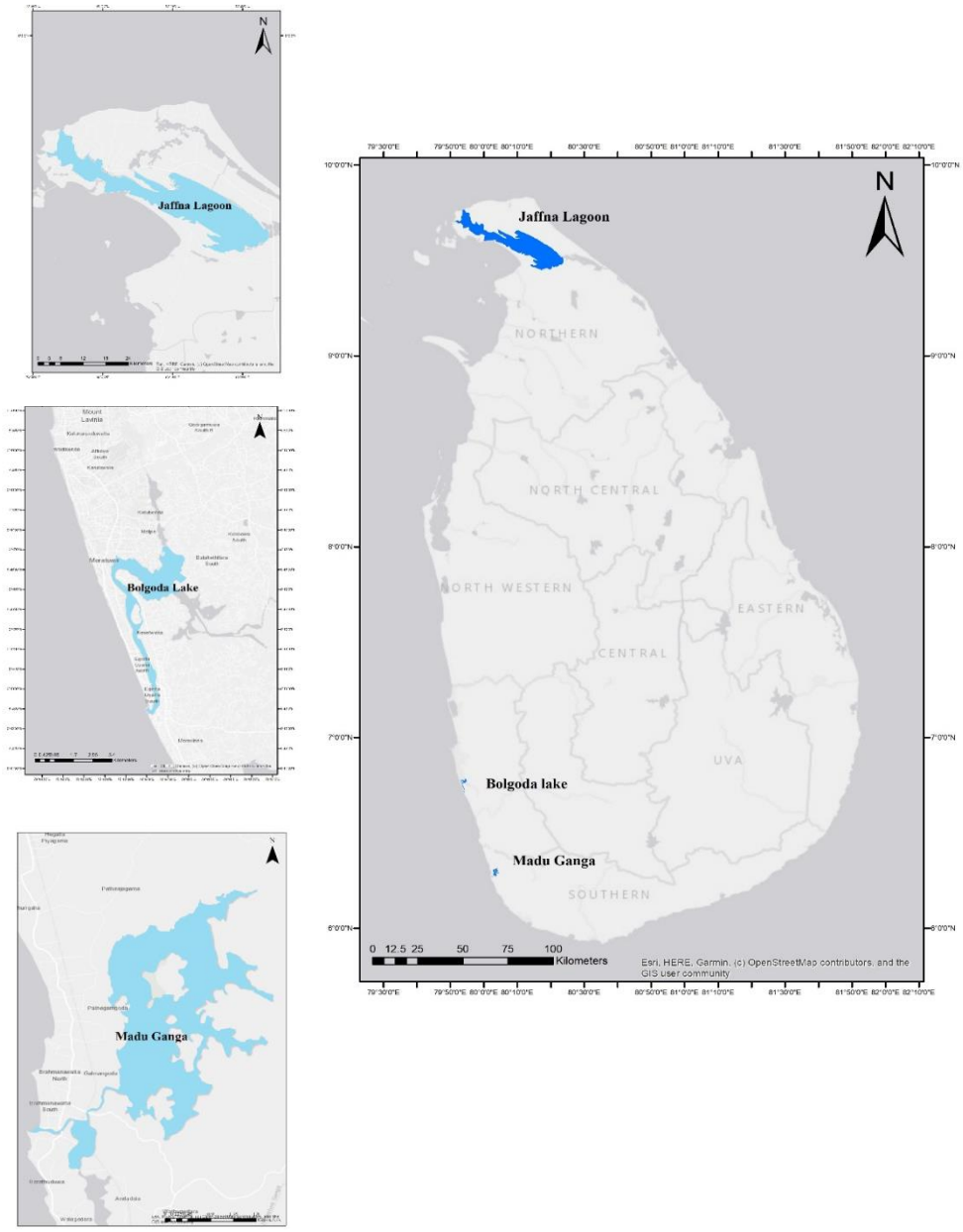

Fig 1. Map of the coastal belt of Sri Lanka showing the study area of Jaffna lagoon, Bolgoda lake and Madu ganga.

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The information was gathered based on a five-point Likert scale (Likert, 1932) with categories ranging from 1 to 5 where 1 was assigned for noncompliance, 2 for low compliance, 3 for moderate compliance, 4 for high compliance and 5 for very high compliance. These levels of compliance were evaluated for each of the 11 modified design principles. Accordingly, each community's overall median value for each design principles category is of concern. A total of 3-7 components were included for each design principle.

Interviews were conducted in fishers' native languages, Sinhala and Tamil, adhering to principles of basic ethnographic studies. Based on the mean and median values of the Likert scale for each component of Ostrom's modified design principles, the institutional robustness for averting the CPR dilemma was determined (Ostrom, 1990; Cox *et al*., 2010). All the interviews and group discussions with respondents were carried out at a place of the fisherman's and fisheries societies' buildings choosing in their mother language.

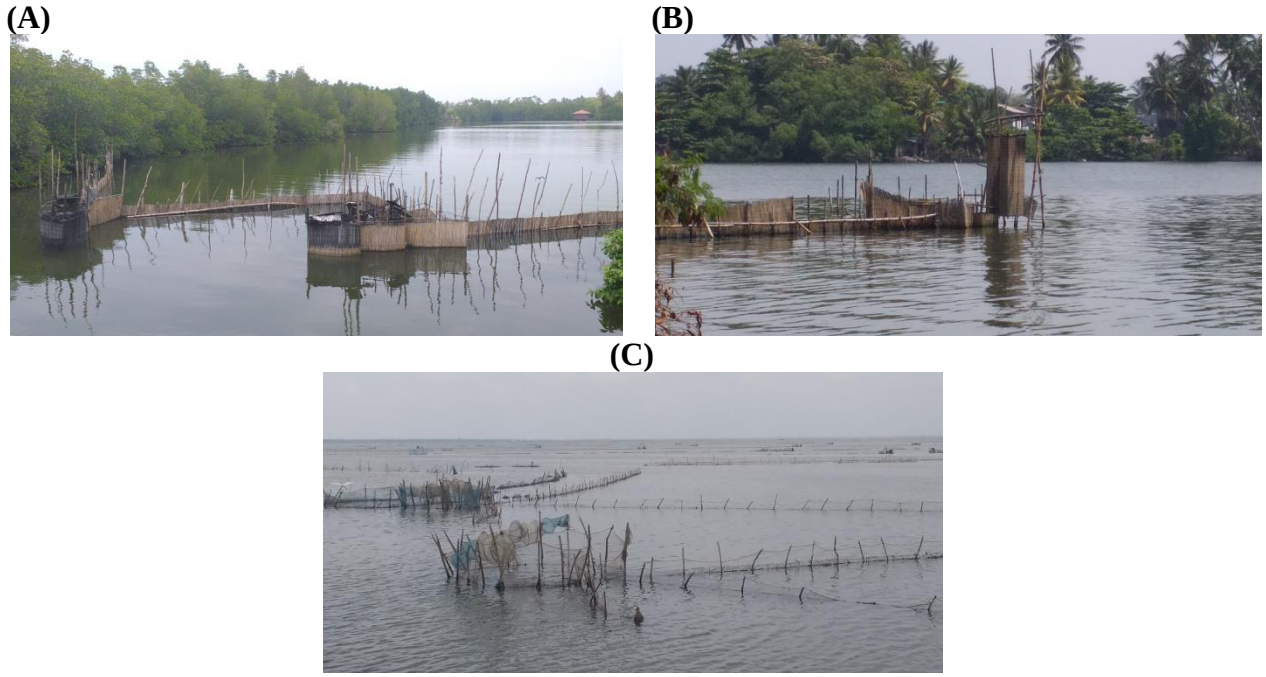

Fig 2. Structures of Kraal (Ja-kotu) in (A)=Madu ganga, (B)= Bolgoda lake and (C)= Jaffna lagoon in Sri Lanka.

RESULTS

Socio-demographic information

The socio-demographic profile of Ja-kotu fishers in Madu ganga (Fig. 3), indicated that the majority of fishers (88%), were 40+ yrs age group, with 41%, having over 20 years of experience in traditional fishing. Almost all fishers interviewed—94% of fishers in Madu ganga, stated that the ownership of the Ja-kotu fishery was passed down from generation to generation.

Bolgoda lake (Fig. 4) indicated that the majority of fishers (57%) were 40+ yrs age group, with 43% having over 20 years of experience in traditional fishing. Nearly 71%stated that the ownership of Ja-kotu fishery was passed down from generation to generation. Many of them (57%) in Bolgoda lake have sufficient formal education (up to GCE - Ordinary Level). Most activities related to Ja-kotu fisheries in Bolgoda lake are not full-time occupations and the fisher was engaged in diversified and stretched livelihoods including engagement in other offshore fishing activities, working as labourers and being involved in various types of self-employment (Fig.4).

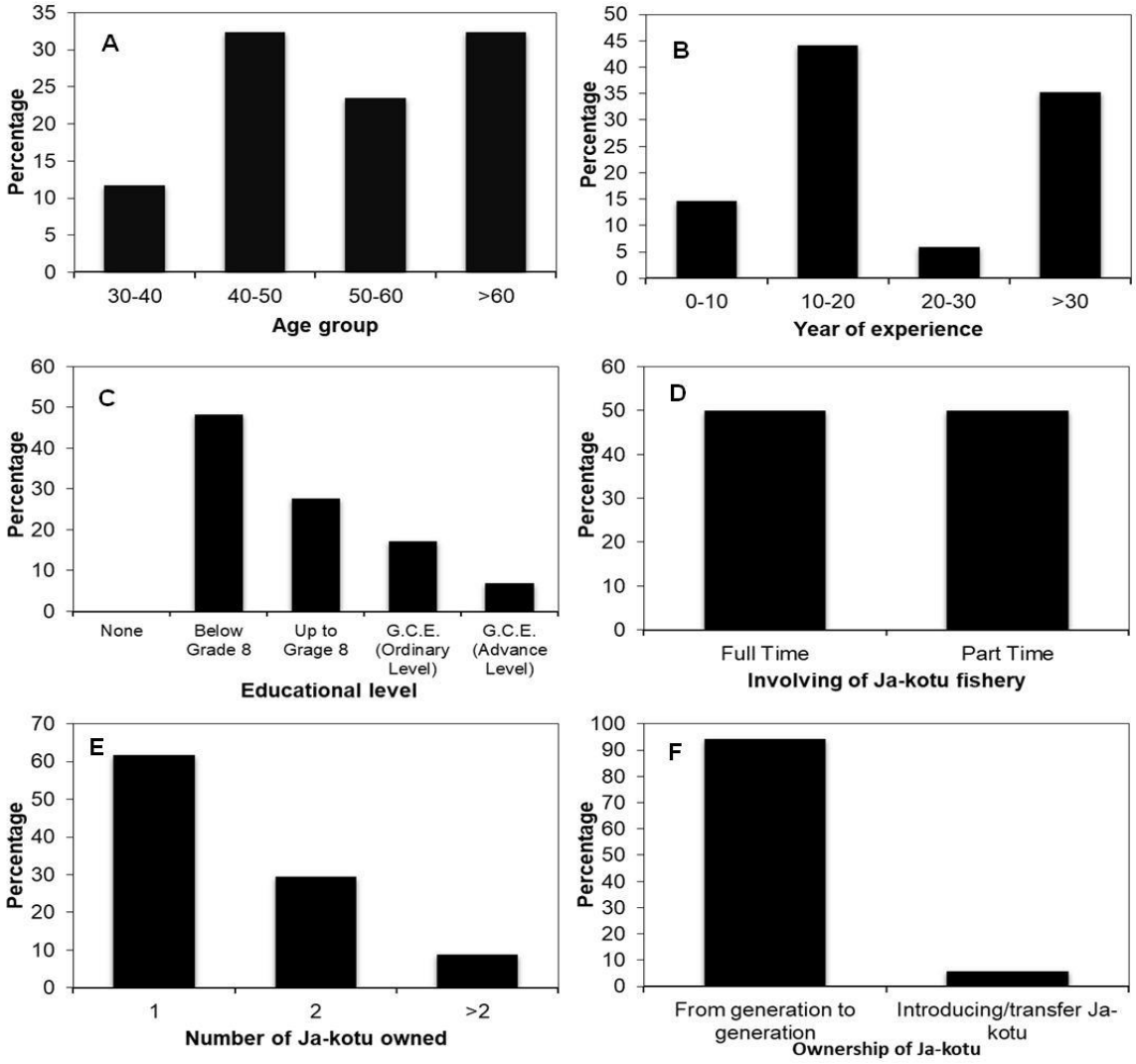

Fig 3. Distribution of fishermen by A) age group; B) year of experience in operating Ja-kotu; C) educational level; D) involving of Ja-kotu fishery as full-time or part-time; E) number of Ja-kotu owned by one fisherman and F) ownership of Ja-kotu in Madu ganga estuary.

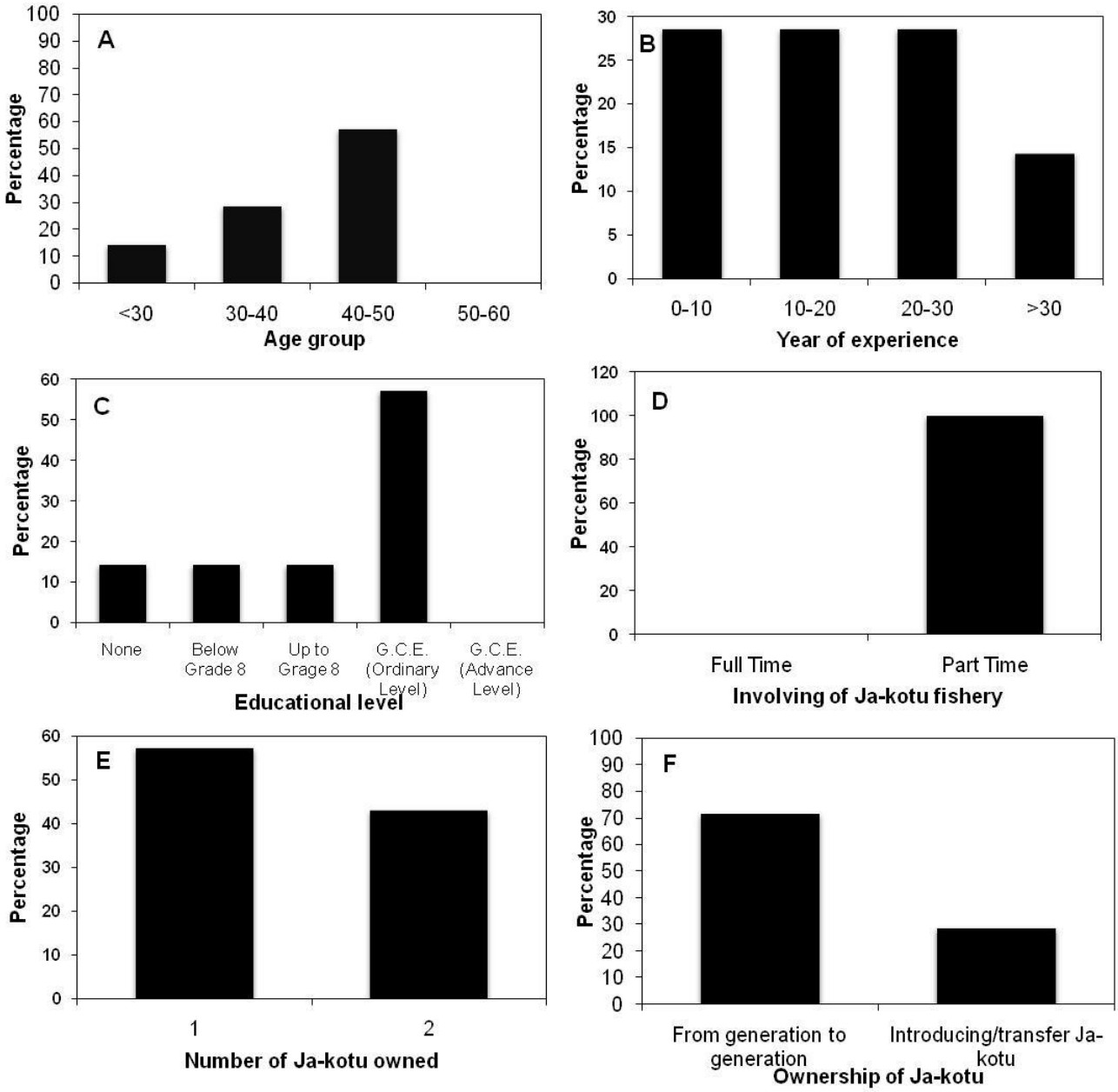

Fig 4. Distribution of fishermen by A) age group; B) year of experience in operating Ja-kotu; C) educational level; D) involving of Ja-kotu fishery as full-time or part-time; E) number of Ja-kotu owned by one fisherman and F) ownership of Ja-kotu in Bolgoda lake.

Jaffna lagoon (Fig. 5) indicated that the majority of fishers (72%) were 40+ yrs age group, with 54% having over 20 years of experience in their traditional fishing activities. Of almost all fishers interviewed, 98%of fishers in Jaffna lagoon stated that the ownership of Ja-kotu fishery was passed down from generation to generation.

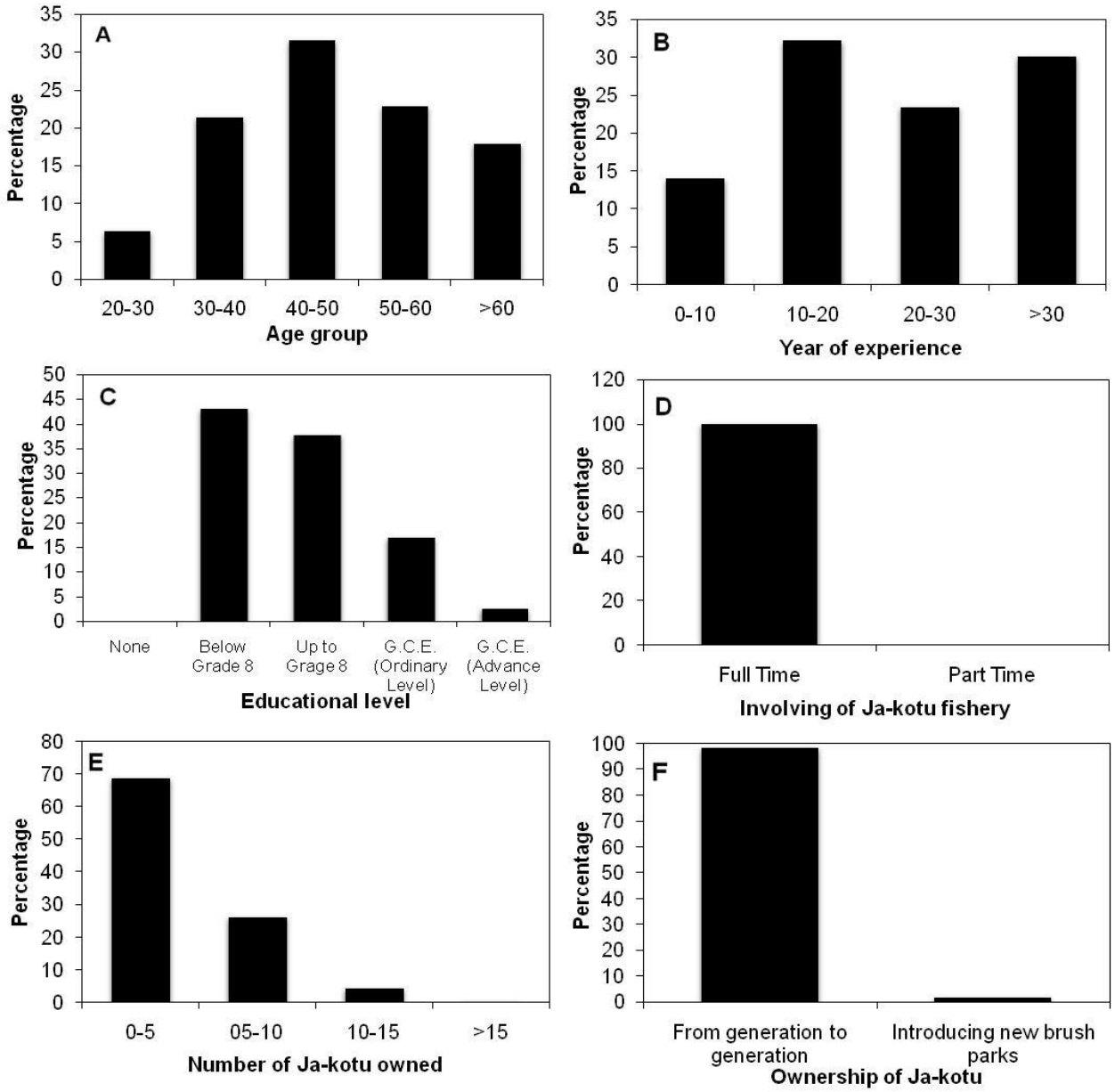

Fig 5. Distribution of fishermen by A) age group; B) year of experience in operating Ja-kotu; C) educational level; D) involving of Ja-kotu fishery as full time or part time; E) number of Ja-kotu own by one fisherman and F) ownership of Ja-kotu in Jaffna lagoon.

The kraal fisheries production in three sites

The catch consists in Madu ganga is mainly shrimp, local name Kalissa (*Penaeus monodon*), Rathissa (*Metapenaus monoceros*), Malissa (*Penaeus indicus*), Kurutuissa (*P. semisulcatus)*, mangrove crabs (*Scylla serrata*) and fish species including Indian anchovy (*Stolephorus indicus*), perchlet (*Ambassis gymnocephalus*), pony fish (*Leiognathus* sp.), sea bass (*Lates calcarifer*), mullets (family Mugilidae), grouper (*Epinephelus* sp.), Anchovy (*Stolephorus* sp.), cat fish (*Arius* sp.), trevallies (*Caranx* sp.) and Pearl spot (*Etroplus suratensis)*. Based on the experience of Ja-kotu fishers in Madu ganga, the highest catch of *P. indicus* was observed during full moon day and the highest catch of black tiger prawn (*P. monodon*) was recorded during new moon day.

Ja-kotu fishers in Bolgoda lake target the shrimp locally called Malissa (*Penaeus indicus*) used as bait for coastal fishing. Rainy season fishers received maximum production of freshwater prawn (*Macrobrachium rosenbergii*) in their catch, and as other fish and shrimp production is the minimum, the majority of fishers refrain from fishing during the south-west monsoon period from May to September each year.

In the Jaffna lagoon, the harvest of kraal represents shrimp and crabs mainly *P. indicus, P semisulcatus,* blue swimming crab (*Portunus pelagicus*) and grouper (*Epinephelus* sp.), silverbiddy (*Gerres* sp.), milkfish (*Chanos chanos*) muglids and spinefoot (*Siganus* sp.).

Ostrom's modified design principles

Considering all facts of compliance with Ostrom's modified design principles indicated that institutional arrangements of fisher communities of Ja-kotu fisheries in three lagoons are at different levels of compliance and Jaffna lagoon had high levels of compliance with the benchmarks set by design principles (Ostrom, 1990; Cox *et al*., 2010) (Table 1).

Table 1. Components of different design principles and semi-structured questionnaire used for collecting information for traditional Ja-kotu fishers (based on Ostrom modified design principles). M=Madu ganga, B=Bolgoda lake and J=Jaffna lagoon.
Level of compliance (5=Very high compliance, 4=High compliance, 3=Moderate compliance, 2=Compliance at lower level, 1=No compliance).

Design Principle	**Components evaluated/ examined**	**Median (and mean) values of compliance**	**Characteristics**
1A	**Clearly defined user boundaries**	M 1.00 (1.86) B 1.00 (2.57) J 4.00 (3.29)	Strictly restricting access to the installation of new Ja-kotu Maintaining minimum distance between Ja-kotu
	Are there clearly defined user boundaries for resource users of Ja-kotu fishery?		
	Are the user boundaries accepted by non-appropriators?		
	Are the user boundaries accepted by government authority/ legitimacy?		
	Are the user boundaries used for resource management purposes?		
	Do the user boundaries exist for resource availability?		
	Are the user boundaries used from generation to generation?		
	Do the user boundaries exist at proximity to the home?		
1B	**Clearly defined resource boundaries**	M 1.00 (1.50) B 1.00 (1.75) J 1.00 (1.50)	Occupy space at each landing site for each fisher to leave his craft and gears. It helps to minimize possible conflicts among fishers.
	Do clearly defined resource boundaries exist?		
	Are the resource boundaries accepted by non-appropriators?		
	Are the resource boundaries accepted by government authority / legitimacy?		

	Are the resource boundaries used for resource management purposes?		
2A	**Congruence with local conditions**	M 2.00 (2.50) B 1.00 (2.33) J 1.00 (2.00)	User rights are restricted by registration of craft according to the Article-15 of Fisheries and Aquatic Resources Act, No. 2 of 1996.
	Is there a similarity existing between the resource environment and its governance structure (rules)?		
	Excludability rules: Do eligibility rules exist?		
	Do intercommunity access rules exist?		
	Subtractability rules: Do temporal allocation rules exist?		
	Do restricting time/place/gear/ technology rules exist?		
	Do fishing behavior rules exist?		
	Do conservation rules exist?		
2B	**Congruence between appropriation and provision**	M 4.00 (3.50) B 5.00 (4.00) J 5.00 (4.00)	Clear arrangements of sharing income that vary according to the ownership of Ja-kotu and craft
	Does an analogy between cost and benefits exist?		
	Does a mechanism to proportionally share the cost exist?		
	Does a mechanism to proportionally distribute the benefits exist?		
	Does a mechanism to distribute the benefits to appropriators during non-temporal allocations exist?		
3	**Collective-choice arrangements**	M 3.00 (2.75) B 1.00 (1.00) J 4.00 (3.25)	Fishery regulations on the distance between Ja-kotu, location, restriction number of cod ends etc.
	Are there operational and collective-choice rules existing?		
	Do resource users have the right to make, enforce and change existing rules?		
	Are these rules effective?		
	Do external authorities accept these rules (legitimacy)?		
4A	**Monitoring of users**	M 4.00 (3.67) B 5.00 (5.00) J 5.00 (4.67)	Fishing activities and violations are monitored by individual fishers during 24 hours.
	Is there an effective mechanism to monitor the enforced rules (fishing activities, violations, violators) that exist?		
	Do they regularly monitor appropriators'/non-appropriators' activities/behaviour?		

	Is this monitoring of appropriators' behaviour effective?		
4B	**Monitoring of resources**	M 4.00 (3.67) B 5.00 (5.00) J 4.00 (3.67)	Individual fishers are regularly monitored on resources and the amount of exploitation, opening and closing of lagoon mouth), disturbance from other activities including poaching , tourism activities, etc.
	Does an effective mechanism for monitoring resources (shrimp and fishes) and fishing territory exist?		
	Do they regularly monitor the resources?		
	Is this monitoring of the resource effective?		
5	**Graduated sanctions**	M 1.00 (1.00) B 1.00 (1.00) J 3.00 (3.00)	Formulating and implementation of fishing rules through collective agreement and strength of implementation process
	Does a mechanism for graduated sanctioning exist?		
	Is this mechanism effective?		
	Do government beurocratic authorities accept the mechanism/ legitimacy?		
	Is there an official appointed accountable for appropriators?		
6	**Conflict-resolution mechanisms**	M 2.00 (2.67) B 2.00 (2.00) J 4.00 (4.33)	Empowered to apprehend fishing rule violators and responsibility of controlling fishing rules
	Whether low-cost mechanisms exist to resolve conflicts between resource users?		
	The degree of effectiveness of the existing mechanism?		
	Do users support effective monitoring and rule enforcement?		
7	**Minimal recognition of rights to organize**	M 2.00 (2.33) B 2.00 (1.67) J 2.00 (2.67)	Responsibility for the decision-making process and implementation of management decisions. The rights of appropriators to make their own decisions within the community and institutions are not challenged by external governmental authorities.
	Is there an ability to compromise and devise their own decisions within the community?		
	Higher-level state authorities recognize the right of the community institution/resource users to self-govern		
	Is the community and collaborative decision making process with government authorities effective?		
8	**Multi-level institutional structure**	M 2.00 (2.40) B 3.00 (3.20) J 5.00 (4.80)	A multi-layer institutional structure which links fisher societies (horizontal integration) and regional fisheries officer, the department of fisheries at the district level, Ministry of fisheries at the national level (vertical integration)
	Are there multiple layers of the institutional structure established?		
	Is there a vertical integration existing?		
	Is there a horizontal integration existing?		
	Is there a frequent procedure existing for measuring each linkage?		
	Degree of the effectiveness of these multilevel institutional structure		

User boundaries (1A)

The major criterion for site selection is based on the water depth (1.2-2.4meters) with a muddy condition, moderate currents with narrow canals, monsoonal pattern, wind prevailing, availability of wooden poles, resources availability and ability to operate by the fishermen at high depth. In general, fishers are refraining from installing Ja-kotu in T-shaped junctions in the estuary to avoid damage by eroding the estuary bank, especially in Madu ganga. The length of the Ja-kotu depends on the availability of raw materials, construction cost, distance to adjacent Ja-kotu, and availability of space in the estuary. The durability of raw materials of Ja-kotu depends on the location where they are placed in the estuary. The salinity and maturity of bamboo strips act as major impediment factors that reduce the durability of Ja-kotu. In general durability of bamboo strips varied from 3 to more than 6 months during high and low saline water respectively.

Atoliya or atoli dela is a stick-held net generally associated with Ja-kotu in Madu ganga estuary. According to the operation of Ja-kotu regulations, there should be a navigable space of at least 16 feet (5 m) in between Ja-kotu and the distance should be 7 feet (2.1m) in Bolgoda lake. Normally Atoli net consists of two ends which are fixed by long sticks or poles and the other two ends are held by two people who are operated just outside this gap. The net is held by the two people below the surface of the water and raised when fish pass over it thus capturing the fish.

The Department of Fisheries introduced regulations to control this fishery and was published in Government Gazette No. 10,332 on 21st December 1951. According to regulations in the gazette, the minimum distance between two Ja-kotu should be fifty yards (46 m) and the maximum length of the Ja-kotu should not exceed more than 70 yards or 210 feet (64 m) in Madu ganga. Further, this indicates that a completely unobstructed space of at least 16 feet (5 m) between the bank and the end of Ja-kotu should be left for the navigable passage of boats. Traditional fishers mentioned that these regulations were enforced only until 1969. Those regulations are not commonly practiced today by the many fishers, and as a result, many types of poor management have taken place such as an increasing number of Ja-kotu fishers, the occurrence of disputes among fishers and other stakeholders, including other types of fishing and tourism activities, who depend on the estuary for their livelihood.

The regulations made by the Moratuwa Urban District Council, under Local Government Ordinance No, 11 of 1920, in 1931 to regulate the Ja-kotu fishery in the Bolgoda lake associated with the Panadura River. Under these regulations, fishing by kraal is permitted only under a license issued by the Chairman of the Moratuwa Urban District Council for a fee of Rs.25. Every kraal should leave a central gap 27.5 m wide for the passage of craft and a gap inshore at each end 9 m wide. No kraal shall be permitted within 45 m of any other kraal. Fishing by kraals is prohibited during the months of April, May and June. These regulations were enforced by the Moratuwa Town Council, which is now defunct.

Ja-kotu, having a wing net called "sirahuvalai" has a more than ninety years of long tradition and is very popular in the shallow lagoon and near shore areas of the seas in the northern province, of Sri Lanka. There are 3,000 fishers presently operating more than 6,000 Ja-kotu and kudu del in the Jaffna lagoon. Many fishers pointed out that they have been using the same place to install Ja-kotu since 1960. After 1990 during the civil war period, Sri Lankan NAVY strictly controlled fishing activities in coastal waters around Jaffna. The Sri Lankan NAVY declared an area and operation time for Ja-kotu fishery in the area. Since the allocation time wasnot long enough to operate Ja-kotu in the far area in the sea, all fishers converted Ja-kotu to Kudu del which was installed in a shallow area in the lagoon. Kudu del requires less wooden material and limited space is needed compared to Ja-kotu.

Each Ja-kotu comprises two parts a fence net and a cod-end. Two fences (wings) are constructed for shrimp and only one fence is built for targeting fish. Such an essential feature of the Ja-kotu is the 100-200m long fencing net vertically constructed with the aid of wooden poles sticking upwards from the beach, running at right angles to the shoreline, around fifty meters long, that is intended to interrupt the natural swim of the fish and other species and direct them along with it away from the shore. At the end of the net, there is a series of traps that collect target species called cod-end. This net fence is called leader and fish then enter into the area called the playground. While they are

swimming around in the playground area, some enter the trap area. Nets with smaller meshes are used for the chamber/trap and those with large meshes are used for the wing. The mesh size of the wing varies from 5.0 to 5.8 cm for targeting shrimp and 6.4 cm for fish. Nets with smaller meshes varied from 5/8 inch to build for the trap. The height of the netting varies with the depth at which the fences are erected, the netting always reaching above the level of the water.

When Ja-kotu have not been used for fourteen days, any other traditional fishers can install new Ja-kotu in the same place by using the same or new material in the Jaffna lagoon. Basically, the criteria for the selection of locations are not based on the distance from the home and are not adhered to by the fishers.

Resource boundaries (1B)

The wooden poles which have pointed ends being used for fencing are approximately 5 m in length and have a minimum height of 2m. Nearly 200 wooden poles are used between 6 feet distance each for the construction of one Ja-kotu in the Jaffna lagoon. Earlier wooden poles were purchased from the timber cooperation and later it was harvested from the Oddusudan forest area. However, after Oddusudan forest was declared a conservation zone by the Department of the Forest no one was allowed to enter the forest for any activity.

The modern type of stake net has developed only following the recent civil war and is significantly different. Set stake nets are large stationary fishing gear which is set in one to 1.5 m depth in the migratory path of the target species to guide them into trapping enclosures. Many fishers use 9.0 m long, 100-metal pipes, which are not recommended for use instead of wooden poles, with a 12 feet (3.7m) distance for the construction of Ja-kotu.

Congruence with local conditions (2A)

Access to fishing grounds

The Madu ganga wetland was declared in 2003, in terms of the Ramsar Convention, an area of high biodiversity and a unique ecosystem receiving high visitation. On 17th July 2006, it was declared as a national sanctuary by the Department of Wildlife Conservation. Sri Lanka Tourism Development Authority declared this area a tourist development area on 21st October 2002.

Up to 1935, no licenses were issued for the control of Ja-kotu in the Madu ganga (Atapattu,1987). In 1935, the Ambalangoda Village Committee (V.C.) issued licenses for the control of Ja-kotu fishery. These licenses were issued under regulation 2 (a), published in Gazette No. 8135 of 26th July 1935. The license fee was LKR 25/= for Ja-kotu and LKR 100/= for an Atoliya which is associated with Ja-kotu.

According to Atapattu (1985), there were 95 people involved in operating 70 Ja-kotu in the Madu ganga and 20 in the Kudakalapuganga in 1985. Further, mentioned that up to 1957, the Kosgoda Village Council had issued licenses for the construction and operation of Ja-kotu. However, it had been taken over by the Department of Fisheries in 1958 and the system was continued until 1969. The majority of Ja-kotu fishers mentioned that there is no licensing system today.

Licenses have been issued to Ja-kotu fishers in Bolgoda lake since 1980. Currently, property rights are transferred to another member of the community in Bolgoda lake. In Jaffna lagoon and Bolgoda lake licenses were issued by the Department of Fisheries for the operation of the canoe, and no licenses were issued for Ja-kotu. At the beginning of each year, detailed information on all individual fishing operations (type of fishery, registration number of the canoe, location, time period, number of nets used, mesh type, harvest, etc.) should be provided to the Department of Fisheries in Jaffna. That information is used by the Department of Fisheries as an operation license for regulating fisheries. The majority of fishers use destructive fishing gear called "Kudu del," which is operated in a shallow area in the Jaffna lagoon. Compared to Ja-kotu, a small mesh size of 1 cm for the wing net and a mesh size of 0.8 cm for the trap are used for kudu del.

Fishers should be registered with their fishing society in their respective area. The new president of the society is appointed at the beginning of each year. Only married fishers are eligible to receive membership in the Thamtpaty Rural Fisheries Co-operative Society in Jaffna, restricting access to the fishery.

Ja-kotu in Madu ganga is constructed by using bamboo strips that are tied tighter using coir or

nylon rope and this acts as vertical barriers. Nearly 3.5-4.5mlong bamboo poles are cut down into 4 -5 strips and those strips are used to tight and fix at the bottom at least keeping 0.75 m above water level. The strips are leading into 2-3 traps. Each trap has three rooms called an outer cage, a middle cage, and a fish cage where shrimp are trapped. Strong wooden poles are fixed to the muddy bottom of the estuary to tie the bamboo sheets as well as used on the edge of the Ja-kotu. Commonly three or two traps are constructed in each Ja-kotu to trap shrimps. In Bolgoda lake trap can be lifted and shrimp are harvested without a hand net. Since bamboo poles are not found in adjacent areas, fishers purchased them from regular suppliers at a rate of LKR 15-17 each in Madu ganga and LKR 225 each (10.5 – 12.0 m. in length) in Bolgoda lake.

Normally bamboo poles are harvested from natural forests belonging to the government and private lands located in Ratnapura and Ingiriya, in Ratnapura and Kalutara districts. Permits are issued by the Divisional Secretariat in respective areas to transport raw materials. Bamboo poles are purchased from suppliers. Fishers use their locations which come from generation to generation to construct Ja-kotu. The locations were marked with concrete posts. When installation of the new Ja-kotu, the bottom with muddy conditions, and moderate currents with narrow canals are selected for construction of the Ja-kotu.

Congruence between appropriation and provision (2B)

Resources sharing

Ja-kotu in Madu ganga is operated from around 18.00 to 6.00 hrs the following day. The kerosene lamps of each trap are lit by the fishers around 18.00 hrs. Accordingly, three kerosene lamps are lit in the single Ja-kotu. Shrimps are harvested around 4.00 hrs with lighting in the morning and again at 6.00 hrs without light. The total harvest varied from 0.5-3kg to 15-20kg during the dry and rainy seasons respectively. A substantial proportion of 50-90 kg of sub-adult shrimp stock was recorded during the southwest monsoon period with heavy rains.

Presently, nearly 30 fishers are operating a total number of 50-55 Ja-kotu in the Madu ganga estuary for which they have traditional user rights. A few people operate Ja-kotu in partnership with another. The owner invests in the building of Ja-kotu and the partner gets a 1/3 of the share from the catch following a set of rules. The majority of fishers sell the harvest to marine fishers who use shrimp as bait for their daily fishing activities. Total income excluding all expenses of marine fishers is divided into two equal positions between boat owners and operators. According to the set of rules, Ja-kotu fishers receive 1/5 from boat owners and the another 1/5 from boat operations for supplying shrimp.

The Ja-kotu fishers in Bolgoda lake share ¼ of the income from the operator for lighting the lamp, removing garbage inside the Ja-kotu and harvest of shrimp. All expenses are borne by the owner of the Ja-kotu and share ¾ of the total income. Their constitution conforms that hiring labour for operating Ja-kotu based daily should pay LKR 3000 per/day (USD 8.4)by the owner. Fishers receive some LKR 850 per kg for large shrimp and LKR 750 per kg for small shrimp during the off-season.

The majority of fishers in Jaffna lagoon use their own craft and gear for fishing. When two fishers are involved in fishing, they equally bear expenses including net and operational costs and equally share income between them. Ja-kotu is operated throughout the year, and the maximum harvest is received after 15 days of the full moon each month. A recent study by Ragavan *et al.* (2021) reveals Stake net (37 ± 7) reported a significantly higher catch rate (catch in kg fisherman/day) than fyke net (18 ± 3), seine net (17 ± 6), and crab net (16 ± 3) ($p<0.05$; ANOVA). The relatively highest daily income of LKR 2000-5000was received during the north-east monsoon period from November to December when the highest rainfall occurred, and daily income went down up to LKR 500-1000 during the south-west monsoon season. Each fisher belongs to the Thamtpaty Rural Fisheries Cooperative Society in Jaffna Lagoon must donate LKR 10 of each kg of shrimp (LKR 4 to the Kovil and LKR 6 to the fisheries society) according to the set of rules by the cooperative society. Generally, under-sized or low-value/unwanted fish or by-catch is thrown back into the lagoon live and rarely by-catch is used for dry fish production and as chicken feed in the Jaffna lagoon.

Collective-choice arrangements (3)

In general, Ja-kotu fishing rights are locally handed down from generation to generation through ancestral families or coming as birthrights in a family from generation to generation, called exclusive rights or primary rights. In the Madu ganga estuary, particular locations are marked by a fisher for installing concrete posts at the estuary bank. Other fishers refrain from installing new Ja-kotu in the same location. However, there are a few instances where Ja-kotu is sold to another community member at a rate of one hundred thousand Sri Lankan rupees in the Madu ganga estuary. There was high demand for purchasing Ja-kotu in lower areas associated with narrow canals due to immensely high income during both dry and rainy seasons.

Monitoring of users and resources (4A & 4B)

Ja-kotu fishing in Jaffna lagoon and Madu ganga is carried out throughout the year. However, in the Jaffna lagoon, especially during the inter-monsoon and north-east monsoon seasons (October to April), it received maximum production compared with other months in the year. Fishing activities are not carried out during the rainy season from May-September (southwest monsoon) each year in the Bolgoda lake. The highest shrimp production was received from January to April every year in Bolgoda lake. Fishing activities and resources in all locations are voluntarily monitored by individual fishers.

Regularly, monitoring of disturbances from other fishing activities, resources, and lighting of kerosene lamps is done voluntarily by individual fishers at nighttime when Ja-kotu operates from around 18.00 to 6.00 hours the next day until the catch is collected. Generally, Madu ganga and Bolgoda lake fishers use padlocks in the fish traps to avoid poaching. In Bolgoda lake Ja-kotu are consist the gate called "Doruwa" to allow shrimp to enter the trap during the nighttime and especially when shrimp are available, fishers spend the whole night nearby Ja-kotu.

In Jaffna lagoon, Ja-kotu operates from 2.00 to 6.00 am. every day. Monitoring of resources and violations are voluntary actions by the fishers at different times. When the Ja-kotu is 10-15 km from the land, the fishers spend the night near the Ja-kotu or a nearby island, which reduces the fuel cost for the trip back home.

Graduated sanctions (5)

Ja-kotu fishing in Jaffna lagoon is carried out throughout the year and during the inter-monsoon and north-east monsoon seasons (October to April), ensuring the high abundance of shrimps in the lagoon compared with other months in the year. Mechanisms that exist for resource sharing, equitable access to the fishing grounds and graduated sanctions are remarkably high in the Jaffna lagoon. Fisheries societies are under strong pressure to manage traditional customs in their fisheries. Resolving internal conflicts among members, violation of customary rules for the first time by any fisher is fined by the fisheries society and the second time, all fishing gears are taken over to the fisheries society. The violation of customary rules in the other two lagoons is common and not a proper mechanism for social and economic sanctions or violators were not punished by the society.

Mechanisms for conflict resolution (6)

The most common fishers' tradition in Ja-kotu in Jaffna lagoon is flexible, and fisher communities are responsible and empowered by fisheries societies to strictly follow and control fishing rules. As such any violations or misunderstandings carried out by the fishermen in fishing activity are solved among themselves.

Minimal recognition of rights to organize (7)

Some regulations enforced by the Department of Fisheries to control and regulate Ja-kotu fisheries in three lagoons do not support the fisher's expectations. Fisheries societies can make independent decisions up to a certain level for managing the fishery and related resources. Nevertheless, regulating the number of Ja-kotu, length and distance between Ja-kotu in each lagoon are challenged by the Department of Fisheries. Further harvesting of wooden poles from the conservation forests is not allowed by the Department of the Forest and is challenged by the government bureaucracy. These environmental

issues especially faced by the Ja-kotu fishers in Jaffna lagoon today were not in existence in the past.

Horizontal and vertical integration (8)

In the three lagoons the number of Ja-kotu fisheries community associations commonly called "samithi" are established taking collective action to ensure sustainable use of resources by effectively managing at the community level. Vertical integration facilitates coordination between different levels of governance institutions and many problems are directly solved by organizing the fisherman group discussion in the village or Fisheries Inspector of the Department of Fisheries in Maduganga. Very rarely issues are produced by the police or court. Nevertheless, after being declared as a wildlife sanctuary, the involvement of the Department of Fisheries is minimal and vertical and horizontal integration are not enough to manage Ja-kotu fisheries in the Madu ganga estuary. The affected fisher's community has made complaints to relevant authorities on several occasions, but the authorities have failed to take any action.
Bolgoda lake Freshwater Fisher's organization has the power to manage its own resources. Ja-kotu fishers are members of the common fisheries society of the estuary.

Ja-kotu fishers in Jaffna lagoon commonly share information and have regular discussions among themselves or with other nearby communities. There are number of fisheries societies are established in different fishing inspection (FI) areas in the Jaffna lagoon. The combination of a number of those fisheries societies called "Samasa" is established to strengthen decision-making process among societies. Horizontal integration between community societies is rather strong and vertical integration appears to be comparatively strong with the other two lagoons. Vertical integration is facilitating coordination between different levels of governance institutions, including the Fisheries Inspector, Assistant Director of Fisheries, Secretary to the Provincial Ministry of Fisheries and Secretary to the Ministry of Fisheries and Aquatic Resources Development (MoFARD) of the central government.

Compliance with modified design principles

Institutional arrangement of Ja-kotu fisheries were not completely in accordance with Ostrom's eight modified design principles (Ostrom, 1990). According to the results of questionnaire survey, there were different levels of compliance of institutional structure of Ja-kotu fisheries in the three lagoons. Robust, long-term institutional characterized for modified design principles are illustrated in Fig.6.

Ostram's modified design principles 4A & 4B (monitoring of users and monitoring of resources) of Madu ganga and Bolgoda lake have high compliance and very high compliance, and design principles 2B (Congruence between appropriation and provision) only have a high level of compliance and very high level of compliance, rest of the design principals showing a moderate and lower level of compliance and no compliance indicating weakest of institutional arrangement in term of compliance with design principles.

The Ja-kotu fisheries in Jaffna lagoon showed a very high level of compliance with design principles 8 (multi-layer institutional structure), design principles 2B and 4A and a high level of compliance with design principles 1A (Clearly defined user boundaries), 3 (Collective-choice arrangements), 4B and 6 (Conflict-resolution mechanisms), moderate compliance of design principles 5 while rest of the design principle having a lower level or no compliance indicating that Jaffna lagoon can be classified as the one with the strong institutional arrangement of Ja-kotu fisheries compare with other two lagoons.

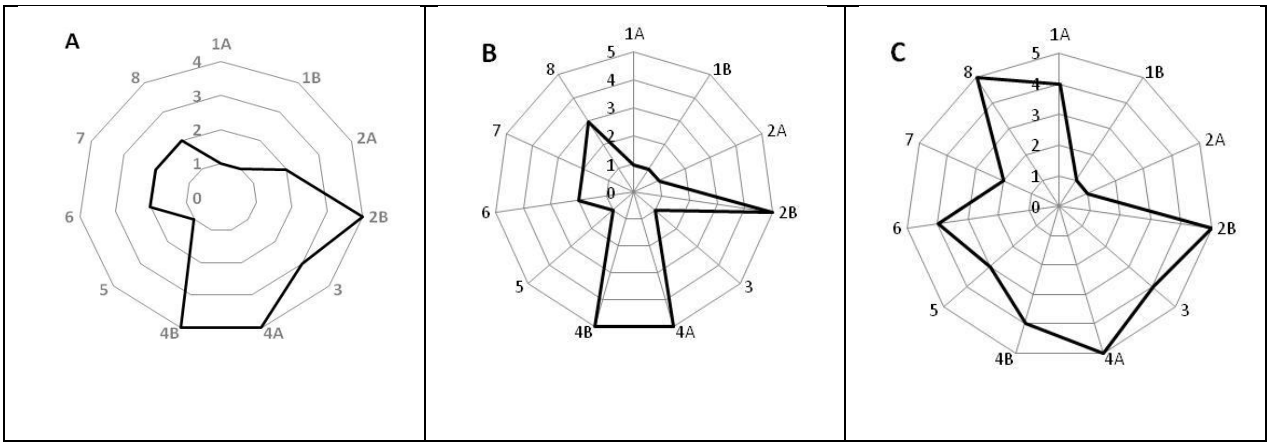

Fig 6. Radar diagram for exhibited levels of compliance (indicated in shaded areas) of institutional robustness in the Ja-kotu fisheries in (A) Madu ganga, (B) Bolgoda lake and (C) Jaffna lagoon with Ostrom's modified design principles (1A, 1B, 2A, 2B, 3, … 8; see Table 1 for definitions). Axis labels are indicated as, 5 (very high compliance); 4 (high compliance); 3 (moderate compliance); 2 (low compliance); and 1 (non-compliance).

DISCUSSION

In Sri Lanka's coastal fisheries, there are different types of fishing craft, both mechanized and traditional, as well as other types of traditional fishing gear used to exploit these resources. Many traditional fisheries in Sri Lanka have been associated with various types of property rights for centuries and community-based fishery management has a strong tradition in Sri Lanka (Deepananda *et al*., 2016a). As such, territorial use rights in fisheries (TURFS) are exercised in many places in coastal areas, lagoons and estuaries in Sri Lanka. The community institutions of Sri Lanka are often non-codified and consist of norms and working rules and state-sponsored cooperative societies have a relatively long history in the region. However, many of these village-based organizations are defunct (Wickramasinghe & Bavinck, 2015).

Rapid population growth resulted in increased requirements for food and the development of a cash economy (the need to sell catches to fund other purchases) was placing increasing pressure on local resources through overharvesting and increases in fishing capacity. Many countries have granted a limited fishing permit to manage small-scale fisheries in their countries. Bourillón-Moreno (2002) pointed out that any commercial fisher in the Gulf of California must have a fishing permit or authorization granted by the government prior to entering the marine area and obtaining products from it. With the lifting of a ban on fishing after the civil war, which ended in May 2009 resulted in large numbers of fishermen venturing into coastal fishing and with a considerable improvement in income. Illegal fishing is increasing every day as a threat to the fish resources in the northern province of the country. The modern type of stake net has developed after the civil war significantly different and increasingly obstructed by the movement of fish towards the shore and operating fishing boats, damaging coral reefs, and creating a large fence in the sea, consisting of 20 to 50 pieces of nine meter long sharp galvanized iron poles to which the enormous nets are fixed in a stretch of about 50 m long in the coastal sea (Sosai,2015). Though several regulations are implemented by the Department of Fisheries, in practice, with poor enforcement of fishing laws, it is impossible to control the fishing effort in Sri Lanka. The authority has a device to address the excludability problem, and the process has been strengthened by providing legitimacy to community-demarcated user boundaries and restricting the number of crafts by registration. It also recommended limiting the number of Ja-kotu and introducing alternative livelihood activities including mariculture activities and preparing a zoning plan for mariculture activities (Sea bass, Sea cucumber, Seaweed etc.).

Institutional collective action by defining their domains through claims of territorial and social

jurisdiction of small-scale fishers along the coast of Tamil Nadu, India by Bavinck & Vivekanandan (2017) reported their responsibility for the wellbeing of their village populations. They have a strong history of regulating gears that they feel are harmful to the profession. Some of the fishing nets interfere with the marine food chain and cause the disappearance of species that are important for fisher livelihoods similar to a large number of Kudu del that are practiced with small mesh size in a shallow area in Jaffna lagoon. The regulating mesh size of Ja-kotu (wing and cod end) is 3.0 cm. for the cod-end and 1.6cm. The mesh size recommended to use for the fence net (guide net) strictly follows the regulation of distance between two Ja-kotu is not less than 300m according to the present gazette in Jaffna lagoon. In the Ja-kotu fishery, too measures are adopted by the Ja-kotu fishermen in Bolgoda lake to protect the prawn. Under this regulation, the fishermen remove the reed panel and other structures during the period of larval growth to prevent larvae from getting caught in the traps. Further delaying the bringing of bamboo reeds for the construction of panels and impeding their construction are the sanctions imposed by the community on persons who do not obey the rules. Further Bolgoda lake has been subject to heavy pollution by effluent discharged from industries, dumping garbage and the prawn (Ja-kotu) fishery has been threatened. The pollution problem needs to be managed and acted on by the Central Environmental Authority based on the imposed regulations. The several discussions that have taken place to regulate these matters at the regional level are not successful and need stronger mechanisms of social control and gathering of higher institutional levels to discuss the matter.

George & Domi (2002) reported that the literacy rates of fishing communities in South Asian countries are low compared with other occupational groups. However, it was revealed that a considerable percentage of the members of fishing communities in three lagoons had received at least primary education and more than 57% of fisher communities in Bolgoda lake reported the highest percentage of primary education. The highest percentage of years of experience and education levels of fisher communities have positive impacts on the decision-making process and effective management of Ja-kotu fisheries in the Jaffna lagoon.

Fish kraals or Ja-Kotu are types of passive fishing devices associated with western, southern and northern coastal areas of Sri Lanka. The history of Ja-kotu fishery in Maduganga, southern coastal region has endeavored a few centuries, dating back to 200 years. According to personal communication, the fishery was started in Nelligoda, Pathirajagama in the southern area by the people of Javanese, an ethnic group native to the Indonesian island of Java.

Though there is no proper legislation to define user boundaries in Ja-kotu fishers in all lagoons, the multi-layer institutional structure of Ja-kotu fishers in Jaffna lagoon was comparatively strong enough for own decision-making process and fisher knowledge based on their own management system is well documented and explain clearly how it works as a management system. The Ja-kotu fishery in the Madu ganga estuary faces many challenges such as lack of legalization, increase in the number of unauthorized Ja-kotu, unplanned development activities, development of tourism activities, and environmental pollution. Furthermore, immediate action is needed to regulate the operation of motorized boats and engine capacity, introduce speed limits, time restrictions, and use of petrol engines for boat operators in Madu ganga.

Ja-kotu fixed at the lagoon mouth and canal areas allow better circulation of water and avoid disturbing migration patterns of fish and shrimps and rapid urbanization. Such direct and indirect issues negatively affect traditional user rights and the livelihood of fishers. Low compliance with several design principles in the fishing community indicates the establishment of a coordinating body that involves relevant stakeholders, the Department of Fisheries, members from local fisheries societies, local administrators, the Coast Conservation & Coastal Resource Management Department, the Forest and Wildlife Departments and the Sri Lanka Tourism Development Authority necessary to manage the Madu ganga wetland with special attention on tourism and fishing activities.

Mapping of existing Ja-kotu installed in Madu ganga and Jaffna lagoon and scientifically defining the maximum number of Ja-kotu that could be operated and suitable locations can help to regulate Ja-kotu fishery in both lagoons. Fishing activities and traditional institutions associated with Ja-kotu fisheries are often embedded and developed within local environmental and socioeconomic contexts.

The traditional community rights and institutional structure of Ja-kotu fishers in Madu ganga and Bolgoda lake are not strong enough to make responsible fisheries management compared with Ja-kotu fisheries in Jaffna Lagoon. There has been a well-established community-based management system mainly to protect shrimp resources. In this self-management system run by the community, there are "rules" and unwritten norms governing the fishery and sanctions are imposed. The uncertainty of institutions in a society can be reduced by imposing formal and informal rules.

The community participation in the effective utilization of fisher knowledge that creates expert fishers and making decisions in resource management is evaluated in stilt fishery (Deepananda et al., 2016b) and beach seine fishery (Deepananda *et al*., 2015) in southern Sri Lanka explained to set up a baseline for the management of fisheries base on the traditional fisher knowledge and improving dialogue between fisher and management agencies. Fishers in marine reserves in Northwest Mexico enforced three forms of rules, resources based-rules (fishing banned), monitoring rules (participation and financial contributions) and administrative rules (cooperative meetings and financial contribution) and sanctions and enforcement relied on variations of peer pressure and public shame by threatening the rule-breaker's reputation and his social bonds and norms with the rest of the members of the group (Cudney-Bueno & Basurto, 2009). Similarly, the community has developed its own informal self-management regimes and unwritten norms in the three lagoons. Certain types of gear are banned and sanctions are imposed on those breaking the rules. However, the local management system cannot cope with certain problems, such as lack of government recognition, changes in local government leadership, resources used by non-local fishermen and use of gear that was banned by the local authority. Thus, the responsibility for fisheries management in three lagoons should be shared between the local community and the central government to sustain the livelihoods of fishers.

The livelihoods of numerous millions of people are dependent on fisheries resources, and they are permitted to enjoy the benefits from their resources. The community-managed fisheries approach is not like present revenue-based fisheries management and is not driven by the overarching desire for profit. As a result, communities are responsible for managing their own resources and managing production and conservation priorities which results in sustainability and equitable sharing of resources (Fisher *et al*., 2015). As such fisheries management and decision-making should follow an interdisciplinary approach based on the social, economic and ecological dimensions of the fisheries system as a guiding principle for sustainability.

Hardin (1968) and Ostrom (1990) pointed out the challenge of development resource management institutions to successful management of common-pool resources. However, in the present traditional informal management system, these organizations have not played a significant role in fisheries management. For improvement of the current situation in the Ja-kotu fishery, robust participation of the centralized management authorities is needed to manage their own resources. Although top-down control measures have a particularly mixed reputation, it seems that the government has an imperative responsibility to play in the management of traditional small-scale fisheries, recognize and respect the contribution of self-governance institutions by supporting the development and persistence of strong local institutions. Active participation in implementing management decisions, research and monitoring activities is critically important for the sustainability of the fisheries. As such, co-management regimes that share power and responsibility between the government and local resource users through the intervention of centralized management authorities that local communities to have a formal role in the management and incorporate scientific and local traditional ecological knowledge to make resource management decisions are essentially needed to be implemented for the sustainability of the fishery.

DECLARATION OF COMPETING INTEREST

The author declares that he has no conflict of interest.

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REFERENCES

Amarasinghe, U.S., W.U. Chandrasekara, & H.M.P. Kithsiri 1997. Traditional practices for resource sharing in an artisanal fishery of a Sri Lankan estuary. Asian Fisheries Science 9:3:11-323.https://doi.org/10.33997/j.afs.1997.9.4.009

Arthur, R., D.J. Skerritt, A.Schuhbauer, N. Ebrahim, R.N. Friend, U.R. Sumaila 2022. Small-scale fisheries and local food systems: Transformations, threats and opportunities. Fish & Fisheries 23:109-124.doi: 10.1111/faf.12602.

Atapattu, A.R. 1987. Territorial use rights in fisheries (TURFs) in Sri Lanka. Case study on Ja-kotu fisheries in the Madu ganga estuary and kattudel fishery in the Negombo lagoon. Symposium on exploitation and management of marine fishery resources in South Asia, Indo-Pacific Fisheries Commission, RAPA Report, 10, 397-410.

Bavinck, M. & V. Vivekanandan 2017. Qualities of self-governance and wellbeing in the fishing communities of northern Tamil Nadu, India - the role of Pattinavarur panchayats. MaritimeStudies16:16.doi; 10.1186/s40152-017-0070-8.

Bavinck, M., D. Johnson, O. Amarasinghe, J. Rubinoff, S. Southwold, & K.T. Thomson 2013. From indifference to mutual support - a comparative analysis of legal pluralism in the governing of South Asian Fisheries. European Journal of Development Research 25(4): 621-640. doi:10.1057/ejdr.2012.52z.

Berkes, F. 2018. Sacred Ecology. 4th Edition. Routledge, New York.https://doi.org/10.4324/9781315114644.

Berkes, F. 2009. Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. Journal of Environmental Management 90: 1692-1702. doi: 10.1016/j.jenvman.2008.12.001.

Berkes, F., D. Feeny, B. J. McCay, & J.M. Acheson 1989. The benefits of the commons. Nature, 340, 91-93. doi: http://dx.doi.org/10.1038/340091a0.

Berkes, F., R. Mahon,P. McConney, R.C. Pollnac,& R.S. Pomeroy 2001. Managing small-scale fisheries: alternative directions and methods. International Development Research Centre, Ottawa, Ontario, Canada.

Bourillón-Moreno, L. 2002. Exclusive fishing zone as a strategy for managing fishery resources by the Seri Indians, Gulf of California, Mexico. Dissertation. The University of Arizona, Tucson, Arizona, USA.

Cox, M., G.Arnold, & S.V. Tomas 2010. A review of design principles for community-based natural resource management. Ecology &Society15 (4):38.doi:http://www.ecology and society.org/vo115/iss4/art38.

Cudney-Bueno, R.X. 2009. Lack of Cross-Scale Linkages Reduces Robustness of Community-BasedFisheries Management. PLoS ONE 4(7):e6253. doi:10.1371/journal.pone.0006253.

De Bruin G.H.P., B.C. Russell & A. Bogusch 1995. FAO Species Identification Field Guide for Fishery Purposes. The Marine Fishery Resources of Sri Lanka. Food and Agriculture Organization of the United Nations, Rome, Italy. 400 p.

Deepananda, K.H.M.A., U.S. Amarasinghe, & U.K. Jayasinghe-Mudalige 2015. Indigenous knowledge in the beach seine fisheries in Sri Lanka: An indispensable factor in community-based fisheries management. Marine Policy 57: 69-77. doi: 10.1016/j.marpol.2015.03.028.

Deepananda, K.H.M.A., U.S.Amarasinghe, & U.K. Jayasinghe-Mudalige 2016a. Neither bust nor boom: Institutional robustness in the beach seine fishery of southern Sri Lanka. Ocean and Coastal Management 128: 61-73. doi: 10.1016/j.ocecoaman.2016.04.020

Deepananda, K.H.M.A., U.S. Amarasinghe, U.K.Jayasinghe-Mudalige, & F. Berkes 2016b. Stilt fisher knowledge in southern Sri Lanka as an expert system: a strategy towards co-management. Fisheries Research 174, 288-297.https://doi.org/10.1016/j.fishres.2015.10.028

Farr, E.R., J.S. Stoll, & C.M. Beitl 2018. Effects of fisheries management on local ecological knowledge. Ecology and Society 23 (3):15. https://doi.org/10.5751/ES-10344-230315.

FAO 2020. The State of World Fisheries and Aquaculture 2020: Sustainability in action. FAO, https://doi.org/10.4060/ca9229en

Feeny, D., F. Berkes, B.J. McCay, & J.M. Acheson 1990. The tragedy of the commons: twenty-two years later. Human Ecology 18(1):1-19. http://dx.doi.org/10.1007/BF00889070.

Fischer, J., J. Jorgensen, H. Josupeit, D. Kalikoski, C.M. Lucas eds. (2015). Fishers' Knowledge and the Ecosystem Approach to Fisheries: Applications, Experiences and Lessons in Latin America. FAO Fisheries and Aquaculture Technical Paper, No. 591. FAO, Rome, Italy.278 pp. doi:http://www.fao.org/docrep/field/003/ab825f/AB825F00.htm#TOC.

Frawley, T.H., E.M. Finkbeiner, & L.B. Crowder 2019. Environmental and institutional degradation in the globalized economy: lessons from small-scale fisheries in the Gulf of California. Ecology & Society 24(1):7. https://doi.org/10.5751/ES-10693-240107

Gammanpila, M., M.J.S. Wijeyaratne, & U.S. Amarasinghe 2019. The dwindling community-based management strategies in the brush park fishery of a tropical estuary: Need for co-management. Ocean and Coastal Management167:145-157. doi.org/10.1016/j.ocecoaman. 2018.10.008.

George, M.K. & J. Domi 2002. Residual illiteracy in a coastal village: Poovar village of Thiruvanthapuram. Discussion Paper (45). Centre for Development Studies, Thiruvanuthapuram, India.

Gunawardena, N.D.P. & U.S. Amarasinghe 2016. Capturing local knowledge of beach seine fishers in the north- western province of Sri Lanka. Sri Lanka Journal of Aquatic Sciences, 21(2):125-149. doi:10.4038/sljas.v21i2.7508.

Gunawardena, N.D.P., T. Jutagate, & U.S. Amarasinghe 2016. Patterns of species composition of beach seine fisheries off north-western coast of Sri Lanka, fishers' perceptions and implications for co-management. Marine Policy 72: 131-138. doi:10.1016/ j.marpol.2016.07.007.

Halls, A.S., Md. G. Mustafa, & M. Dickson 2017. Community-based fisheries management approach adopted in Bangladesh. Advance in Research 11 (6): 1-17. doi: 10.9734/AIR/2017/36320.

Hardin, G. 1968. The tragedy of the commons. Science 162(3859):1243-1248. https://doi.org/10.1126/science.162.3859.1243

Hossain, Md. M., Md. A. Islam, S. Ridgway, & T. Matsuishi 2004. Community based fisheries management as the future fisheries management option for small-scale fisheries of Bangladesh. IIFET Japan proceedings. 1-12.

Iwasaki, S. 2014. Adaptive management and welfare enhancement of Kattudel fishery in Negombo Lagoon. Commoners and the Changing Commons: Livelihoods, Environmental Security, and Shared Knowledge, The Fourteenth Biennial Conference of the International Association for the Study of the Commons, June 3-7, Mt. Fuji, Japan. http://hdl.handle.net/10535/8916

Johannes, R.E., M.M.R. Freeman, & R.J. Hamilton 2000. Ignore fishers' knowledge and miss the boat. Fish&Fisheries 1: 257-271. doi:10.1111/j.1467-2979.2000.00019.x.

Kittinger, J.N., E.M. Finkbeiner, N.C. Ban, K. Broad, M. H. Carr, J. E. Cinner, S. Gelcich, M. L.Cornwell, J. Z. Koehn, X. Basurto, R. Fujita, M.R. Caldwell, & L.B. Crowder 2013. Emerging frontiers in social-ecological systems research for sustainability of small-scale fisheries. Current Opinion in Environmental Sustainability 5:352-357. http://dx.doi .org/10.1016/ j.cosust.2013.06.008\.

Likert, R. *1932.ATechnique for the Measurement of Attitudes. Archives of Psychology140:1-55.*

Nunes, M., G.Hallwass, & R. Silvano 2019. Fishers' local ecological knowledge indicates migration patterns of tropical freshwater fish in an Amazonian river. Hydrobiologia 833(1): 197-215. doi: 10.1007/s10750-019-3901-3.

Ostrom, E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge, UK.pp.280.https://doi.org/10.1017/CBO9780511807763

Paolisso, M. 2002. Blue crabs and controversy on the Chesapeake Bay: a cultural model for understanding watermen's reasoning about blue crab management. Human Organization 61 (3):226-239. http://dx.doi.org/10.17730/humo.61.3.2dc5c4gxap2f6nwv.

Pomeroy, R.S., R.B. Pollnac, B.M. Katon & C.D. Predo 1997. Evaluating factors contributing to the success of community-based coastal resource management: the Central Visayas regional Project-1, Philippines. Ocean& Coastal Management 36: 97-120. http://dx.doi.org/10.1016/S0964-5691(97)00016-1.

Pushpalatha, K.B.C., M.G. Kularatne, & U.S. Amarasinghe 2020. Institutional robustness of culture-based fisheries in perennial reservoirs of Sri Lanka. Asian Fisheries Science 33:91-105. https://doi.org/10.33997/j.afs.2020.33.2.002.

Ragavan, N., D.C.T. Dissanayake & S. Kuganathan 2021. Status of the fishery of Jaffna lagoon, Sri Lanka. Sri Lanka Journal of Aquatic Sciences 26(1):55-66. http://doi.org/10.4038/sljas.v26i1.7584.

Richmond, L. & A. Levine 2012. Institutional analysis of community-based marine resource management initiatives in Hawaii and American Samoa. United States Department of Commerce, NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-35. pp.1-48.

Rivera, V.S., P.M., Cordero, D.C. Rojas, & B. O'Riordan 2017. Institutions and collective action in a Costa Rican small-scale fisheries cooperative: the case of CoopeTárcoles R. L. Maritime Studies 16 (22):1-19. doi:10.1186/s40152-017-0077-1.

Ruddle, K. 1994. Local knowledge in the folk management of fisheries and coastal marine environments. In: Dyer,C. L., McGoodwin, J. R. (Eds). Folk management in the world's fisheries: lessons for modern fisheries management. University Press of Colorado, Niwot, CO. pp. 161-206.

Saenz-Arroyo, A., C.M. Roberts, J. Torre, & M. Carino-Olvera 2005. Using fishers' anecdotes, naturalists' observations and grey literature to reassess marine species at risk: the case of the - Gulf grouper in the Gulf of California, Mexico. Fish& Fisheries 6:121-133, http://dx.doi.org/10.1111/j.1467-2979.2005.00185.x.

Schultz, O.J. 2017. The micro-politics of small-scale fisheries governance in South Africa: a case study of community-based political representation as a form of brokerage. Maritime Studies 16(01). doi:10.1186/s40152-017-0060-x.

Sosai, A.S. 2015. Illegal fishing activity - A new threat in Mannar island coastal area (Sri Lanka). Transylv. Review of Systematical and Ecological Research 17 (01): 95-108. doi: 10.1515/trser-2015-0051.

Wickramasinghe, W.A.R. & M. Bavinck 2015. Institutional landscapes affecting small-scale fishing in Southern Sri Lanka - legal pluralism and its socio-economic effects. Maritime Studies 14(01): 18.doi:10.1186/s40152-015-0036-7.