Livelihood status of the fishing community of Mahakanadarawa reservoir in Anuradhapura, Sri Lanka

C. K. Illangasingha, I. U. Wickramaratne, R. M. S. M. Rathnayaka, W. M. S. U. Dassanayake and M. G. K. N. Gamage*

Department of Animal Science, Faculty of Animal Science and Export Agriculture, Uva Wellassa University, Sri Lanka

*Corresponding author: chamanthikavindya@gmail.com

https://orcid.org/0009-0006-6345-2946

Abstract Mahakanadarawa reservoir located in Anuradhapura is one of the major, perennial reservoirs in Sri Lanka, extending over 1,457 ha. It provides livelihood opportunities through fisheries, irrigation for agriculture, and fostering economic growth in the surrounding region. Yet the fisheries-based livelihoods of the Mahakanadarawa reservoir have not been fully assessed. Hence, this study investigated the fishery and fisher profile of the reservoir. Primary data were collected from eight landing sites. A pre-tested questionnaire was used to interview 72 fishermen using a mixed method. Main variables including social, human, physical, natural, and financial capitals, fishery profile, fish and fisheries-based post-harvesting techniques, market chain analysis, and fisheries management practices, catch per unit effort for the gillnet fishery were calculated. Secondary data including stocking fish fingerlings and species-wise harvesting data for the past 10 years were collected from the district aquaculture extension office (Anuradhapura) of the NAQDA. A secondary study on the length-weight relationship of *Oreochromis niloticus* along with its condition factor value was performed. It was revealed that *O. niloticus* had negative allometric fish growth (b = 2.6667) with a condition factor value of 1.9092. The female fish had a higher mean total length compared to the male fish. In the fishing community, 95.83% of males and 4.17% of females were engaged in fishery activities. Mainly gill nets and non-mechanized fiberglass canoes were used for fishing. The average CPUE was 0.000339 kgm^{-2}day^{-1}. A strong positive (r =0.841) correlation was reported for fish stocking and fish production. Fish smoking and sun drying were the common fish processing techniques. The fish supply chain targeted the regional market. A cooperative level co-management system was identified among the reservoir fishing community. The current study discloses the livelihood capitals of the fishing community along with the existing supply chain which can be utilized for the sustainable management strategy of the Mahakanadarawa reservoir in the long run.

Keywords: Market chain; Post harvesting; Co-management

INTRODUCTION

As an island nation with rich freshwater resources, inland fisheries in Sri Lanka hold major importance in the economy of the country. Sri Lanka has around 260,000 hectares of potential freshwater bodies for fisheries-related activities. Among them, 155,000 hectares mainly deal with 103 perennial reservoir fisheries (Chandrasoma & Pushpalatha 2018). Fish accounts for 70% of animal protein consumption in Sri Lanka, and major inland reservoirs provide the bulk of the fish supply in the dry interior (Murray. & Little 2000) which focuses on North Central, Northern, and Eastern provinces (Murray 2004). According to statistics, 73,230 MT of annual production in the country is through inland fisheries, which contributes 0.2% of the GDP (MFAR 2020).
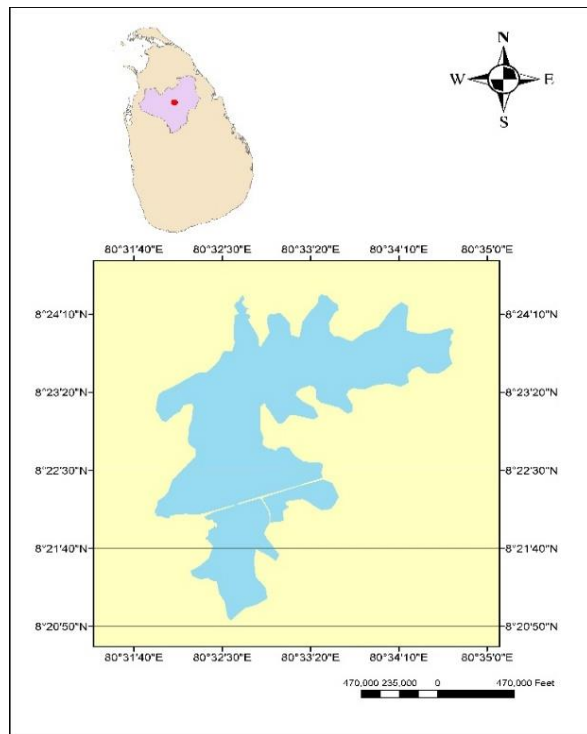
Sri Lanka consists of around 44 major irrigation inland reservoirs. Among them, Mahakanadarawa reservoir is a large-scale major reservoir (FAO, 2016), located in the Kanadara oya river sub-catchment (Figure 01), consisting of a 1,457 ha land area and 5.8 m of mean depth (MFAR 2020). The total area of the reservoir provides a conducive environment for a diverse range of fish species, hence, it generates employment prospects for the fishing community and leads to play a significant role in subsistence and self-sufficiency economy. Fishery livelihood is extensively dependent on natural resources, opportunity for various sources of income, accessibility of financial, social, human, and physical assets, and governance of the related

bodies (Sarker *et al.* 2020). According to Welcomme *et al.* (2010)., inland fisheries have the most important contribution in providing labour for unskilled employees who rely largely on fishing and fishery-related industries such as fish processing and post-harvesting to enhance their livelihoods.

Analyzing the livelihood status is a dynamic process by which individuals can meet their needs by adopting various livelihood strategies to minimize vulnerability, safeguard assets, and preserve the environment (Ellis & Allison 2001). The estimation of livelihood status in the fisheries sector takes into account five key factors, namely physical, social, financial, natural, and human capital (Ahmed *et al.* 2021). Moreover, the Mahakanadarawa reservoir, which is utilized for both agricultural and fishing purposes, experiences high fishing pressure and undergoes biological changes in the water body (Pet *et al.* 1995). Unfortunately, research studies are scarce and systematically analyzed data on the status of the Mahakanadarawa reservoir fishery is limited. This highlights a lack of knowledge that prevents

informed decision-making. Furthermore, the focus on assessing the livelihoods of the fishing community implies a problem of uncertainty around their economic well-being and how their livelihoods are impacted by the factors mentioned above. This study aims to characterize the fishery using quantified fish species composition, catch abundance, fishing practices, and trends in harvest data. This study also assess livelihoods via evaluating the community's livelihood capitals (physical, social, human, natural, and financial) and identify areas of vulnerability or opportunity. This study examines the Mahakanadarawa reservoir's ecosystem, including the length-weight relationship and condition factor of key fish species.

These biological factors provide baseline data for evidence-based fishery management decisions. Understanding fish populations helps identify areas for conservation and sustainable practices. Additionally, the study assesses the fishing community's livelihoods, highlighting vulnerabilities and potential strategies to enhance well-being.

MATERIALS AND METHODS

Mahakanadarawa reservoir, which comprises eight landing sites namely Siyabalagaswawa, Pothana, Welamkulama, Karawilagala, Horowwa, Dhakunu ela, Kudagama, and Koggala, was selected as the study area for this research. A total of 120 fishermen were registered with the fishery society for fishery activities in the area. The number of relevant fishermen for each landing site is presented in Table 01. A stratified random sampling method was employed, with a sample size of 72 fishermen, which constituted 60% of the total sample size, collected through questionnaires at the eight landing sites of the reservoir. This approach was chosen due to its representativeness. It ensures fair inclusion of fishermen from all landing sites and with varying levels of fishing activity. Also, fishermen engage in activities seasonally, thus stratified sampling prevents the underrepresentation of occasional or part-time fishers. The sample size was determined based on the data repetition principle (Galappaththi & Berkes 2014).

Fig 01 Study Site - Mahakanadarawa Reservoir

The interviews were conducted after obtaining the consent of the interviewees through the mention of the research purpose in the questionnaire. A pre-test was conducted for one month in the area to assess the Mahakanadarawa reservoir and gain a general understanding of the study site. This study was conducted from February to July of 2022, which spans over a period of six months. A total of 72 fishermen were interviewed to gather primary data using semi-structured, dichotomous, and five-point Likert scale-type questions in a questionnaire format. The interviews were conducted in the Sinhala language. A mixed approach was used to collect all data. The quantitative component involved a pre-tested questionnaire administered to 72 fishermen, supplemented by other potential tools such as a socioeconomic survey, catch data analysis, and biological measures length weight of fish, and the qualitative component was comprised of direct interviews with fishermen and fishery society leaders. The primary focus of the interviews was on the livelihood status of the fishermen in terms of human capital, natural capital, physical capital, financial capital, and social capital. Observations of the common harvested organisms

were made in situ, and further identification was conducted using a book titled "Marine and Freshwater Fishes of Ceylon". Secondary data, including basic information about the reservoir, fish stocking, harvesting from the year 2011 to 2021, and species-wise fish production in 2021, were collected from the district aquaculture extension office (Anuradhapura) of the National Aquaculture Development Authority of Sri Lanka.

In estimating the length-weight relationship of *Oreochromis niloticus* in the Mahakanadarawa reservoir, the total fish length and body weight of 400 specimens of *Oreochromis niloticus* were measured in situ to the nearest 0.1 cm and 0.1 g respectively 50 species in each 08 fishing landing sites. Length-weight relationship and condition factor data were analyzed statistically (Ricker 1973;Pauly 1983). Questionnaire data were analyzed and interpreted using descriptive statistics. The relationship between fish stocking and total production was determined using correlation analysis. The Statistical Package for Social Sciences (SPSS 26.0 version) and Microsoft Excel 2019 were used to analyze and interpret the collected data.

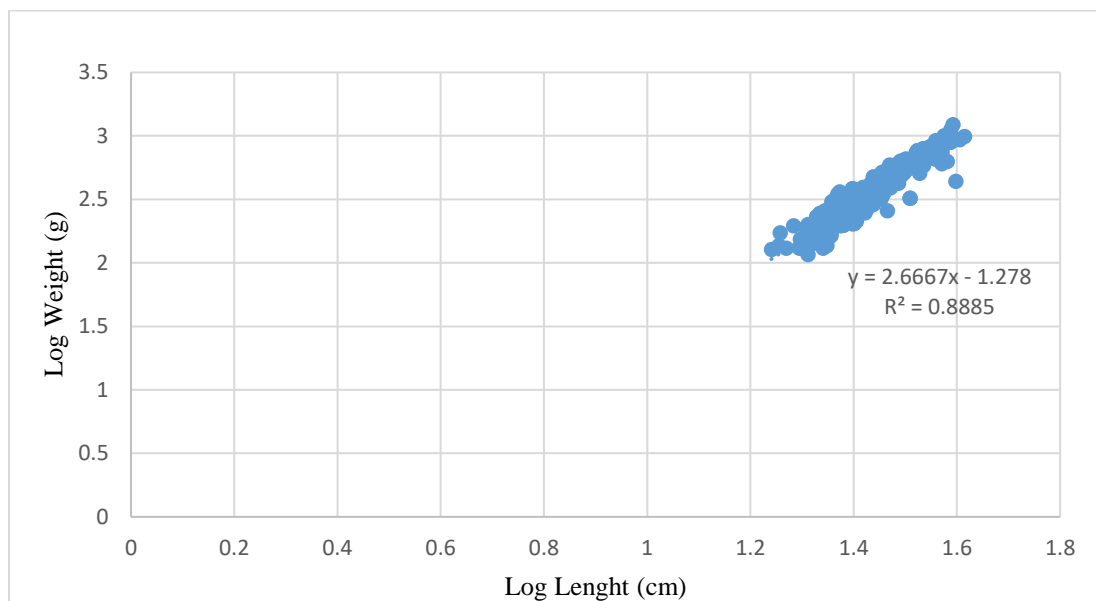**Table 01** Landing sites and sample size

Sample No	Landing site name	Pop. Size	Sample Size	Stratum Size according to the total population	Stratum Size according to the sample size
Sample 01	Siyabalagaswawa	120	72	15	9
Sample 02	Pothana	120	72	8	5
Sample 03	Welamkulama	120	72	20	12
Sample 04	Karawilagala	120	72	7	4
Sample 05	Horowwa	120	72	8	5
Sample 06	Dhakunu ela	120	72	15	9
Sample 07	Kudagama	120	72	20	12
Sample 08	Koggala	120	72	27	16

RESULTS

Length- Weight relationship of Oreochromis niloticus and condition factor of the reservoir

The current research study found that the mean total length of females was 27.90 ± 0.30 cm, the mean total length of male was 26.22 ± 0.36 cm, the mean total weight of female was 401.45 ± 13.76 g, and the mean total weight of male were 355.15 ± 14.89 g. Therefore, it can be concluded that the mean total length of females is higher than that of males and the mean total weight of the females is higher than males. According to the analyzed data, there was a significant difference between male and female total weight ($p = 0.023$) and also a significant difference between male and female fish total length ($p = 0.000$). Length-weight relationship and condition factor of fish *Oreochromis niloticus* is 2.667 and 1.9092 respectively (Figure 02). According to the findings, *Oreochromis niloticus* had negative allometric fish growth in the Mahakanadarawa reservoir.

The chart shows data points with the fitted line:
$$y = 2.6667x - 1.278$$
$$R^2 = 0.8885$$
(x-axis: Log Lenght (cm), y-axis: Log Weight (g))

Fig 02 Length-Weight Relationship of fish *Oreochromis niloticus* in Mahakanadarawa reservoir

Socioeconomic status of fishermen

Analyzed data revealed that the gender distribution of the fishing community was 95.83% males and 4.17% females. When considering age distribution among fishermen, 31.94% of respondents belonged to the age group above 51, 15.28% of the respondents represented the age group 21- 30, while 25.0% of respondents belonged to the 31-40 age group and 27.78% to the 41-50 age group. There were no respondents under the below 20 age categories. The majority of fishermen (88.89%) were Sinhalese and the rest were Muslim.

Fishing experience was highest in the age group above 21 years (33.33%). Most of the fishermen were Buddhists (70.83%). Fishermen were asked to self-identify as 'part-time' or 'full-time' based on their perception of their primary occupation The majority of fishermen (56.94%) were involved in full-time fishing and 43.06% were involved in part-time fishing. Part-time fishermen were mainly involved in paddy farming (68.97%), livestock husbandry (3.45%), small trade (3.45%), small own business (3.45%), and as hired labour/Tenants (20.69%) as their auxiliary income sources.

Livelihood status of fishermen - Human capital

The relevant data were collected related to human capital including the level of education, literacy level, mental health, and access to training programs. Education is one of the most important

components of human capital (Ahmed *et al.* 2021). Out of the total selected fishermen, only about 6.94% of the respondents were not educated. Besides, the majority of them had the ability to read and write (63.89%). According to Ahmed *et al.* (2021) , the skill and ability to catch fish can be affected by the frequency of diseases which also indicate physical health. Frequent illnesses among fishermen can hinder their ability to develop fishing skills and catch fish effectively. In this study, the highest reported illness frequency was 3 times per year.

The skills of fishermen also varied from individual to individual. The skill of fishermen is represented by the amount of catch per day. The study found that the highest catch by the respondents was 6-10 kg per day. Mental health is also an important human capital for every individual in our society. Recreational activities are necessary for ensuring better mental health (Goodman *et al.* 2016). Mahakanadarawa fishermen involved themselves in different kinds of recreational activities which are shown in Table 02. The study revealed that the majority of respondents watched TV and participated in the family gathering and some of them join organized trips.

Table 02 Different human capital assets presented in Mahakanadarawa reservoir

Asset	Description	Visual amount as percentage (%)
Education Level	No education	6.94
	1-5	23.61
	1-9	36.11
	Ordinary Level	31.94
	Advance Level	1.39
Mental Health	Watching TV	54.17
	Family Gathering	26.39
	Organizing Trips	18.06
Access to Training Programmes	Yes	20.83
	No	79.17
Fishing Skill – Amount of harvest per day (kg)	1-5	6.94
	6-11	44.44
	11-15	26.39
	16-20	19.44
	Above 21	2.78

Financial Capital

Financial resources included monthly income, monthly savings, and percentage of the household income through fisheries (Ahmed *et al.* 2021). Table 3 shows that the fishermen had the highest income (37.5%) of above Rs 50,000 per household per month. The saving amounts of fishermen was very low as they hardly could save per month after meeting household expenditure. The fishers had minimal access to formal and semi-formal loans as they lacked collateral. They also got loans from other informal sources i.e., their relatives, neighbours, and friends who were in a better position financially. Very few of the respondents had savings in kind. It was estimated that the respondents had savings in kind of Rs 3000-5000 per month.

Natural Capital

Natural capital is the quality and quantity of natural resources that are available to people and above all, the access and control people have over these natural resources (Deswandi 2017). To measure the natural capital, respondents were asked about the land size, access to potable water, and access to usable forest and aquatic resources. The fishers

(37.5%) had a large land area which consisted of 40-60 perches. Most of the fishers (94.52%) hardly got access to reservoir drinking water. The study found that there was a forest near their residence from where they have been benefitted. All fishers had access to the aquatic resources of the Mahakanadarawa reservoir.

Physical Capital

Physical capital included fishing gear, fishing craft, housing quality, drinking water sources, and capital acquisition of fishermen. The boats of the fishermen comprised the largest contribution in their physical capital as non-mechanized fiberglass canoe. The fishing net is another important physical asset of the fishers as it is their main equipment for fishing. One hundred percent (100%) of the fishers used gill net for fishing. The highest number of fishermen had complete permanent houses and few had no houses to live. With regard the percentage of the drinking water source of fishermen, highest amount used treated water while 5.2% of respondents used reservoir water. The main reason for using treated water as the drinking water in the Mahakanadarawa fishery community is because Medawachchiya, Rambewa, and Mihinthale Divisional Secretariat (DS) Divisions are considered kidney disease-prone areas and there are a large number of people with kidney disorders (Sri Lanka Government 2019; Abeyrathne *et al.* 2020). Using treated water as a safety measure is prominent.

Social capital

Social capital such as sharing socially held knowledge, mutual trust and reliability, relationships with neighbours, and women involvement in the decision-making process were common and almost all fishers had a high social status. There was well-organized hierarchical fisheries community that made decisions and regulations for the proper management of sustainable fisheries. About 80% of the fishermen had high mutual trust and reliability in the members, and 83% of fishers shared knowledge about communities, fishing grounds, and family matters. Strong neighborly relationships are vital for support during difficult times and build a sense of community. It was also found that the majority (38.03%) of the fishers had a good relationship with

their neighbors. Having the power of women in a family decision-making process ensures the probability of improving the livelihood in every aspect. It was found that 98.71% of the households' female members participated in decision-making.

Fishing gears and craft operated for fishery activities

Gill net and non-mechanized fiberglass canoes were identified as the main fishing gear-craft type of Mahakanadarawa reservoir. Different types of fishing gear were used in fishery activities in the Mahakanadarawa reservoir. Angling (Billy hooks) and traditional hooks (Katuwel) were some traditional fishing gears used other than the gill nets. One hundred percent (100%) of fishermen who engaged in fishing activities in Mahakanadarawa reservoir used gill nets for fishing activities. About 19.4% of respondents used Angling in addition to a gill net for fishing activities, and 13.9% of respondents used traditional hooks for fishing activities other than the gill nets.

According to the analyzed data, 100% of fishermen who engaged in fishing activities in Mahakanadarawa reservoir used non-mechanized fiberglass boats as fishing craft. There were approximately 80 operating non-mechanized fiberglass canoes. While Sri Lankan government's prohibition of mechanized boats in inland water bodies aims to protect the ecological balance and prevent overfishing, it has several negative consequences for the livelihoods of fishermen in the Mahakanadarawa reservoir. Fishermen are limited in the quantity of fish they can catch due to the slower speed and limited range of non-mechanized boats, resulting t less income. Due to this limitation, fishermen cannot reach potentially more productive fishing grounds further from shore and it also leads to less productive time because longer fishing trips reduce the time that could be spent on other income-generating activities.

Although the upfront cost of mechanized boats is a concern, their long-term benefits including increased catch, efficiency, and safety could lead to higher income for fishermen. However, potential competition for permits and inflated permit prices could create additional economic burdens for the fishing community. In Mahakanadarawa reservoir, fishing operations were conducted daily and the

operating fishing hours were approximately 6-12 hours. The study findings revealed that 73.61% of respondents had their boat to engage in fishing activities and 26.39% of respondents engaged in fishing without their fishing boat.

Species composition

During the study period, 19 commonly harvested species were identified in the Mahakanadarawa reservoir. Nile Tilapia (*Oreochromis niloticus*), Green Chromide (*Etroplus suratensis*), Rohu (*Labeo rohita*), Murrel (*Channa striata*), and Giant

Freshwater prawn (*Macrobrachium rosenbergii*) were most commonly harvested species.

Fish Production

Depending on secondary data from NAQDA, the highest total fish stocking was in 2020, and the minimum stocking was in the year 2015. Total highest production was in 2019 and the lowest production was observed in 2013. There was a strong positive correlation (r = 0.841) between total fish stocking and total fish production from the year 2011 to 2021 (Figure 03).

Fig 03 Comparison of fish stocking and total production

Catch per Unit Effort (CPUE) in Mahakanadarawa Reservoir

CPUE (Catch Per Unit Effort) is a standardized method mainly used for estimating fishery resource stocks based on used fishing gear (Ramlah *et al.* (2020)). The average catch per unit effort (kg per net square meter per day) of the fisherman for the gill net used to catch the fish was estimated as 0.000339 kgm^{-2} day^{-1}.

Post Harvesting Practices

Fish smoking and sun-drying were the common post-harvesting methods in the Mahakanadarawa

reservoir. A majority (76.39%) of respondents weren't involved in post-harvesting whereas 23.61% of respondents were involved in post-harvesting practices. The involvement of women in post-harvesting was as high as 88.24%. Fish processing, marketing, and transportation were the most common steps involved during post-harvesting practices. About 29.41% of respondents directly allocated fish to post-harvesting and 70.59% allocated the remaining fish for the post-harvesting. When considering the demand and interest among consumers, 64.71% of respondents mentioned that strongly agree with consuming post-harvest products such as dry fish and smoked fish in the Mahakanadarawa reservoir. The unique taste

and crispiness of the product are the main reasons for the increased demand for the products. The drying process concentrates flavors, often creating a more intense and savory taste profile compared to fresh fish.

Market chain

A market chain analysis is defined as the process of raw materials coming to the final output in fisheries businesses (Rosales *et al.* 2017). The fish market chain here functions with notable simplicity. Fishermen directly sell 70.8% of their catch to fish vendors, who then manage further distribution. This direct sales approach highlights the importance of vendors in the local market. Post-harvesting product pricing is mainly handled by the fishermen and the sellers in the area. According to their perspective, the pricing process mainly fluctuated with 62.5% demand and supply, while 30.56% fluctuated with quality and quantity of fish, where 4.17% fluctuated with commission agent, and 2.78% fluctuated due to climate changes. The fish supply chain mainly targeted the regional market and was conducted by secondary networks of 2- 2-wheeler vendors (Figure 04).
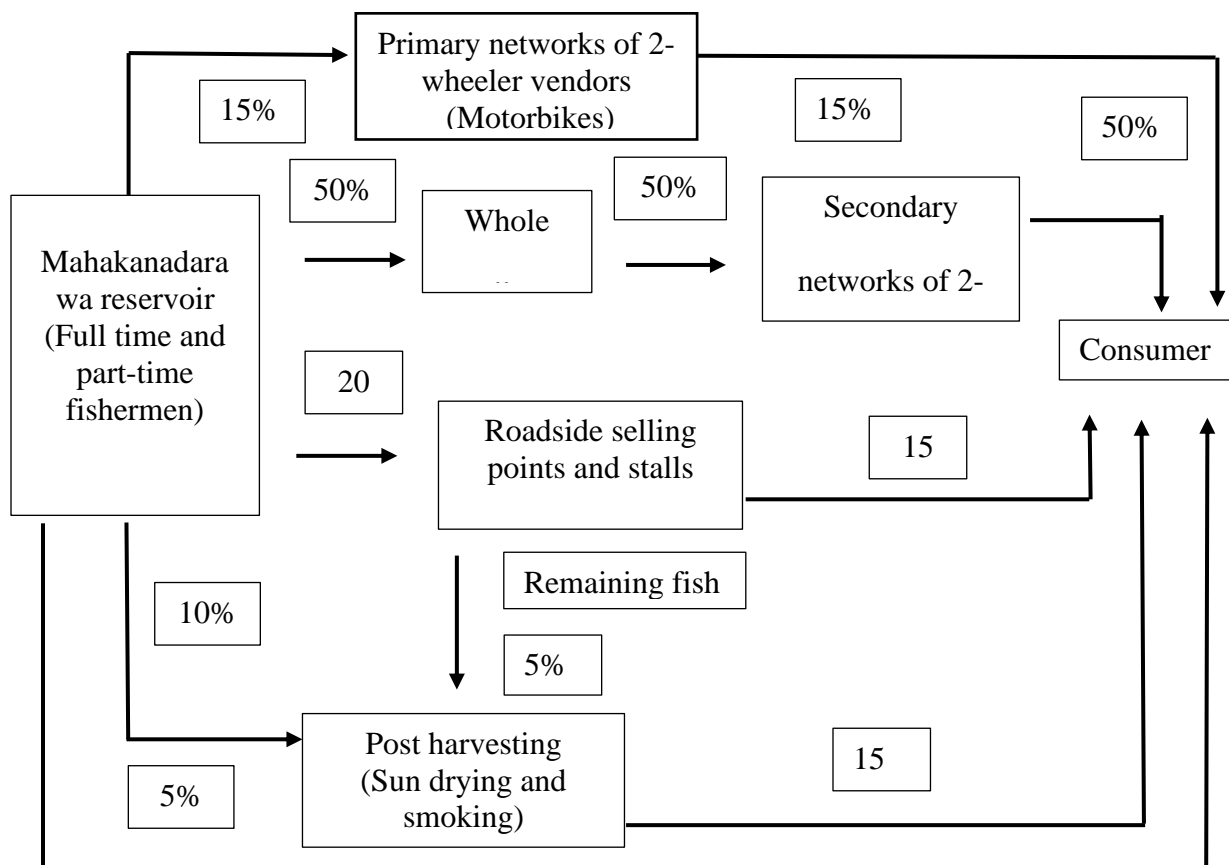
Fig 04 Market chain analysis of Mahakanadarawa reservoir (Field information).

Fisheries management system

The fisheries management system of Mahakanadarawa reservoir was identified using some qualitative boundaries such as clearly defined boundaries for fisheries, congruence between appropriation provision rules and local conditions, collective choice arrangement, monitoring, graduated sanctions, conflict resolution mechanism, minimal recognition of rights to organize, and nested enterprises. According to these facts, a fisheries co-management system was identified in the Mahakanadarawa reservoir and it is a cooperative-level co-management system.

DISCUSSION

In the discourse of the Length-Weight relationship and the condition factor of *Oreochromis niloticus* within the context of the Mahakanadarawa reservoir, it has been observed, through the current research inquiry, that the dimensions of females are markedly greater than those ascribed to males, both in the metric of total length and the quantum of total weight, the females manifesting a mean total length of 27.90 ± 0.30 cm in contrast to the males at 26.22 ± 0.36 cm, and a mean total weight of 401.45 ± 13.76 g in a comparative stance to that of the males, which was noted as 355.15 ± 14.89 g. This observed disparity in dimensions not only suggests sexual dimorphism but also underscores a significant diacritical difference in bulk and span between the sexes, as indicated by p-values at 0.023 for weight and with even more pronounced significance at 0.000 for length. Concomitant with these findings, it can be extrapolated that the substantial difference in mean total length and weight between sexes has pivotal implications for fishery practices within the reservoir, possibly influencing selective pressures and population dynamics of the species. The superior size of females may make them a more desirable catch, leading to gender-specific harvesting patterns. This could potentially impact the reproductive capacity of the *Oreochromis niloticus* population, as larger females are more likely to contribute significantly to future generations. These insights are supported by previous studies that examined the trophic structure and fish yield of other recently constructed reservoirs, such as Huruluwewa, Nachchaduwa, and Mahakanadarawa (Fernando & Indrasena 1969 ; Jyoti Sharma 2014).

Additionally, the data further narrates that the growth pattern of *Oreochromis niloticus* in the Mahakanadarawa reservoir follows a negative allometric trajectory, with condition factors calculated at 2.667 and 1.9092 respectively, as vividly depicted in Figure 02. This denotes that the increase in weight is not proportional to the increase in length, ostensibly suggesting that as the fish grow longer, they do not experience a commensurate increase in weight. The negative allometric growth pattern, as manifested in *Oreochromis niloticus* within this freshwater system, prosaically suggests potential underlying constraints in their habitat, possibly related to nutritional or environmental stressors that intrinsically affect their growth (Sarkar 2018). This can be corroborated by the citation found in the synthesis of scientific literature where it was explicated that when the parameter 'b' in the length-weight relationship is less than 3, such a connotation implies that the fish do not accrue weight commensurately with length, henceforth leading to a more elongated and consequently slender frame as they progress through their growth trajectory, a pattern that was similarly observed across different studies and species, as remarked in the summaries provided in different literature (Dewiyanti *et al.* 2020; Li *et al.* 2023; Peña *et al.* 2023; Xu *et al.* 2023).

In the broader context of fisheries management in Sri Lanka, and specifically within the reservoirs that propagate the limnological sustentation of fish stock, the apparent sexual size dimorphism and the discerned pattern of growth in *Oreochromis niloticus* proffer insights critical for the formulation of future strategies. It is incumbent upon fisheries management frameworks to cogitate on these biological and ecological variables to inform sustainable practices and interventions (Sarkar 2018). Despite the acquired knowledge regarding the dimensions and growth stages of *Oreochromis niloticus*, a multitude of factors intrinsic to the ecology of Mahakanadarawa freshwater dynamism remains to be investigated. Further research orientations might duly consider the contributions of such growth patterns to population and yield modulations across the seasonal and annual spectrums, as well as their interaction with environmental and anthropogenic variables, such as the influence of surrounding land uses on water quality, which inextricably affect the vitality and viability of fisheries subsystems (Herath *et al.* 2022).

In the plenary discussion of the socio-economic status of fishermen within the domain of a defined demographic, the intrinsically acquired data cogitates upon an intricately stratified community largely comprised of male individuals, where a sweeping majority of 95.83% are categorized thusly, compared to a relatively minute female representation of 4.17% (Jyoti Kalita *et al.* 2015; Malkanthi 2023). The discursive spread of ages among fishermen illuminates a preponderance towards seniority, with the transcendent majority, 31.94%, convening above the age of 51, and no responses emblematic of the age group below 20.

The cultural composition of the fishing cohort is predominantly Sinhalese at 88.89%, while a minority is identified as Muslim.

Concerning the fishing experience, a pivotal connection to age is discerned, with the apex of expertise aligning with the age group exceeding 21 years at 33.33%. The spiritual or religious orientation reveals a predominant Buddhist demography at 70.83%. Distinctions abound in the nature of fishing engagement, with 56.94% of individuals partaking on a full-time basis and the remainder, 43.06%, concurrently melding fishing with various other economic activities, such as paddy farming (68.97%), bolstering the fabric of a diverse income framework (Islam *et al.* 2017).

Underpinning the livelihood discourse, human capital indicators, such as educational attainment and access to training programs, resonate significantly, for they are cornerstones of empowerment and capacity building (Ahmed *et al.* 2021). The dimension of natural capital, incorporating land ownership and access to clean water, carries profound implications for familial subsistence and fishermen's ability to weather financial perturbations. Physical capital, notably fishing gears and crafts, reflects on economic autonomy and the facility to enhance productivity. According to Zamroni and Yamao (2021), social capital, including the social nexus and levels of communal trust, as well as the integration and participation of women in decision-making processes, provides a tapestry from which the robustness of community resilience may be gauged. It has been underscored through various studies that women play an integral role in the socio-economic weave of fisheries, a role often obscured yet vital in sustaining the local economies and contributing to gender analysis in fisheries (Alati *et al.* 2023).

Financial capital, manifested in monthly income and savings, particularly as a percentage contributed by fisheries, proffers a financial pulse to the vitality of the fishermen's household economies. Financial capital is an essential asset that can be utilized to procure other forms of capital, including natural capital (e.g., land), physical capital (e.g., fishing equipment), or human capital (e.g., education or training). In addition, financial capital can also improve one's social capital as high socio economic status often correlates to financial position. (Ahmed *et al.* 2021). The Monthly income, it must be noted, is not solely a function of fish sales; it is a composite of diversiform income streams accreted through multifarious pursuits augmented by members within the household (Kawarazuka and Béné 2010; Rahim *et al.* 2021). In the conceivable progression of discussion, one might perpend the scope and impact of training programs, which, as indicated by studies, when implemented effectively, have the propensity to increase household income and thereby improve the general welfare among fisheries-dependent communities. The intercession of education could indeed precipitate an escalation in diversifying income sources and catalyzing a transition towards more sustainable fisheries livelihoods (Islam *et al.* 2017). Succinctly, the dimensions of human, physical, social, and financial capital coalesce to narrate the bio-economic tableau of fishermen in a given milieu, underpinning the need for a multi-faceted approach to augment the socio-economic status of fishermen and their dependents, ensuring, therewith, the sustenance of fisheries as a viable and resilient economic sector (Paul & Chakraborty 2016; Smith & Bennett 2019; Paul-Sanon *et al,* 2021).

Moreover, gear selectivity, with the predominant use of gill nets of specific dimensional constraints within the Mahakanadarawa reservoir, brings to light the preferred methodological praxis for fish capture, which, while advantageous in certain respects regarding design simplicity and operational efficiency, does necessitate regulation to mitigate the potentiality for over-exploitation or habitat degradation as alluded to in previous extrapolations of empirical data. (Mazumder *et al.,* 2016; Alati *et al.* 2023; Jayasinghe 2010). Using a non-mechanized outrigger canoe is a defining feature of these fisheries (Kulatilake *et al.* 2010).

Herein, the nexus between stocking rates and production yields has been illuminated by the positive correlation coefficient, underscoring the importance of regular stocking for the maintenance of sustainable yield within culture-based fisheries, resonating with the findings in various spheres of ichthyologic research. The use of different mesh-sized gill nets and regulated fishing efforts, such as the limitation on the number of gill nets per fisher, contribute to sustainable fish harvesting. Various researchers have documented alterations in the output of fish from inland reservoirs. Recently, data

has become available for comparing the production of freshwater fish in reservoirs within the Kirindi Oya irrigation system in the Hambantota district for three different periods and observed positive development of production with stocking rate (Weligamage 2014).

Besides, Co-management is a governance strategy that involves collaboration between different stakeholders to address resource management challenges (Carlsson and Berkes 2005). It is a logical approach to resolving resource management issues through partnership (Carlsson and Berkes 2005). The same study by (Kulatilake *et al.* 2010) identified several tasks, such as data collection, logistical decisions (e.g., harvesting, timing), allocation decisions, resource protection, regulation enforcement, and long-term planning, that can be more effectively accomplished through well-functioning co-management systems in Senanayaka Samudra and Mahavilachchiya Reservoir. Co-management integrates various capacities and advantages (Carlson & Berkes 2005). By allocating tasks, specialization is enhanced, and efficiency is increased in all types of co-management systems.

Based on the comprehensive analysis of the research findings on the Mahakanadarawa reservoir's fisheries sector, several key conclusions can be drawn, leading to actionable recommendations for the improvement of the livelihood status of the fisher community. The study highlights the significance of fisheries management practices, community involvement, sustainable fishing methods, and the socioeconomic factors affecting the livelihoods of those dependent on the reservoir for their income. The involvement of both the government and fishery society in managing the fisheries suggests that co-management approaches are beneficial. Such strategies enhance the livelihoods of fishermen by promoting shared decision-making and resource management responsibilities. The condition factor and the negative allometric growth pattern of fish in the reservoir point toward the need for monitoring environmental and biological factors that influence fish health and productivity. These aspects are directly tied to the economic value and sustainability of the fishery. The research outlines the challenges related to inadequate facilities, gear, and crafts, alongside the low economic value of inland fish, as significant constraints impacting the fishery's productivity and the community's livelihood.

Enhanced Co-management framework and implemented targeted training and awareness programmes focusing on sustainable fishing practices, fish stock management, and environmental conservation is needed. These programmes should be designed to enhance the skills of the fisher community and promote the adoption of practices that ensure the long-term viability of fish stocks. This includes the introduction of technology and practices that can improve post-harvest management and add value to the fishery products. It is recommended to develop a comprehensive welfare system for fishermen, including insurance, health care, and education programs for their families- and to develop sustainable utilization of reservoir enhanced Co-management framework while strengthening the co-management of fisheries by fostering greater collaboration between the government, fishery societies, and the community. This should include regular consultations, shared governance models, and community-led conservation initiatives. It is also recommended to continue research and monitoring efforts to fill knowledge gaps, particularly in understanding the ecological dynamics of the reservoir, the socioeconomic factors affecting the community, and the impacts of climate change. By implementing these recommendations, it is possible to improve the livelihood status of the fisher community in the Mahakanadarawa reservoir, ensuring the sustainability of the fishery and the well-being of the community dependent on it. Such efforts require the commitment and cooperation of all stakeholders, including government bodies, the fishery community, and non-governmental organizations, to achieve long-term success.

ACKNOWLEDGMENTS

C.K Illangasingha et al.

REFERENCES

Abeyrathne, A.H M.T.G., U.K. Jayasinghe-Mudalige, W.M.H.K. Wijenayake & de Croos M.D.S.T. 2020. Sustainable Livelihood and Market Chain Analysis of Giant Freshwater Prawn Culture-Based Systems in Two Selected Reservoirs in Puttalam District, Sri Lanka. Sri Lanka Journal of Aquatic Sciences, 25(1).

Ahmed, M., S.M. Saha, M.E. Hossain, M.A. Khan & M.M.H. Prodhan 2021. Assessment of livelihood and food poverty status of the floating fishermen in riverine system of Bangladesh. Social Sciences & Humanities Open, 4(1), p.100219.

Alati, V.M., K. Osuka, L.M. Otwoma, P. Tuda & L.M. Nordlund 2023. Gender analysis in fisheries: The case of the shelled Mollusca fisheries in Kenya. Marine Policy, 158, p.105863.

Ahmed, M., S.M. Saha, M.K. Hossain, M.A. Khan & M.M.H. Prodhan 2021. Assessment of livelihood and food poverty status of the floating fishermen in riverine system of Bangladesh. Social Sciences & Humanities Open, 4(1), p.100219.

Alati, V.M., K. Osuka, L.M. Otwoma, P. Tuda & L.M. Nordlund 2023. Gender analysis in fisheries: The case of the shelled mollusc fisheries in Kenya. Marine Policy, 158, p.105863.

Carlsson, L. & F. Berkes 2005. Co-management: concepts and methodological implications. Journal of environmental management, 75(1), pp.65-76.

Chandrasoma, J. & K.B.C. Pushpalatha 2018. Fisheries enhancements in inland waters in Sri Lanka with special reference to culture based fisheries: current status and impacts, Sri Lanka Journal of Aquatic Sciences, 23(1), p. 49. DOI: 10.4038/sljas.v23i1.7546.

Deswandi, R., 2017. A case study of livelihood strategies of fishermen in Nagari Sungai Pisang, West Sumatra, Indonesia. In Redefining Diversity & Dynamics of Natural Resources Management in Asia, Volume 4 (pp. 45-60). Elsevier.

Dewiyanti, I., S. Aminah, A. Helmahera, N. Nurfadillah & C.N. Defira 2020, May. Growth patterns and condition factor of fish live in Kuala Gigieng waters of Aceh Besar as the basic for sustainable fisheries development. In IOP Conference Series: Earth and Environmental Science (Vol. 493, No. 1, p. 012020).

Allison, E.H. & F. Ellis 2001. The livelihoods approach and management of small-scale fisheries. Marine policy, 25(5), pp.377-388.

FAO, 2016. FAO Fishery Country Profile - Sri Lanka, FID/CP/LKA. Available at: https://www.fao.org/fi/oldsite/FCP/en/lka/profile.htm (Accessed: 18 February 2024).

Fernando, C.H. & A.H. Indrasena 1969. The freshwater fisheries of Ceylon.

Galappaththi, E.K. & F. Berkes 2014. Institutions for managing common-pool resources: the case of community-based shrimp aquaculture in northwestern Sri Lanka, Maritime Studies, 13(1), pp. 1–16. DOI: 10.1186/s40152-014-0013-6.

Goodman, W.K., A.M. Geiger & J.M. Wolf 2016. Leisure activities are linked to mental health benefits by providing time structure: comparing employed, unemployed and homemakers. J Epidemiol Community Health, *71*(1), pp.4-11.

Herath, B.M., P.N. Yapa & D.M.S. Duminda 2022. The Impact of the Surrounding Land Uses on Water Quality of Some Selected Cascade and Perennial Tanks in Anuradhapura District, Sri Lanka. Turkish Journal of Agriculture-Food Science and Technology, 10, pp.3063-3069.

Islam, S., M.S. Reza, M. Roknuzzaman, A. Razzaq & M. Joadder 2017. Socio-economic status of fishermen of the Padma River in Chapai Nawabganj district, Bangladesh. International Journal of Fisheries and Aquatic Studies, *5*(1), pp.101-104.

Jayasinghe, J.M.P.K., 2010. Inland Fisheries and Aquaculture for Food Security in Sri Lanka. National Aquatic Resources Research and Development Agency.

Kalita, G.J., P.K. Sarma, P. Goswami & S. Rout 2015. Socio-economic status of fishermen and different fishing gear used in Beki River, Barpeta, Assam. *Journal of Entomology and Zoology Studies*, *3*(1), pp.193-198.

Sarkar, U.K., J. Sharma & B.K. Mahapatra 2014. A review on the fish communities in the Indian reservoirs and enhancement of fisheries and aquatic environment. J Aquac Res Development, 6(1), p.1000297.

Kawarazuka, N. & C. Béné 2010. Linking small-

scale fisheries and aquaculture to household nutritional security: an overview. Food Security, *2*(4), pp.343-357.

Kulatilake, M., H.S.W.A. Liyanage, W.M.J.R. Fernando, J. Chandrasoma & M. Van der Knaap 2010. Development of co-management in the inland fisheries in Sri Lanka: case studies of Senenayake Samudra and Mahavilachchiya reservoirs. Aquatic Ecosystem Health & Management, 13(3), pp.294-300.

Li, Y., M. Feng, L. Huang, P. Zhang, H. Wang, J. Zhang, Y. Tian & J. Xu 2023. Weight–Length Relationship Analysis Revealing the Impacts of Multiple Factors on Body Shape of Fish in China. Fishes, 8(5), p.269.

Rathnachandra, S.D.D. & S.H.P. Malkanthi 2023. Socio-Economic Importance of Inland Fishery: A Case of Fishermen of Udawalawe Reservoir, Sri Lanka.

Mazumder, S.K., S.K. Das, Y. Bakar & M.A. Ghaffar 2016. Effects of temperature and diet on length-weight relationship and condition factor of the juvenile Malabar blood snapper (*Lutjanus malabaricus* Bloch & Schneider, 1801). Journal of Zhejiang University. Science. B, *17*(8), p.580.

MFAR (2020) 'Fisheries Statistics 2020', Ministry of Fisheries and Aquatic Resources Development, pp. 1–70. Available at: https://fisheriesdept.gov.lk/web/images/Statistics/FISHERIES-STATISTICS--2020-.pdf.

Murray, F., 2004. Potential for aquaculture in community-managed irrigation systems of the dry-zone, Sri Lanka: Impacts on livelihoods of the poor.

Murray, F.J. & D.C. Little 2000. Inland fisheries resources and the current status of aquaculture in Sri Lanka.

Paulson, E.J., 2018. Framework, Handbook of College Reading and Study Strategy Research, Third Edition, p. 1. doi: 10.5040/9781350248397.0006.

Pauly, D. 1983. in FAO Fisheries Technical PaDer No. 234.

Paul, P. & S. Chakraborty 2016. Impact of inland fisheries on the socio-economic development: a focus on perspectives on development, Nadia District, West Bengal, India. International Journal of Fisheries and Aquaculture: 6(1), pp.59-76.

Peña, R., C.U. McGregor-Bravo & M. Contreras-Olguín 2023. Allometric growth and larval development in Pacific red snapper Lutjanus peru under culture conditions. Journal of Fish Biology, 102(2), pp.413-425.

Pet, J.S., J.W.M. Wijsman, P.J. Mous & M.A.M. Machiels 1995. Characteristics of a Sri Lankan reservoir fishery and consequences for the estimation of annual yield. Fisheries Research, *24*(1): pp.9-33.

Rahim, A., W. Rossali, A. Laapo, W. Sabar, U. Syam & S. Rijal 2021. July. Factors Affecting Household Income in the Post-Empowerment of Small-Scale Fishermen Wives. In IOP Conference Series: Earth and Environmental Science (Vol. 828, No. 1, p. 012049). IOP Publishing.

Ramlah S., La Sara, Ayub Padangaran, & Muslim Tadjuddah 2020. The status of catch per unit effort (Cpue) and utilization rate of skipjack tuna (katsuwonus pelamis) in the kolaka waters, southeast Sulawesi, Indonesia. INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH,9(01).

Ricker, W.E., 1973. Linear regressions in fishery research. *Journal of the fisheries board of Canada*, *30*(3), pp.409-434.

Perera, R.T., N. Dayananda, S. Botheju, J. Liyanage, A. Ranasinghe, R.H. Karunarathna & G.P. Kumara 2021. Heavy metal contamination in surface sediments of major tanks in Anuradhapura district; A CKDu endemic district in Sri Lanka. EQA - International Journal of Environmental Quality, 41, 40–48.

Rosales, R.M., R. Pomeroy, K. Juntarashote & O. Nabangchang 2017. Value chain analysis and small-scale fisheries management. Marine Policy, 83, 11-21.

Sarkar, U.K., S. Jyoti & B.K. Mahapatra 2015. A review on the fish communities in the Indian reservoirs and enhancement of fisheries and aquatic environment. *Journal of Aquaculture Research and Development*, *6*(1).

Scoones, I., 1998. Sustainable rural livelihoods: a framework for analysis.

Welcomme, R.L., I.G. Cowx, D. Coates, C. Béné, S. Funge-Smith, A. Halls & K. Lorenzen 2010. Inland capture fisheries. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), pp.2881-2896.

Xu, B., D. Li, K. Wei, X. Zhu, J. Xu & B. Ma 2023. Allometric Growth Patterns and Ontogenetic Development during Early Larval Stages of *Schizothorax waltoni Regan* and *Percocypris retrodorslis* in Southwest China. Water, 15(4), p.824.

Zamroni, A. & M. Yamao 2011. Sustainable household economics: A case of altering income of small-scale fishermen in Indonesia. In *International Conference on Financial Management and Economics* (Vol. 11, No. 11, pp. 343-347).