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The Lost Coin: Redefining the economic and financial value of small-scale fisheries, the case of Lake Victoria, Kenya

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ABSTRACT

Whereas small-scale fisheries account for the largest proportion of fish catches and employment in most developing countries, their value remain underestimated due to inadequate data collection systems, open access challenges and unreported landings. This study provided a methodological option to compare, contrast and validate official fisheries statistics in small-scale fisheries of Lake Victoria, Kenya. A standardized Fishing Business Model (FBM) was applied to reconstruct estimates of economic returns from Lake Victoria fisheries; taking into account fish auto-consumption, post-harvest losses and landings from illegal gears which are often missing in the official estimates. Primary data was collected using electronic questionnaires in various fish landing sites in July 2020 while secondary data was sourced from latest surveys on fish stocks, catches and fishing effort in the lake. Results indicate that fish catches amounted to 151,002 mt (Sd = 1767.0), which implies 1.6 times the official estimates, and that Total annual Fishing Revenue (TFR) was USD 297, 172, 579.39 (Sd = 2,674,359.0) which was 1.9 times higher than published statistics. Further, a small-scale fisher was found to earn a daily wage of USD 17.6, inclusive of the value of auto-consumption, under-sized fish and other unsold catch which are usually unreported. We recommend a review of official fisheries statistics in order to correct under-valuation in small-scale fisheries and to re-adjust the management cost recovery and revenue allocation frame-work in the fisheries sub-sector. This study thus makes a valuable contribution to literature on income and cost analysis for different fishing enterprises in small-scale fisheries.

1. Introduction

Small Scale Fisheries (SSFs) are generally dynamic, labor intensive and involve artisanal crafts for subsistence or commercial fishing with relatively small amounts of capital (Hillary & Xavier, 2019; Food and Agriculture Organization (FAO), 2003). These fisheries account for ninety percent (90%) of the 120 million fishers and fish workers globally, ninety seven percent (97%) of whom live in developing countries, with one-third of the catches coming from fresh water systems (Zelasney et al., 2020). Since SSFs in developing countries are often dispersed, characterized by open access and informal with weak monitoring, there is prevalence of unreported fishing which often leads to misreporting and undervaluation (Mills et al., 2011a; Food and Agriculture Organization (FAO) et al., 2018). Teh and Sumailia (Teh & Sumaila, 2011), have similarly observed that underestimation of fisheries statistics may be due to inadequate data collection systems, illegal fishing or unreported landings. Kelleher and Mills (Kelleher & Mills, 2012), in a World Bank/FAO Study on "The Hidden Harvests" indicated that inland small-scale fisheries are under-reported by seventy percent (70%) in developing countries, despite these fisheries providing ninety to ninety five percent (90–95%) of locally consumed fish in rural settings where poverty rates are usually high and quality nutrition low.

In Africa, approximately 200 million people derive high-quality and low-cost proteins from fish (Obiero et al., 2019). The combined fishery

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of Lake Victoria from its riparian East African countries provides the world's largest small scale freshwater fishery, accounting for about 1% of global capture fisheries with an estimated annual catch of 1 million tons of fish and a fisheries carrying capacity of 200 million metric tons (Kimani et al., 2018a). Assuming the logistic model of growth, where a sustainable catch is estimated at around half the carrying capacity, this would imply that the sustainable potential catch for the lake is 100 times more than the present (Brites & Braumann, 2017; Supriatna et al., 2015). On the contrary, steady state models with fishing effort as the main driver indicate that some of the Lake's fish species (e.g Nile perch) have been overfished, thus being in danger of collapse (Getabu et al., 2003; Matsuishi et al., 2006; Pitcher et al., 1995). The latter view is strongly held by the Lake's fisheries management bodies, with several measures being proposed to contain fishing effort in the Lake (Lake Victoria Fisheries Organization (LVFO), 2016d). None the less, other researchers have invalidated the management views of overfishing claiming that they are not supported by empirical observations (Kolding et al., 2008). Given that our premise is a gross underestimation of fish catch estimates from the Lake, especially from illegal and unreported fishing, we believe that both schools of thought are greatly limited in making sustainable fisheries management proposals while using the imprecise catch data.

The lake is shared by three partner states of Kenya (6%), Uganda (43%) and Tanzania (51%). It employs an estimated 200,000 people directly and provides livelihood to about 4 million people (Njiru et al., 2014). In Kenya, the fishery of Lake Victoria accounts for seventy three percent (73%) and sixty five percent (65%) of total quantity and total value of national fish catches respectively (Ministry of Agriculture Livestock & Fisheries (MoALF), 2016). Based on 2018 estimates, the fisheries yield from the Kenyan part of Lake Victoria was 98,150 metric tons, amounting to 0.3% of Kenya's GDP. For Lake Victoria SSFs, Odongkara et al. (Odongkara et al., 2010) noted that the fisheries contribution to the national economies of partner states is usually grossly undervalued and inaccurately reported, thus the official fisheries data on catches and employment may not be reliable.

Owing to the socio-economic and nutritional significance of SSFs in developing countries and local economies, an accurate valuation of SSFs is required. Precise data on the value of SSFs would ensure viable policy considerations, attraction of investments, business support mechanisms for nascent SSFs' enterprises, sustainable management of effort and catch rates, and appreciation of the relative contribution of SSFs to GDP. This study applied novel data reconstruction techniques in order to generate economic and financial indicators for Lake Victoria, Kenya. The reconstructed data estimates captured additional catch and value information such as fish auto-consumption, post-harvest losses, landing from illegal gears and capital investments which are often missing from official estimates.

1.1. Socio-economic context of Kenyan SSFs

1.1.1. National trends

Kenya is sub-divided into 47 devolved government units referred to as counties, five (5) of which are riparian to Lake Victoria. In 2019, Kenya had a population of 47, 564, 296 people, half (50.04%) of whom were females (Kenya National Bureau of Statistics (KNBS), 2018), and with 11% percent of the population residing in the counties riparian to Lake Victoria, Kenya. The official statistics in (Kenya National Bureau of Statistics (KNBS), 2018) further indicate that fisheries contributed a modest 0.5% of Kenya's GDP in 2018 (Table 1), with only 363 employees engaged in informal wage employment within freshwater fisheries, at a cumulative annual income of USD 858 thousand. Whereas the former estimate is a subject of our study, the two latter statistics are out-rightly erroneous judging by overt observation, reality on the ground and frame survey statistics which indicate that fishers are about forty-four thousand (Lake Victoria Fisheries Organization (LVFO), (2016a; 2016b; 2016c; 2016d).

Table 1
National Socio-economic indicators.

Year	2014	2015	2016	2017	2018
Population (Projections, Millions)	43.0	44.2	45.8	47.0	47.8
GDP (Billion USD)	54.0	62.8	70.2	81.4	89.0
GDP Growth Rate (%)	5.4	5.7	5.9	4.9	6.3
Fisheries production (Billion USD)	1.8	1.6	1.5	1.4	1.5
Fisheries proportion of GDP	0.7	0.6	0.5	0.4	0.5
Fisheries growth rate (%)	2.1	−8.6	−17.3	−1.7	9.7

[1]Compiled statistics using KNBS Statistical abstracts, (Kenya National Bureau of Statistics (KNBS), 2018; Kenya National Bureau of Statistics (KNBS), 2017; Kenya National Bureau of Statistics (KNBS), 2016; Kenya National Bureau of Statistics (KNBS), 2015; Kenya National Bureau of Statistics (KNBS), 2014).

1.1.2. County trends

In the 2018/19 Financial Year (FY), whereas the fisheries sector in Kenya received a national revenue allocation of USD 2398 million, implying 0.17% of the national revenue, all of the riparian counties had a relatively higher proportional allocation of revenue to fisheries development than the national percentage (Table 2). Homabay County, which is the largest among the five riparian counties by surface area, accounted for about 63% of all fish catches in Lake Victoria. It also had the highest per capita fish consumption.

1.1.3. Trends in fish catches

Catch trends for the whole Lake indicate a generally increasing pattern from 1965 onwards (Fig. 1(a)). This was also true for all the three key commercial species, with the largest contribution to the increase coming from the *dagaa* fishery. The results tally well with trend data from the lake's hydroacoustic surveys that have shown quite stable fish biomasses, including an increasing biomass for *dagaa* (Lake Victoria Fisheries Organization (LVFO) (2016a, 2016b, 2016c, 2016d). However, at the national level, total fish catches from Kenya's sector of the Lake showed an increasing trend until the year 1995, before exhibiting a moderate but constant decline in successive years (Fig. 1(b)). While there has been no conclusive answer on the specific cause of the decline in fish catches from Kenya's sector of the lake, some studies have cited increase in the use of illegal fishing gears, proliferation of macrophytes and poor catch estimation techniques (Kimani et al., 2018b; Owiti et al., 2018; Njiru et al., 2008, 2010). Should the observed decline in Kenya be accurate, it could have far reaching socio-economic consequences, which include loss of income and livelihoods, food and nutritional insecurity and conflicts over the limited resources at community, national and regional levels (Namisi, 2005).

1.1.4. Fishing effort

Fishers in the Lake Victoria, Kenya mainly use Sesse boats that are pointed at both ends when using sails or Sesse boats flat at one end when using outboard engines. The main fishing gears used are the Long Line (LL) and Gill Net (GN) for Nile Perch and Tilapia fisheries respectively; and the Small seine for the Dagaa fishery (Table 3). In spite of the prevalence of gears such as monofilaments, beach seines and boat seines, they are generally outlawed gears by the Lake Victoria Fisheries Organization partner states owing to their perceived negative impacts on aquatic habitats. Reliable information on fishing effort provides useful socio-economic indicators on the level of employment and returns from fishing inputs and extractive activities.

2. Materials and methods

2.1. Data sourcing

Field level data was collected through a questionnaire survey approach. The questionnaire was administered to fishing enterprise owners (boat owners) or their representatives since they were perceived to possess a more holistic understanding the vessel's economic and

Table 2
County Socio-economic indicators.

	Total Area (km^2)	Water Mass (km^2)	Population (2019 Census, Millions)	Fisheries' Allocation (Million USD, 2018/19)	% of Total Revenue (2018/19)	Total Catch (mt, 2018)	Value of Catch (MillionUSD, 2018)	Per Capita Fish Consum. (kg)
KENYA	610,000	29,391	47.70	27.9	0.17	148,347	2398.3	3.1
Homabay	4760	2064	1.13	0.38	0.5	81,399*	90.1*	71.9
Kisumu	2677	567	1.16	0.19	0.2	2601*	2.6*	2.3
Busia	1830	144	0.89	0.29	0.4	6150*	13.7*	6.9
Siaya	3542	1089	0.99	0.55	0.8	28,519*	33.8*	28.7
Migori	2597	478	1.12	0.26	0.3	8638*	10.7*	7.7

[2]Compiled statistics using KNBS Statistical Abstracts (Kenya National Bureau of Statistics (KNBS), 2018; Kenya National Bureau of Statistics (KNBS), 2017; Kenya National Bureau of Statistics (KNBS), 2016; Kenya National Bureau of Statistics (KNBS), 2015; Kenya National Bureau of Statistics (KNBS), 2014) (*Data available for year 2014).

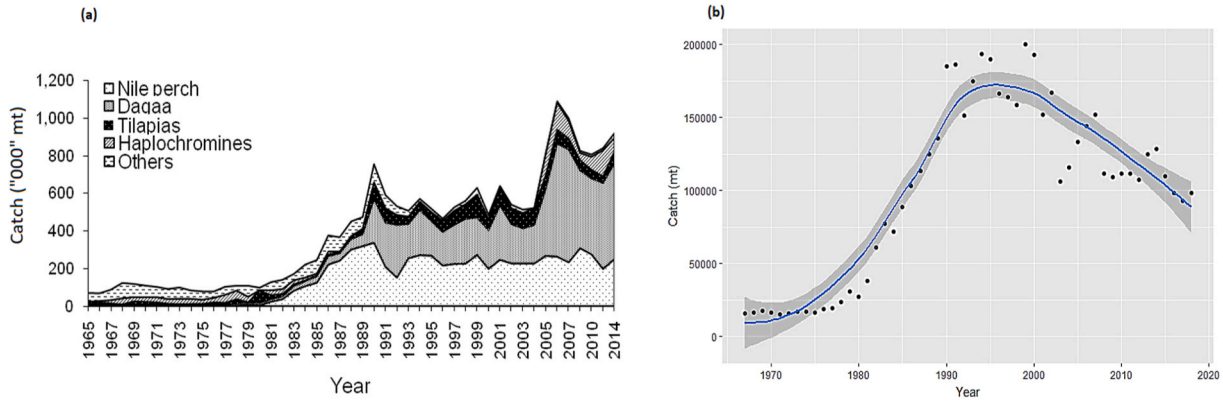

Fig. 1. (a) Quantity of fish (mt) landed by key species in Lake Victoria, 1965–2014 (*Adapted from LVFO-FMPIII, 2016–2020*) (Lake Victoria Fisheries Organization (LVFO) (2016a, 2016b, 2016c, 2016d, **(b)** Quantity of fish (mt) landed in Lake Victoria, Kenya 1967–2018 (*Constructed using KNBS Statistical Abstracts, 1967–2018*) (Ministry of Agriculture Livestock & Fisheries (MoALF) and Kenya, 2013; Lake Victoria Fisheries Organization (LVFO), 2015).

Table 3
Fishing effort Indicators in Lake Victoria, Kenya.

Indicator	Total Number
Landing sites	338
Fishers	43,653
Total number of fishing crafts	14,209
Outboard Engines	3155
Paddles	6884
Sails	4169
Foot fishers	156
Dugout (DO)	3
Parachute (PA)	2902
Raft (RA)	18
Sesse Flat at one End	3503
Sesse Pointed at Both	7783
Beach seine	906
Boat Seines	901
Cast net	75
Gill nets	192,987
Hand lines	2810
Long line hooks	2,507,893
Monofilament	20,842
Small seines	13,156
Traps/baskets	1097

[4]Compiled using data from (Lake Victoria Fisheries Organization (LVFO) (2016a, 2016b, 2016c, 2016d).

financial costs and kept records for its catches and revenue. In most instances, the vessel owners were also a part of the crew; and in the case of foot fishers they represented both vessel and crew. In the survey approach, given that fishing revenue and costs were sometimes regarded as trading secrets and that vessel and gear operations could be contentious when perceived to be illegal, the questionnaire omitted any information which could lead to respondent identification or incrimination such as names, contact, and identification or registration numbers (Onyango, 2021a, 2021b). The data was collected from July–August 2020 in selected fish landing sites within Lake Victoria, Kenya. In addition, this study utilized secondary data from two routine surveys by the Lake Victoria Fisheries Organization (LVFO), namely, the Frame survey (FS) 2016 (Lake Victoria Fisheries Organization (LVFO) (2016a, 2016b, 2016c, 2016d and Catch Assessment Survey (CAS) 2015 (Lake Victoria Fisheries Organization (LVFO), 2015) to supplement the primary data. The FS provides a census of fishing effort variables such as fishers, vessels and gears, and fish landing facilities such as toilets, Beach Management Unit (BMU) offices, electricity, potable water, cold room, fish store, accessibility to all weather road, designated net and boat repair facilities, and jetties. It has been conducted in Lake Victoria biennially from the year 2000–2016. On the other hand, CAS generates information on the quantity of fish caught. The CAS is conducted periodically and used together with the FS to arrive at catch rates using different fishing effort combinations, spatial distribution as well as trends overtime. The FS 2016 and CAS 2015 (Lake Victoria Fisheries Organization (LVFO), 2015; Lake Victoria Fisheries Organization (LVFO) (2016a, 2016b, 2016c, 2016d, which were the latest available datasets for Lake Victoria, were helpful in EFIA sampling and data comparison with the reconstructed estimates.

2.2. Sampling

The sampling unit for the EFIA study was the fishing unit or enterprise, which referred to a combination of fishing craft, gear used and target fish species (Sweenarain., 2011, p. 75). Using FS and CAS data, the study sample was arrived at after stratification at various levels, including administrative units, nature of landing sites, type of crafts and gears, and target species, in order to gain representative combinations of

the fishing units of Lake Victoria, Kenya. The landing sites and respondents were then randomly selected within each strata. In addition, owing to the mobility of fishers and traders across the various fishing grounds (Nunan, 2010; Nunan et al., 2012), this study assumed that they use relatively similar fishing grounds at county and sub-county levels, hence implying geographical uniformity in fishing grounds within a counties and its sub-counties.

Primary data was then collected from fishing unit owners, who were the boat owners, using an electronic fishing enterprise questionnaire on the EFIA module, and transmitted in real time to LVFO's eCAS application (LVFO). Using sampling theory (Taherdoost, 2017), a sample size of at least 150 respondents was expected from the stratification. In this sense, we applied the basic formulae for estimating the sample size of a finite population for the proportion of boat owners in Lake Victoria, Kenya, and moderating for cost and time considerations. The research team used local field guides, community opinion leaders and elected beach management officials who were familiar to fishing enterprises owners as the initial entry point. This access strategy enhanced co-operation by fishing enterprise owners and greatly improved their participation. It was also specifically realized that the beach management leaders gained a special interest in the study owing to its prospects for correcting their perceived catch underestimation; they thus encouraged more boat owners that we had expected to participate. We therefore attained a response rate of 137%, and interviewed a total of 206 respondents from six (16) landing sites across the five (5) riparian counties in varying proportions. These included Siaya (50), Homabay (46), Migori (44), Kisumu (33) and Busia (32). The high response rate was occasioned by great enthusiasm that the respondents had in the research because of the study's prospect to clear the long-standing discontent on catch and revenue statistics from officially published documents.

2.3. Analysis

We applied a Fishing Business Model (FBM) to reconstruct estimates of economic returns from Lake Victoria fisheries (Table 4) (Sweenarain., 2011, p. 75). This model provides a complete assessment of a fishing enterprise: the value of assets, cost of production and an evaluation of the profitability of a fishing unit. It tracks operations from input to produce, and business from seller to buyer. The FBM is based on accounting principles that enhance verification, reliability and ease of replication and adoption in similar contexts. The analysis was conducted in order to estimate the annual fishing revenue, operating fixed and variable costs, value added along the trading chain and the income from fishing.

Table 4
Fishing business model.

Cost centres	Ref.	Notes/Year of reference
A. Fishing revenue		
No. of active fishers	A	(No of f/boats x no. fisher/boat)
Catch Per Fisherman Day (CPFD)	B	CAS/FS 2016 (Survey& Interviews)
Mean Primary Sale Price catch	C	Market Data (Survey & Interviews)
Number of Effective Fishing days	D	Survey, Interviews & Focus Group
êTotal Fishing Revenue/Turnover	TFV	(A x B x C x D)
B. Operating Fixed Costs		
Depreciation (F/boat + Engine …)	E	F/Asset Cost/economic life (Ownership?)
Insurance Premium F/Assets & Fishers	F	If applicable
Major repairs & maintenance	G	Interviews & Focus Groups
Other Op fixed costs: Watchman	H	If any, applicable to the context
êTotal Operating Fixed Cost	OFC	(E + F + G + H)
C. Operating Variable Costs (excl. Labor Cost)		
Fuel and Lubricants	K	(OVC per trip x No of trips/year)
Fishing Baits, Food & Water	L	Survey & Interviews
Minor repairs and Maintenance	M	Survey & Interviews
Others: Transportation, Telephone etc.	N	Survey and Interviews
êTotal Operating Variable Cost	OVC	(K + L + M + N)
êTotal Gross Value Added	GVA	(FR - (OFC + OVC))
D. Labor costs		
Fishers' Wages (including Owner-Fisher)	W	Cost/Income Sharing Arrangement
E. Gross Income	GOI	= FR – (OFC + OVC + W)

3. Results and discussion

3.1. Description of the fishing unit

The respondent categories mainly included fishers (82%) and fish traders (8%), with rest being fish processors. The sample comprised 197 crafts which were mainly wooden (99%) and locally built, operating within urban (49%), rural (36%) and island (15%) sites. Most of these crafts were built between the year 1988 and 2020, and were propelled with sails (28%), outboard engines (41%) and paddles (31%). The fishing unit build up was dominated by traditional materials and its propulsion was relatively labor-intensive (Table 5).

3.2. Economic and financial indicators

3.2.1. Fishing and trading assets

The main fishing assets that were identified in the EFIA study were mainly linked to the vessel, propulsion, fishing method, fish processing and trade (Table 6). Of these, propulsion and vessel expenses accounted for most of the input costs. From among the vessel costs (which comprised the anchor, rope and craft/boat) the boat was the most costly asset to acquire with a retailing average of USD 1127.08 (Sd = 54.92). This result underscores the importance of the fishing boat as an input in the production enterprise. Moreover, the engine was the most expensive propulsion mode (Mean = USD 1575.96; Sd = 31.29) whereas the beach seine emerged as the most highly priced fishing gear (USD 1380.00). Fish traders and processors were found to incur most expenses on freezers (USD 500) and ice boxes (USD 100–350).

3.2.2. Fish catches and revenue

Findings on the fishing enterprise indicate that the average fishing crew per boat is three (Mean = 3, Sd = 0.20) and this ranged from one (1) crew for hand-liners to 12 crew for beach seiners. The mean daily catch ranged across the fishery types from 1 kg to about 419 kg, with the average effective fishing days being 233 (sd = 8.0) days per year. For Nile perch fishers, those who used Motorized Sesse Boats generated the

Table 5
Socio-demographic indicators of the fishing unit.

Indicator	Statistics		
Counties	5		
Sub Counties	10		
Type of occupation	Fishers 169 (82%);		
	Fish traders 16 (8%);		
	Fish processors 21 (10%)		
Craft	No. Sampled	169	
	Material	Wooden (99%); Reed (1%)	
	Origin	Local = 99%	
	Ownership	Own = 95%; Rented 5%	
	Operation	Urban (49%); Rural (36%); Island (15%)	
	Year Built	Range	1988–2020 (32yrs)
		Mode	2017 (Median = 2015)
	Propulsion Type	Sail	28%;
		Engine	41%;
		Paddle	31%
Gear	Handline (HL)	8	
	Boat Seine (BoS)	8	
	Gill net (GN)	58	
	Long line (LL)	38	
	Beach seine (BS)	1	
	Small Seine	38	

Table 6
Cost of fishing unit assets.

	Main Fishing Asset	Mean (USD)	Stdev (USD)	Min (USD)	Max (USD)
Vessel (n = 169)	Anchor	17.75	4.64	12.00	30.00
	Anchor rope	2.66	0.45	0.60	5.00
	Craft/Boat	1127.08	54.92	715.00	1500.00
	Grand Total	1137.62	25.81	721.53	1520.00
Propulsion	Engine (n = 69)	1575.96	31.29	850.00	2500.00
	Paddle (n = 52)	4.55	0.62	1.50	8.50
	Sail (n = 48)	46.90	21.79	10.00	100.00
	Grand Total	1583.62	23.10	852.50	2530.00
Gear (n = 169)	Parachute- Boat Seine (PA-BoS)	491.63	21.14	410.00	570.00
	Parachute-Gillnet (PA-GN)	531.93	20.32	351.00	800.00
	Parachute-Monofilament (PA-MF)	450.00	–	450.00	450.00
	Sesse Flat– Boat Seine (SF-BoS)	730.00	23.25	360.00	1100.00
	Sesse Flat– Beach Seine (SF-BS)	1380.00	–	1380.00	1380.00
	Sesse Flat– Gill net (SF-GN)	1655.11	27.41	715.00	2268.00
	Sesse Flat–Monofilament (SF-MF)	215.00	49.50	180.00	250.00
	Sesse Flat– Small Seine (SF-SS)	524.66	32.84	420.00	700.00
	Sesse Pointed–Boat Seine (SP-BoS)	480.00	13.13	400.00	560.00
	Sesse Pointed– Gill Net (SP-GN)	365.20	9.03	300.00	480.00
	Sesse Pointed–Monofilament (SP-MF)	343.00	11.75	317.00	450.00
	Sesse Pointed–Small Seine (SP-SS)	432.83	24.93	320.00	585.00
Processing (n = 21)	Basin/buckets/ sadoline	2.41	0.20	2.00	2.50
	Drying net	15.00	–	15.00	15.00
	Drying rack	10.00	–	10.00	10.00
	Frying pan	11.50	5.35	3.50	25.00
	Ice box	350.00	–	350.00	350.00
	Kiln	51.17	48.26	3.50	100.00
	Knives	0.35	0.21	0.20	0.50
	Grand Total	433.76	22.91	381.20	501.00
Trading (n = 16)	Basin/buckets	2.71	0.86	1.00	3.50
	Freezer	500.00	–	500.00	500.00
	Ice boxes	205.00	10.36	100.00	350.00
	Other fish trade assets	22.12	13.62	1.00	45.00
	Polythene sheet	1.00	–	1.00	1.00
	Weighing scale	5.00	–	5.00	5.00
	Grand Total	729.64	21.62	607.10	902.00

highest annual landings (Mean = 8,141 mt; Sd = 112.2) and revenue (Mean = USD 50, 878, 322.89; Sd = 132,758.9) when using the gill net. Besides, the mean primary sale price for the fish was USD 1.86 per kg. The reconstructed estimates from the SFBM indicate that total annual catches in Lake Victoria, Kenya amount to 151,002 mt (Sd = 1767.0) while the annual value is USD 297 million (Table 7).

3.2.3. Operating costs and income

Results indicate that in the fishing enterprise, Sesse Flat boats using Long Line gears (SF-LL) and Sesse Flat boats using Small Seine gears (SF-SS) incurred the highest annual operational costs of USD 1705.40 (Sd = 12.3) and USD 1205.70 (Sd = 25.3) respectively. Generally, since SF boats have gasoline powered outboard engines, different from all the other vessels which mainly use sails or paddles, they have a relatively more costly propulsion. In addition, the LL gear, which mainly targets

Table 7
Reconstructed catches and revenue for Lake Victoria, Kenya (mean ± Sd).

Fishing Type	Primary Fish Sale Price (USD/kg)	Average Annual Landings (Tons)	Total Annual Fishing Revenue (USD)
Lake Victoria, Kenya	1.86 (0.22)	151,002 (1767.0)	297,172,579.39 (2,674,359.0)
Sesse Flat-Beach Seine-Nile Perch	2.00 (0.03)	1602 (48.0)	10,011,420.00 (59,217.2)
Sesse Pointed-Gill Net-Nile Perch	2.00 (0.22)	2447 (72.8)	15,292,300.00 (77,628.9)
Sesse Pointed-Long Line-Nile Perch	2.50 (0.14)	2686 (69.2)	20,988,108.47 (64,083.1)
Sesse Flat-Long Line-Nile Perch	2.00 (0.15)	7210 (50.1)	45,063,409.33 (79,683.4)
Sesse Flat-Monofilament-Tilapia	2.50 (0.12)	901 (21.7)	5,866,075.00 (38,673.5)
Sesse Pointed-Monofilament-Tilapia	2.50 (0.10)	2050 (52.6)	13,345,981.25 (29,368.2)
Sesse Flat-Small Seine-Dagaa	0.52 (0.12)	30,098 (100.9)	8,151,629.38 (57,921.3)
Sesse Pointed-Monofilament-Nile Perch	2.00 (0.17)	1070 (42.8)	6,687,320.00 (65,223.8)
Sesse Pointed-Gill Net-Tilapia	2.50 (0.13)	3004 (20.3)	19,554,235.00 (126,537.9)
Sesse Pointed-Small Seine-Dagaa	0.52 (0.17)	15,158 (68.5)	4,105,348.53 (88,569.1)
Parachute-Monofilament-Tilapia	4.50 (1.25)	2151 (42.9)	25,209,192.86 (99,621.0)
Sesse Flat-Monofilament-Nile Perch	2.00 (0.21)	2753(30.3)	17,207,140.00 (86,787.3)
Sesse Flat-Gill Net-Nile Perch	2.00 (0.25)	8141 (47.0)	50,878,322.89 (132,758.9)
Parachute-Monofilament-Nile Perch	0.80 (0.20)	3003 (28.4)	5,005,712.00 (60,113.2)
Raft-Hand Line-Tilapia	2.50 (0.01)	680 (10.5)	4,426,425.00 (55, 731.8)
Sesse Pointed-Hand Line-Tilapia	2.50 (0.00)	1589 (32.7)	10,346,383.75 (79,062.7)
Foot Fisher-Hand Line-Tilapia	2.50 (0.01)	405 (11.6)	2,639,540.00 (62,165.6)
Sesse Flat-Boat Seine-Dagaa	0.52 (0.18)	45,051 (112.2)	12,201,428.20 (68,116.3)
Parachute-Long Line-Nile Perch	2.00 (0.12)	1074 (22.9)	6,713,492.13 (27,836.0)
Parachute-Gill Net-Tilapia	2.50 (0.05)	481 (15.9)	3,129,211.25 (19,212.3)
Parachute-Gill Net-Nile Perch	2.00 (0.13)	799 (11.3)	4,992,765.73 (18,975.2)
Parachute-Long Line-Nile Perch	0.80 (0.16)	220 (8.4)	366,286.72 (20,176.1)
Sesse Pointed-Boat Seine-Dagaa	0.52 (0.18)	10,646 (55.1)	2,883,365.99 (22,121.0)
Parachute-Boat Seine-Dagaa	0.52 (0.17)	7781 (36.7)	2,107,485.90 (23,953.7)

nile perch, leads to addition expenses on fishing bait. On the other hand, the SS gear which mainly targets dagaa, incurs additional expenses on lighting as a necessary input in its selective fishing. Given the relatively higher number of crew required to operate the boat seine (BS), an LVFO classified illegal fishing gear due to its non-selectivity, wage expenses were found to be highest for SF boats operating this gear. Among the fishing enterprises, SF vessels operating gill nets generated the highest gross operating income which was USD 15,529.30 (Sd = 98.7) per annum. However, fish traders still had the highest overall expenses (Mean = USD 2792.00; Sd = 120.8) and income (USD 46,092.60; Sd = 782.1) from fishing activities, the latter being probably because of the additional value which they created to the fish product (Table 8).

Table 8
Annual costs and income estimates for vessel gear combinations in Lake Victoria, Kenya (mean ± Sd).

Vessel-gear combination	Total Operating Costs (TOC, USD)	Gross Value Added (GVA, USD)	Wages (USD)	Gross Operating Income (GOI, USD)
Sesse Flat-Beach Seine	71.30 (10.1)	4934.40 (22.3)	4095.60 (56.0)	838.90 (17.58)
Sesse Pointed-Gill net	235.00 (11.5)	7420.00 (32.6)	2832.50 (23.7)	4587.50 (28.2)
Sesse Pointed-Long Line	1042.40 (17.6)	7352.90 (37.4)	2901.50 (28.3)	4451.30 (21.9)
Sesse Flat-Long Line	1705.40 (12.3)	20,826.30 (127.0)	6122.90 (11.5)	14,703.30 (32.7)
Sesse Flat-Monofilament	68.40 (13.7)	5406.60 (23.6)	2047.20 (17.1)	3359.40 (18.3)
Sesse Pointed-Monofilament	50.30 (12.6)	4503.60 ((14.9)	1782.00 (14.6)	2721.60 (13.1)
Sesse Flat-Small Seine	1205.70 (25.3)	14,470.50 (35.1)	5425.50 (29.4)	9045.00 (28.6)
Sesse Pointed-Small Seine	304.40 (10.7)	7590.50 (22.4)	4302.60 (24.0)	3287.90 (18.1)
Parachute-Monofilament	55.10 (6.2)	5546.90 (10.1)	1949.80 (13.4)	3597.10 (12.0)
Sesse Flat-Gill net	407.40 (9.0)	25,031.80 (100.2)	9502.50 (25.6)	15,529.30 (98.7)
Raft-Hand Line	122.60 (11.2)	1648.00 (13.1)	142.40 (8.1)	1505.60 (16.2)
Sesse Pointed-Hand Line	27.00 (6.7)	4111.50 (9.8)	1605.70 (10.0)	2505.90 (13.2)
Foot Fisher-Hand Line	85.90 (9.5)	970.00 (10.3)	23.30 (2.0)	946.60 (11.3)
Sesse Flat-Boat Seine	719.10 (14.1)	22,745.20 (90.5)	11,012.80 (21.8)	11,732.40 (96.1)
Parachute-Long Line	560.00 (8.8)	2072.00 (26.0)	766.60 (10.5)	1305.40 (13.6)
Parachute-Gill net	59.90 (6.4)	2125.30 (13.9)	820.40 (10.1)	1304.90 (12.0)
Sesse Pointed-Boat Seine	62.50 (7.1)	5482.50 (8.6)	2372.80 (11.8)	3109.70 (15.4)
Parachute-Boat Seine	267.80 (9.9)	3785.00 (14.9)	1726.70 (10.3)	2058.30 (14.5)
Fish Trader	2792.00 (120.8)	49,043.00 (961.8)	158.40 (11.2)	46,092.60 (782.1)
Fish Processor	199.10 (25.2)	17,918.20 (98.5)	128.30 (13.7)	17,590.80 (78.0)

4. Comparison of estimates

A comparison between the reconstructed estimates and published official data on Lake Victoria fisheries, Kenya indicate that the statistics are quite different, with the latter being generally lower (Table 9). The reconstructed number of fishers was higher, by about 3,251, than those enumerated in the frame survey (Lake Victoria Fisheries Organization (LVFO) (2016a, 2016b, 2016c, 2016d; the fish catches 1.6 times higher than official estimates; and the annual fishing revenue was 1.9 times higher in the constructed estimates than the published statistics. On average, a fisherman earned a daily wage of USD 17.6, inclusive of the value of auto-consumption, under-sized fish and other unsold catch which are usually unreported. The minimum daily wage in Kenya (2017) for unskilled labour was USD 2.7 (Government of Kenya (GoK), 2017), implying that fishermen earn 6.5 times the minimum daily wage. The boat owner was found to earn 3.3 times the wage of a single crew.

Table 9
Comparison between official and reconstructed data (mean ± Sd).

Indicator	Reconstructed Data		Official Data	
	Statistic	Description/ Source	Statistic	Description/ Source
Number of fishers	46,904 (128.6)	((Av. Crew * No. of Crafts) + 156 FF); This Survey & Frame Survey Data (2016)	43,653	(Lake Victoria Fisheries Organization (LVFO) (2016a, 2016b, 2016c, 2016d)
Av. Annual Landings (Metric Tons)	151,002 (1767.0)	(Catch per fisher per day* No. of Effective fishing days)	93,666	(Lake Victoria Fisheries Organization (LVFO), 2007)
Total Fishing Revenue (TFR) (USD '000')	USD 297,172,579.39 (2,674,359.0)	(Catch per fisher per day* Average sale price)	158,260,000	(Lake Victoria Fisheries Organization (LVFO) (2016a, 2016b, 2016c, 2016d)
Individual Fisher's Wage pa (USD)	USD 6335.76 (71.3)	(Crew Wages/ Average number of crew)	–	–
Boat Owner's Av. Income pa	USD 20,687.27 (312.8)	Gross Income per vessel	–	–

*FF-Foot Fishers.

This study has therefore established that published Kenyan fisheries statistics on Lake Victoria represent under-estimation of catch and value which misrepresents the true contribution of this small-scale fishery to Kenya's national income. Consequently, the government is limited by its prevailing official fisheries data collection methodology from implementing equitable taxation and licensing strategies which could further support management cost recovery for the fishery. This could lead to an unchecked fishing effort and abnormal recoup of profit in the fisheries by investors, without proportionate accompanying development of the sector.

5. Conclusions

This study has provided a new perspective with which to view the economic contribution of fishing activity in small-scale fisheries. Whereas fishers have been summarily viewed as 'poor' people (Béné & Friend, 2011; Mills et al., 2011b), this study leads us to interrogate whether the poverty relates to their earnings or the lack of a savings and investment culture among them, especially given that the fisher wage per capita places them above the poverty line of less than $1.90 a day (The World bank, 2020). Fisher wages in Lake Victoria have much prospects than even some levels of skilled labour in Kenya. In addition, investors, especially boat owners, realize relatively high returns amounting to three times what a fishing crew earns. What remains unanswered is whether there are adequate measures to promote re-investment of the economic rents in Lake Victoria Kenya's small-scale fishing industry given the minimal economic development witnessed at various fish landing sites and among fishers. This aspect however was beyond the scope of this study. Further, this study also makes a valuable contribution to literature on income and cost analysis for different fishing enterprises in small-scale fisheries of Lake Victoria, Kenya.

Based on the findings of this study, it is recommended that a review of the small-scale fisheries data collection methods and strategies which are used in obtaining official fisheries statistics be carried out in order to improve the accuracy of data collected to support fisheries management in Lake Victoria. It will also be important to expand the scope of this study in future in order to capture the dynamics of fish trade with regards to income and multiplier effects. It is clear that the fisheries sector has more economic benefits beyond the production level (Bagumire et al., 2018; Nyeko & Wiium, 2004; Odhone et al., 2020), and these

economic ripples need to be measured in order to estimate the real economic impact.

We recommend the following management interventions:

- A review of small-scale fisheries data collection methods and strategies which are used in obtaining official fisheries statistics in order to improve the accuracy;
- Expansion of the scope of this study in order to capture the dynamics of fish trade and its related income and multiplier effects. It is clear that the fisheries sector has more economic benefits beyond the production level (Bagumire et al., 2018; Nyeko & Wiium, 2004; Odhone et al., 2020), and these economic ripples need to be measured in order to estimate the real economic impact;

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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CRediT authorship contribution statement

Horace Owiti Onyango: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft. **Jacob Ochiewo:** Validation, Methodology, Writing – review & editing. **Christopher Mulanda Aura:** Data curation, Resources, Writing – review & editing. **Robert Kayanda:** Conceptualization, Resources, Supervision. **Sweenarain Soobaschand Sunil:** Conceptualization, Methodology. **Patrick Wanguche Otuo:** Investigation, Formal analysis. **Julia Akinyi Obuya:** Investigation, Formal analysis. **James M. Njiru:** Conceptualization, Project administration, Resources.

Declaration of competing interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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