Fishery Potential and Physico-Chemical Characteristics of Small Water Bodies in Narok and Nakuru Counties, Kenya

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Abstract

In 2022, this study assessed the fishery potential of Lake Solai, Kenyatta, Melelo, and Kikuyian Dams, incorporating fisheries data, environmental characteristics, and community perceptions on fishery development. Water quality parameters varied among the water bodies, with Kenyatta Dam recording lower temperatures (<17 °C). Dissolved oxygen levels remained consistently above 5 mg/L in all water bodies. Lake Solai yielded 36 fish, 24 Clarias gariepinus (catfish) and 12 Oreochromis niloticus (Nile tilapia), with a catch rate of 9 fish per hour. The mean sizes were 46.88±5.6 cm for catfish and 24.16±6.6 cm for Nile tilapia, with condition factors of catfish (0.65±0.13) and Nile tilapia (1.7±0.31). Kenyatta Dam had a lower catch rate of 3 fish per hour, with 14 Nile tilapia averaging 23.53±5.50 cm and a condition factor of 1.93±0.22. Melelo Dam had a higher catch rate of 14 fish per hour, with catfish averaging 30.41±10.12 cm and Nile tilapia 23.21±6.2 cm, with a condition factor for tilapia above 1. No fish were caught in Kikuyian Dam. Fish yield estimates ranged from 548.3 t/yr in Solai to 4.8 t/yr in Kenyatta Dam. Communities perceived fisheries as an income-generating activity, highlighting the potential of SWBs to support fish production and rural livelihoods if investments in sustainable management, capacity building, and infrastructure are prioritized.

Keywords: Condition Factor, Fish Catch Rates, Small Water Bodies, Water Quality Parameters, Fishery Potential

Introduction

Small water bodies (SWBs) are crucial components of the modern aquatic ecosystem, constituting a significant economic and environmental resource that provides numerous benefits to many countries, including Kenya. These SWBs are also the most abundant freshwater ecosystems and play a significant role in inland aquatic systems by contributing substantially to the global functioning of catchments, and modulating nutrient retention and recycling along the hydrological transport pathways (Sharpely *et al.* 2015). SWBs play a significant role in global fisheries and contribute notably to fish production in many African countries, supporting both wild capture and aquaculture activities (Aura *et al*. 2022; Bolpagni *et al*. 2019; Dugan, 2003). This is because they have a diverse ecological habitat, thus providing favorable conditions for fish reproduction due to their unique characteristic of confined nature and nutrient-rich environment (Aura *et al*. 2022; Bolpagni *et al.* 2019; Vanni *et al.* 2006).

For many years, particularly in developing countries, there has been a notable lack of emphasis on the development and management of fisheries in SWBs, including reservoirs and other smaller aquatic systems. These bodies of water have largely been overlooked and excluded from comprehensive fisheries management plans (European Commission 2008). However, with the declining trends in capture fisheries production from large lakes and rivers, there is a shift to emerging technologies and innovations such as cage culture, improved climate-smart methods, and investment in other production systems such as SWBs (Aura *et al.* 2023; Aura *et al.* 2022; Musinguzi *et al.* 2019). Currently, the restocking of SWBs has gained prominence as a prevalent method for enhancing fisheries production. The introduction of the tilapia species has proven to be highly successful in the development of fisheries in SWB worldwide. Various tilapia species have been effectively introduced into reservoirs across Africa, Asia, and South America, contributing to the positive growth and expansion of fisheries in these regions (FAO 2020; Paiva *et al*. 1994).

Numerous dams and small reservoirs exist in many developing nations, including Africa, holding substantial potential for fishery production. Leveraging these water bodies could bridge the gap and address the deficit in fish consumption, which currently stands at 10 kg/person/year nationally (FAO, 2020). Kenya is endowed with over 1000 SWBs, with various fish stocking regimes, especially with *Oreochromis niloticus* and *Clarias gariepinus* fish species. These species have gained considerable attention due to their adaptability to a range of environmental conditions and their ability to thrive in confined spaces (Abd El-Hack *et al*. 2022; Njiru *et al*. 2019). There is limited scientific data on the number, size, chemical status, and productivity of small water bodies in many regions, hindering effective fisheries management. Fish production in SWBS is generally affected by morphological, physical, chemical, and biological factors such as water body morphometry and physico-chemical characteristics (Shao *et al.* 2019).

Methods for estimating fish production in aquatic ecosystems vary from simple empirically derived estimators, such as the Morphoedaphic Index (MEI), to complex ecosystem simulation models (Leach *et al*. 2011). The MEI is a widely utilized empirical tool in fisheries science, calculated as the ratio of total dissolved solids (TDS) or conductivity to the mean depth of a water body (Mustapha, 2009). Its simplicity and ease of measurement make it particularly useful for assessing fish production across diverse lake environments, especially when data is limited. Despite limitations, including a tendency to overestimate yields in tropical and oligotrophic waters, a lack of sensitivity to biological factors, and insensitivity to seasonal changes, the MEI remains valuable in temperate lakes. Its general applicability allows for practical static estimates, and with appropriate region-specific adjustments or supplementary indices, it can provide useful insights into fish production potential across various aquatic ecosystems.

Despite the substantial number of SWBs in Kenya and the adoption of restocking practices, particularly with *Oreochromis niloticus* and *Clarias gariepinus,* there is limited scientific data on their fishery potential, especially regarding productivity estimates and the influence of physicochemical conditions. The absence of reliable information on their size, water quality status, and fish yield potential poses a challenge to sustainable fisheries planning and management. Additionally, environmental degradation, anthropogenic influences, and climate variability continue to alter the ecological balance of these ecosystems. Therefore, this study addresses the pressing need to evaluate the productivity and suitability of small water bodies for fisheries development in Kenya. Specifically, by assessing the fish yield potential using the Morphoedaphic Index (MEI), characterizing the water quality conditions, and incorporating community perceptions to provide a comprehensive understanding of the opportunities and challenges for enhancing fisheries in these underutilized systems.

Materials and Methods

Description of Study Areas

This research was conducted in two counties in Kenya-Nakuru County (encompassing Lake Solai and Kenyatta Dam) and Narok County (including Kikuyian Dam and Melelo Dam). These Small Water Bodies (SWBs) were selected based on their ecological diversity, differences in fishery development, and their importance to local livelihoods. The sites represent a gradient in terms of water body size, accessibility, and anthropogenic influence, allowing for a comparative assessment of environmental conditions and fisheries potential. These SWBs have experienced varied stocking regimes involving the introduction of *Oreochromis niloticus* and *Clarias gariepinus* through government initiatives, targeting the enhancement of capture fisheries.

Lake Solai

Lake Solai is a shallow alkaline lake located in a semi-arid region of the Eastern Rift Valley to the NE of Nakuru town along the Nakuru-Nyahururu road, approximately 50 km from Nakuru town. It lies between 0° 3' 39.636"N 36° 8' 56.5434"E at an elevation of 1667m ASL Crops/grassland and woodland/shrubland were the major land uses, covering 65% of the catchment (Koskei *et al*. 2019; De Bock *et al*. 2009). In 2020, the lake was restocked with 15,000 *O. niloticus* and 11,000 *C. gariepinus*.

Kenyatta Dam

Kenyatta Dam is located in Nakuru County, Kuresoi Sub-County, Nyota ward, located at 0°18'06.9"S 35°38'32.1"E. The major economic activity in the area is farming with a wetland surrounded by grassland, which makes it great to look for grassland birds. In the year 2020, the County Department of Fisheries of Nakuru County restocked 40,000 fingerlings (35,000 *O. niloticus* and 5,000 *C. gariepinus*).

Kikuyian Dam

Kikuyian Dam is located in Narok County located at 1° 3' 50.8968"S, 36° 8' 28.4172"E, in Narok East sub-county. The dam sits on private land of about 100 acres. It is used mainly by community members for cattle, domestic use, and small-scale farming. It was stocked with 4,500 *O. niloticus* and 500 *C. gariepinus* fingerlings in 2020.

Melelo Dam

Melelo Dam is located in Narok County, Narok South sub-county at 0°54'09.4"S 35°35'35.8"E. The area covered by the dam is 5 acres. In 2020, it was stocked with 4,500 *O. niloticus* and 500 *C. gariepinus* fingerlings.

Sampling, Sample Handling, Analysis

Sampling was conducted during the period from September 2022 and January 2023.

Water Quality Parameters

Assessment of water characteristics followed published standard methods for aquatic environmental studies (APHA, 2005). In situ physicochemical parameters (temperature, DO, TDS, pH, conductivity, turbidity, salinity) were measured using a HANNA portable meter."Water transparency measured as Secchi depth (SD) was undertaken using a standard Secchi disk of 20 cm diameter. Water samples (500 mL each) for total suspended solids (TSS), soluble reactive phosphate ($PO_4^{3-)}$, and nitrates (NO_{3-}) were collected using a Van Dorn water sampler at the surface. The water samples were then filtered and stored in polyethylene bottles under refrigeration at about 4°C for further laboratory analyses. In the laboratory, SRP filtrate was analyzed using photometric methods according to APHA (2005). Nitrates (NO3-) analyses were performed using the Palintest Photometer 7500 Bluetooth Method Wagtech Potalab +(C). Total suspended solids (TSS) were determined using the gravimetric method as described by APHA (2005). Chlorophyll-*a* (Chl-*a*) as a measure of levels of primary production was also measured by filtering with GF/C filters securely wrapped in aluminum foil before refrigeration at 4°C. Samples were then transported to the laboratory and analyzed according to methods adopted from APHA (2005).

The membrane filtration method was used in the microbiology analysis for total and fecal coliforms according to methods described by the US EPA (2002). Water samples were collected and analyzed in the field using a portable incubator test kit, Wagtech Potalab +(M). Total and fecal coliforms were detected and quantified using selective and differential culture media (Lauryl Sulphate Broth) for 24 hours at 37°C and 44.7°C for total coliforms and fecal coliforms, respectively. Sample volumes depended on the water turbidity of the sampled dam colonies. Discreet yellow colony-forming units developed after incubation were counted manually with the help of the membrane grids for interpretation.

Fisheries

Fish samples were collected using a fleet of 6-gill nets of various mesh sizes (knot to knot: 2, 3, 4, 5, and 6 inches). Each fleet was approximately 600m long, and the different mesh sizes were serially connected from the smallest to the largest mesh size. The nets were set and lifted after a soak time of four hours. At Melelo Dam, a seining method was also used to collect samples of fish due to the shallowness of the SWB.

Socioeconomic Survey

The survey was conducted at the four water bodies (Lake Solai, Kenyatta Dam, Kikuyian Dam, and Melelo Dam). A total of one hundred and twenty-one (N-121) respondents were interviewed using structured questionnaires, which were randomly administered to the members of the community living near each water body. The survey was conducted over four consecutive days (one day per site) between 9.00 am and 4.00 pm. Quantitative data were collected on community knowledge and perception regarding the fishery potential of these water bodies. Additionally, demographic information, including age structure, education level, gender, household number, and occupation, was gathered. The survey also captured community perceptive on fisheries-related aspects such as consumption preference, common fish species, the presence of fish in each dam, and local skills in fisheries. Furthermore, the study documented community-identified challenges likely to affect fishery development.

Data Analysis

The collected data were analyzed using Microsoft Excel. Descriptive statistics (mean ± standard deviation) were used to summarize water quality parameters and fish morphometrics.

The condition factor (K) was calculated according to Fulton's condition factor formula 1 (Froese 2006):

$$K = \frac{100 \, x \, W}{L^3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 1$$

Where W is the weight of the fish in grams, and L is the total length of the fish in centimeters.

The sex ratio was determined using the greatest common divisor method to express the proportion of males to females.

Carrying Capacity Using Morpho-Edaphic İndex (MEI)

Morpho-edaphic index (MEI)

The MEI was calculated according to the formula 2 below (Ryder *et al.* 1974):

$$MEI = Mean\ Conductivity / Mean\ Depth \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Potential fish yield (PFY)

Fish yield estimates were obtained using abiotic variables based on the chemical composition of the water body and the relationship in formula 3 below (Henderson and Welcomme 1974).

$$Y = 14.16\ MEI 0.4581 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where Y is the potential fish yield in kg ha-1 and MEI is the Morpho-edaphic index expressed in µS.cm-

Fish yield (FY)

Fish yield in t yr-1 was obtained by multiplying the potential fish yield in kg ha-1 by the area of the reservoir in hectares and converting it to tonnes per year.

Socioeconomic data collected through structured questionnaires were analyzed using descriptive statistics (frequencies, percentages, and means). These summarized respondents' demographic profiles (age, gender, education, occupation), fish consumption habits, knowledge, and perception of fishery potential, and community-identified challenges to fisheries development.

Results

Water Quality Parameters

The water quality parameters varied across the SWBs, with Kenyatta Dam recording low temperatures of <17 °C compared to the other water bodies (Table 1). Dissolved oxygen levels were above 5 mg. L^{-1} across all four SWBs, with high conductivity and salinity values observed at Lake Solai 4246.14±86 µs.cm^{-1} and 2.60 ppt, respectively. Kikuyian Dam recorded higher values of nitrates (NO_3-) with a mean of 0.21±0.41 mg. L^{-1}, while phosphates (PO_4^{3-}) were highest in Lake Solai with a mean of 7.92±3.09 mg. L^{-1}. Among the four water bodies, Lake Solai recorded the highest mean chlorophyll-a concentration (191.61 ± 24 µg·L^{-1}), which appeared substantially elevated compared to the others. In terms of depth, Kenyata Dam was relatively deeper with a mean depth of 5.7m compared to Lake Solai, Kikuyian Dam, and Melelo Dam. Water transparency was remarkably clear in Kenyatta Dam, with high values of secchi depth compared to Lake Solai and Melelo Dam, where the transparency was <1cm. All four SWBs recorded the presence of total coliforms, with high counts observed in Lake Solai (451 cfu/100ml). Fecal coliforms were only observed at Melelo Dam and Lake Solai with 122 cfu/100ml and 240 cfu/100ml, respectively (Table 2).

Table 1: Mean (±SD) values of water quality parameters in Lake Solai, Kenyatta Dam, Kikuyian Dam, and Melelo Dam during the study period.

TDS = Total Dissolved Solids; NO_3^- = Nitrates; PO_4^{3-} = Phosphates; Chl-*a* = Chlorophyll-*a*; TSS = Total Suspended Solids.

	SWBs			
Parameter	Lake Solai	Kenyatta Dam	Kikuyian Dam	Melelo Dam
Temperature (° C)	23.32±1.15	16.775±0.23	20.28±0.52	24.43±3.00
Dissolved Oxygen ($mg.L^{-1}$)	7.55±0.78	6.45±00	6.33± 0.22	8.00±1.01
Conductivity ($\mu s.cm^{-1}$)	4246.14±52	109.625±60.28	438.2±3.80	186.33±8.08
pH	9.19±0.40	8.70±0.19	8.52±0.03	9.13±0.13
TDS ($mg.L^{-1}$)	2537.34±86	80.5±64.35	219± 1.90	121.43±2.16
Salinity	2.60±0	0.06±0.04	-	0.09±0.00
NO^{3-} ($mg.L^{-1}$)	0.07±0.04	0.05±0.03	0.21 ± 0.41	0.04±0.03
$PO_4{}^{3-}$ ($mg.L^{-1}$)	7.92±3.09	0.3395±0.13	0.27 ±0.05	0.60±0.21
Chl-*a* ($\mu g.L^{-1}$)	191.61±24	8.245±10.60	6.43± 2.90	68.78±33.21
TSS ($mg.L^{-1}$)	1721.72±10	24.39±19.16	12.38± 21.77	345.83±55.19
Secchi (cm)	<1	121.815±123.5	25.6± 2.80	<1
Depth (m)	2.16±0.22	5.755±6.06	2.2± 0.88	2.25±0.85

Values represent mean ± standard deviation (SD). N = 3 replicates per site per parameter

Table 2: Levels of Total and Fecal coliforms in Lake Solai, Kenyatta Dam, Kikuyian Dam, and Melelo Dam expressed as cfu/100ml

SWBs	Total coliforms (cfu/100ml)	Fecal coliform (cfu/100ml)
Kenyatta Dam	142	0
Lake Solai	451	122
Kikuyian Dam	144	6
Melelo Dam	260	240

Fisheries

Lake Solai

A total of 36 fish were caught in Lake Solai, twenty-one (24) *C.gariepinus* (Catfish) and nine (12) *O.niloticus* (Nile tilapia). The catch rate was estimated at 9 fish/hr. The majority of the fish samples (80%) were caught on the western side of the lake. This skewed distribution could indicate the habitat preferences for both feeding and spawning activities. The mean sizes of *C. gariepinus* and *O. niloticus* were 46.88±5.6 cm and 24.16 ±6.6, respectively (Table 3). A large number (66%) of both species were caught using gillnets with mesh sizes of 3.5 and 6 inches. Of the total number of fish caught, 33 % were mature and spawning.

The condition factor indices for the two species were determined as 0.65±0.13 and 1.7±0.31 for Catfish and Nile tilapia, respectively.

Table 3: Descriptive Statistics for C. Gariepinus and O. Niloticus from Lake Solai

C. gariepinus			
Measure	Sample size	Range	Mean size (± SD)
Length (cm)	24	35.5 - 65	46.99 ± 5.6
Weight (g)	24	254 - 1185	685.9 ± 234.1
Condition factor (K)	24	0.2 - 0.9	0.65 ± 0.13
O. niloticus			
Length (cm)	12	13.5-23.5	24.16 ± 6.6
Weight (g)	12	37 - 980	308 ± 264.2
Condition factor (K)	12	1.26 - 2.35	1.7 ± 0.31

Kenyatta Dam

Twelve (14) Nile tilapia fish species were caught during the sampling period. The fish ranged from 20 cm to 40 cm, with the highest weight of fish measuring 1446g (Table 4). The catch rate in Kenyatta Dam was estimated at 3 fish/hr with a female-to-male ratio of 1:3. The condition factor (K), which indicates the overall health and well-being of the fish, ranged from 1.62 to 2.4, with a mean value of 1.93 ± 0.22, suggesting that the fish were generally in good condition.

Table 4: Descriptive Statistics for O. Niloticus in Kenyatta Dam

O. niloticus			
Measure	Sample size	Range	Mean size (±SD)
Length (cm)	14	20 - 40	23.53 ± 5.50
Weight (g)	14	148 - 1446	311 ± 348.9
Condition factor (K)	14	1.62 - 2.4	1.93 ± 0.22

Kikuyian Dam

No fish were caught during the sampling period despite the dam having been stocked with *O. niloticus* and *C. gariepinus* in the year 2020. The marked absence of fish samples from this dam might suggest the possibility of high predation or mortality due to environmental factors.

Melelo Dam

A total of 28 fish were recorded in three hauls within two hours during the sampling period. The catch rate was estimated at 14 fish/hr, indicating moderately higher stock density. Ranges of fish size (total length) were 12 – 32 cm and 17 – 49 cm for *O. niloticus* and *C. gariepinus,* respectively (Table 5). The result of the condition factor for *O. niloticus* was K> 1, indicating the well-being of O. *niloticus* (Table 4). However, the sex ratio of female to male for *O. niloticus* in Melelo Dam was 1:2 despite the good condition factor.

Table 5: Descriptive Statistics for (A) C. Gariepinus And (B) O. Niloticus in Melelo Dam

C. gariepinus			
Measure	Sample size	Range	Mean size (±SD)
Length (cm)	16	17 - 49	30.41 ± 10.12
Weight (g)	16	30 - 857	285.38 ± 278.40
Condition factor (K)	16	0.56 - 1.01	0.71 ± 0.11
O. niloticus			
Length (cm)	12	12 - 32	23.21 ± 6.2
Weight (g)	12	28 - 700	291.83 ± 211.6
Condition factor (K)	12	1.16 - 2.16	1.87 ± 0.29

Potential Fish Yield

The potential fish yield estimate for Lake Solai was higher (456.91 kg ha^{-1}) than that of the other three water bodies. This translates to an annual fish yield of 548.30 tons, highlighting the exceptional productivity of Lake Solai (Table 6). Despite its larger size relative to Melelo Dam, Kenyatta Dam had a lower (PFY) compared to Melelo Dam.

Table 6: Potential Fish Yield (PFY) and Fish Yield (FY) in the Small Water Bodies

SWB	**(PFY) kg ha^{-1}**	**(FY) t yr^{-1}**
Solai	456.91	548.30
Kenyatta	54.60	4.80
Kikuyian	160.08	16.01
Melelo	107.09	0.54

Socioeconomic Survey

Demographic Characteristics of the Community

Table 7 presents demographic data from four water bodies, revealing a predominance of male respondents across all sites, with the highest proportion in Kenyatta Dam (73.8%) and the lowest in Kikuyian Dam (56.3%). The majority of participants were aged between 18–45 years, and most were married. Educational attainment varied, with primary and secondary levels being most common, while farming was the dominant occupation, particularly in Kikuyian and Kenyatta Dams.

Table 7: Summary of Demographic Information of the Respondents in the Four Water Bodies

Variable	Lake Solai (n=39)	Kenyatta Dam(n=42)	Kikuyian Dam (n=16)	Melelo Dam (n=24)
Gender				
Female (%)	41	26.2	43.8	29.2
Male (%)	59	73.8	56.3	70.8
Age				
18–35	56.4	40.5	31.3	37.5
36–45	28.2	40.5	25	37.5
46–55	12.8	9.5	37.5	20.8
>55	2.6	9.5	6.3	4.2
Marital status				
Single	38.5	31	6.3	8.3
Married	59	61.6	81.3	91.7
Separated/Divorced	2.6	4.8	6.3	-
Widowed	-	2.4	6.3	-
Education level				
Primary	33.3	46.3	50	66.7
Secondary	46.2	48.8	37.5	16.7
College Certificate	10.3	2.4	6.3	12.5
Diploma	5.1	-	0	4.2
Graduate	5.1	2.4	6.3	-
Household members				
1–4	51.3	57.1	46.7	37.5
5–7	23.1	19	40	25
>7	25.6	23.8	13.3	37.5
Occupation				
Farmers	23.1	61.9	68.8	54.2
Business/Trade	30.8	21.4	18.8	33.3
Students	5.1	7.1	6.3	-
Teachers/Admin/Other	23.0	9.6	6.3	12.5

Community Perception/Knowledge of Fish and Fisheries Activities

The survey findings reflect varying levels of fish exposure among communities near the four water bodies. A high percentage of respondents around Kenyatta Dam (95.2%) and Lake Solai (94.9%) reported having tasted fish, followed by Melelo Dam (79.2%), while Kikuyian Dam had the lowest at 68.8% (Table 8). Despite limited technical skills in fisheries, a significant proportion of respondents across all sites expressed interest in engaging in fishery activities as a potential source of income (Table 8).

Table 8: Community Experience and Perceptions on Fisheries in Selected SWBs

SWBs	N	Tasted fish (%)	Perceive Fisheries as Income-Generating (%)	Perceive Fisheries as Income-Generating (%)
Solai	39	94.9	97.4	98.4
Kenyatta	42	95.2	78.04	79.04
Melelo	24	79.16	98	99
Kikuyian	16	68.8	91.6	92.6

Across all four water bodies, a high proportion of respondents expressed interest in fisheries-related training, with the highest in Melelo Dam (100%) and the lowest in Kenyatta and Kikuyian Dams (87.5%). Fish farming was the most preferred training area, particularly in Kikuyian (71.4%) and Melelo (60.8%), while interest in value addition and fishing techniques was also reported to varying degrees. Most respondents preferred stocking with a combination of tilapia and catfish, especially in Lake Solai (84.6%) and Kikuyian Dam (80.0%), though some were undecided or mentioned other species such as Omena and

Table 9: Community Training Interests and Stocking Preferences Across SWBs

Water Body	Training Interest (%)	Main Training Areas (%)	Stocking Preference (%)
Solai	94.9	Fish farming (51.4)	Tilapia + Catfish (84.6)
		Fishing techniques (29.7)	Omena (5.1)
		Value addition/marketing (13.5)	Undecided (10.3)
Kenyatta	87.5	Fish farming (45.2)	Tilapia + Catfish (79.5)
		Fishing techniques (25.8)	Nile perch + Omena (5.1)
		Not aware (22.5)	Undecided (15.4)
Kikuyian	87.5	Fish farming (71.4)	Tilapia + Catfish (80.0)
		Marketing (14.2)	Undecided (20.0)
		Fishing and processing (14.2)	
Melelo	100	Fish farming (60.8)	Tilapia + Catfish (77.3)
		Fishing techniques/harvesting (13.0)	Undecided (22.7)
		Not aware (13.0)	

Respondents' Perceived Challenges to Fishery Development

The main challenges reported across the sites varied, with marketing, fishing gears and methods, and capital investment emerging as the most frequently cited concerns, particularly in Solai and Kenyatta Dam. Security matters were high in Kenyatta (22.8%) and Melelo (15%), while cultural beliefs were more pronounced in Kikuyian (19.15%) and Melelo (15%). Less common but still relevant issues included overfishing, pollution, drought/climate change, and lack of government support, with several challenges being site-specific or marginally reported (Table 10).

Table 10: Respondents' Perceived Challenges to Fishery Development in Selected SWBs (%).

Challenge	Solai (%)	Kenyatta (%)	Kikuyian (%)	Melelo(%)
Marketing	21.6	5.3	21.3	13.3
Fishing Gears & Methods	21.6	21.0	12.8	10.0
Capital investment	19.3	22.8	12.8	16.7
Cultural beliefs	12.5	7.0	19.2	15.0
Security matters	6.8	22.8	6.4	15.0
Lack of knowledge	5.7	-	-	-
Time investment	4.5	1.8	2.1	-
Overfishing	3.4	-	-	-
Drought/Climate change	2.3	3.5	4.3	11.7
Ownership issues	1.1	3.5	-	6.7
Pollution	1.1	1.8	-	-
Fish processing	-	3.5	12.8	5.0
Cold weather	-	3.5	-	-
Management	-	1.8	-	-
Lack of government support	-	1.8	-	-
Not aware	-	-	4.3	-
Odour	-	-	2.1	-
Infrastructure	-	-	-	5.0
Predators	-	-	-	1.7
None	-	-	2.1	-

(–) indicate that no respondents reported the challenge

Discussion

The elevated chlorophyll-a concentrations observed in Lake Solai are likely to be influenced by factors such as temperature, light availability, and nutrient inputs. High temperatures may have promoted algal growth, leading to elevated chlorophyll-*a* concentrations. The fluctuations in chlorophyll-*a* concentrations may also be linked to nutrient dynamics in the lake. Runoff from surrounding agricultural areas might have introduced higher nutrient loads, contributing to increased algal biomass. The findings of this study align with previous research on freshwater systems, which highlight the seasonal variability of chlorophyll-a concentrations driven by fluctuations in temperature, light, and nutrient availability (Schagerl & Oduor, 2007). In Kikuyian Dam, elevated nitrate concentrations are likely linked to anthropogenic land use changes, particularly deforestation and intensive farming practices observed during the study. Such practices often involve the extensive use of nitrogen-based fertilizers, which contribute to nutrient runoff into adjacent water bodies. Similar trends have been reported in western Kenya, where agricultural land use was positively correlated with high nitrate levels in surface waters (Aura *et al.* 2023; Nyilitya *et al.* 2020). The resulting nutrient enrichment may pose ecological risks, including eutrophication, reduced water quality, and potential harm to aquatic biodiversity. The high electrical conductivity observed in Lake Solai is likely due to the cumulative effect of reduced inflow and continuous evaporation has led to the buildup of salinity and dissolved ions in Lake Solai, making it a closed system with high electrical conductivity (Bock *et al.* 2009).

Physicochemical water parameters in Lake Solai, Kenyatta Dam, Kikuyian Dam, and Melelo Dam generally fell within tolerable ranges for fish growth. Key indicators such as pH and soluble reactive phosphates aligned with recommended values for aquaculture (Ross *et al*. 2000; Boyd, 2015). Although Kenyatta Dam recorded lower temperatures compared to regional benchmarks like Lake Naivasha and Lake Nakuru, the observed mean temperature of 20 °C and dissolved oxygen (DO) levels exceeding 6 mg/L still indicate suitable conditions for fish development (Rairat *et al*. 2022; Makori *et al*. 2017; El-Sayed & Kawanna, 2008). These DO values are consistent with findings from small water bodies in central and western Kenya, where DO ranged between 5.5 and 7.2 mg/L (Aura *et al*. 2023), further supporting the suitability of these environments for fish growth. However, Melelo Dam exhibited elevated levels of fecal coliforms. This is likely due to its relatively small size and the unrestricted access by livestock observed during the study. Such contamination can compromise fish health by increasing the risk of infections and disease outbreaks, potentially affecting fish population sustainability (Ziarati *et al*. 2022).

The catch rate at Lake Solai was considered low compared to other fisheries waters, such as Lake Naivasha, Nakuru, and Baringo, an indication of low stock density in the lake. *Clarias gariepinus* had a condition factor (K<1) in Lake Solai and Melelo Dam, indicating a stressed population. Such conditions can be influenced by limited food resources, parasitic infestation, fluctuating environmental conditions, and fishing pressure (Haberle *et al*. 2023; Getso *et al.* 2017). Despite the stressed population of *C. gariepinus*, there's an opportunity for reproductive success in Melelo Dam, as indicated by a balanced female-to-male sex ratio. In contrast, *O.niloticus* in Lake Solai, Kenyatta Dam, and Melelo Dam generally exhibit good health conditions (K > 1). The favorable performance of Nile tilapia in Melelo Dam, attributed to high mean temperatures, aligns with studies suggesting an optimum temperature range for tilapia growth (El-Sayed and Kawanna 2008; Mutie *et al*. 2022). For instance, a recent invasion of *O. niloticus* in Lake Nakuru, despite the high salinity levels, has had a high abundance of fish biomass growth due to favorable temperature conditions. The low number of fish caught in Kenyatta Dam indicates low stock abundance, probably due to poor reproductive success, which was evidenced by the sex disparity in the sex ratio.

The prime prerequisite for sound and sustainable fisheries management is to evaluate the fish yield potential of any reservoir for resource planning quantitatively. The estimated fish yield in Kenyatta Dam, Kikuyian Dam, and Melelo Dam (<30 t) was comparable to other Dams mainly found in the western region of Kenya. This low yield could be due to environmental, anthropological, limnological, and biological factors. Lake Solai is a larger water body compared to the other three, which offers significant potential for supporting a diverse range of fish species and habitats. Despite its relatively small size, Kenyatta Dam may still offer opportunities for local fisheries and recreational angling. However, its limited carrying capacity necessitates careful management to prevent overexploitation and maintain ecosystem integrity. On the other hand, Kikuyian Dam presents a balance between resource availability and environmental sensitivity. Fisheries management strategies should emphasize sustainable harvest practices, habitat restoration, and stakeholder engagement. Melelo Dam may have limited potential for supporting large-scale fisheries, but could still play a valuable role in local biodiversity conservation. Given its low carrying capacity, management efforts would prioritize habitat protection, pollution control, and species conservation. Other water bodies with similar carrying capacity in the region to Lake Solai (Nakuru County) are Kiserian (522.95 t, Kajiado County) and Chinga (396.90 t, Nyeri County) as reported by Aura *et al*. 2022.

The survey results highlighted differing levels of familiarity and engagement with local fishery activities across the four water bodies. Kenyatta Dam and Lake Solai demonstrated high percentages of respondents who have tasted fish, indicating a robust fishery presence and significant community participation in fishing activities. Conversely, Melelo and Kikuyian Dam exhibited slightly lower percentages of respondents who have tasted fish compared to Kenyatta Dam and Lake Solai. This disparity of community encountered may suggest barriers to access or consumption, potentially influenced by factors such as the older demographic, a stronger focus on agriculture rather than fishing, limited fishery resources, or lower promotion of fish consumption in these areas. Across Lake Solai, Kenyatta Dam, Kikuyian Dam, and Melelo Dam, respondents' strong interest in receiving training in fisheries activities, particularly fish farming and fishing techniques. The community's preference for stocking the water bodies mainly with tilapia or a combination of tilapia and catfish reflects a community's desire for sustainable fishery management. There is also a need for targeted training programs to improve local capacities and promote sustainable fishery practices in these areas. These findings have significant policy implications, particularly in the context of Kenya's national fish consumption deficit. Small Water Bodies (SWBs), despite their size, offer valuable opportunities for decentralized, climate-resilient food production. Strategic investment in the management and development of SWBs can enhance local fish supply, reduce reliance on imports, and contribute to national food and nutrition security goals under Kenya's Blue Economy and Vision 2030 frameworks.

Conclusion

The physicochemical water parameters recorded in the four Small Water Bodies (SWBs) indicate favorable conditions for fish growth and production. The estimated fish yields further underscore the potential of these ecosystems for increased investment and integration into mainstream fisheries production to advance blue growth initiatives. Despite some community-level challenges, there is strong local interest in engaging with fisheries activities and a clear demand for sustainable management practices. Unlocking this potential will require targeted capacity building, infrastructure development, and enabling policy frameworks that support community participation. By promoting the sustainable utilization of SWBs, Kenya can not only address its national fish consumption deficit but also strengthen climate-resilient food systems and enhance rural livelihoods.

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