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KENYA Aquatica

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KMFRI

Editorial

Editorial: Kenya Aquatica Journal Vol 10(1) – *A Showcase of KMFRI's Pioneering Research in Freshwater Ecosystems*

The latest edition of Kenya Aquatica Journal, Vol 10(1) showcases pioneering research by KMFRI scientists on Kenya's freshwater ecosystems. This edition, supported by KMFRI and WIOMSA, covers ecological, socio-economic, and environmental challenges, providing valuable insights into sustainable management practices.

One notable study investigates disease surveillance and antimicrobial resistance in fish from lacustrine caged farms, emphasizing responsible antibiotic use to maintain fish health. Another study explores the impact of organochlorine pesticides on macroinvertebrates in Lake ecosystems, advocating for Rhagovelia spp. as a bioindicator for pesticide monitoring across food webs.

Research on Lake Baringo's small-scale fishery assesses the catch and effort composition, stressing the need for regulatory enforcement to avoid overfishing and advocating for capacity building among stakeholders for sustainable management. Additionally, a study on wild fish kills in Lake Victoria focuses on eutrophication and pollution, recommending integrated watershed management to protect the lake's fisheries and local livelihoods.

A comprehensive study on Lake Elementaita – one of Kanya's flamingos' sanctuaries, combines water quality, fisheries studies, and community surveys, calling for integrated watershed management, conservation, and sustainable agriculture. Research on fisheries co-management in Lake Baringo highlights the importance of local community involvement and sustained achievements in ecosystem management, despite challenges in law enforcement.

An article on the socio-economic dynamics of Lake Victoria proposes establishing a regulatory framework incorporating citizen science to manage the lake's resources for long-term sustainability. Addressing plastic pollution in Lake Turkana, a study recommends waste management solutions, public awareness, and better enforcement of regulations to tackle the issue.

The journal also features research on antimicrobial resistance (AMR), with a review exploring Kenya's aquatic biodiversity for potential novel antimicrobial agents. A genetic research study evaluates freshwater fish populations, identifying gaps and proposing future directions for conservation and management.

Lastly, the journal presents an evaluation of fish market dynamics in Lake Naivasha, recommending infrastructure development like fish markets and hatcheries to support the region's fishery sector.

This edition of Kenya Aquatica Journal provides crucial insights into Kenya's freshwater ecosystems, covering a wide range of research on sustainable management, environmental challenges, and the socio-economic factors influencing aquatic resources. The research highlights KMFRI's ongoing contributions to understanding and addressing these issues, fostering a deeper understanding of Kenya's aquatic biodiversity.

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About Kenya Aquatica

Kenya Aquatica is the Scientific Journal of the Kenya Marine and Fisheries Research Institute (KMFRI). The aim of the Journal is to provide an avenue for KMFRI researchers and partners to disseminate knowledge generated from research conducted in the aquatic environment of Kenya and resources therein and adjacent to it. This is in line with KMFRI's mandate to undertake research in "marine and freshwater fisheries, aquaculture, environmental and ecological studies, and marine research including chemical and physical oceanography", in order to provide scientific data and information for sustainable development of the Blue Economy.

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Submitting Articles

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Featured front cover picture: Researcher sampling surface plankton in the Kerio River inlet to Lake Turkana. (Photo credit: Mr. John Malala)

Featured back cover picture: Chair of KMFRI Board of Management Amb. Dr. Wenwa Akinyi Odinga Oranga (seated middle), on her right, Ag. KMFRI CEO Dr. James Mwaluma, flanked by KMFRI Heads of Sections: Front (L-R) Dr. Victoria Tarus, Ms Caroline Mukiira, Dr. Jacob Ochiewo, Dr. Irene Githaiga, Mr. Abraham Kagwima. Back (L—R) Mr. Paul Waluba, Ms Jane Kiguta, Dr. Gladys Okemwa, Dr. Eric Okuku, Dr. Joseph Kamau, Mr. Isaac Kojo, Ms Joan Karanja, Mr. Milton Apollo. (Photo credit KMFRI)
Research Vessel MV Mtafiti in the background

Water quality, ecology of Magadi Tilapia (*Alcolapia grahami*), and socio-economic dynamics in the protected wetland of Lake Elementaita, Kenya

Alice Mutie*, Edna Waithaka, George Morara, Patrick Loki

Kenya Marine and Fisheries Research Institute, P.O Box 837- 20117, Naivasha, Kenya

***Corresponding Author:** amutie@kmfri.go.ke

Abstract

Lake Elementaita is a protected wetland in Kenya that serves a vital ecological function while also supporting local socio-economic activities. This study assessed its water quality, the ecology of *Alcolapia grahami*, and the socio-economic factors influencing its conservation and management. An integrated approach incorporating water quality assessments, fisheries studies, and community surveys was employed to provide a comprehensive understanding of the Lake's ecosystem. The findings revealed that Lake Elementaita experiences wide temperature variations (21°C – 43°C) and high dissolved oxygen levels of up to 16.9 mg L^{-1}. The mean total dissolved solids (8076 mg L^{-1}) and electrical conductivity (15,292.8 µS cm^{-1}) were high. Despite low nitrate (0.03 mg L^{-1}) and phosphate levels (0.09 ± 0.05 mg L^{-1}), chlorophyll-a levels (33.48 mg L^{-1}) were high, indicating substantial phytoplankton biomass in the Lake. Fisheries assessments highlighted the ecological resilience of *Alcolapia grahami*, with population structure analyses showing varying catch rates and an average yield of 0.9 kg hr^{-1}. Length-frequency data indicated positive allometric growth ($b > 3$), suggesting favourable environmental conditions for the species. Additionally, the species exhibited a relatively balanced sex ratio (F:M = 0.92:1). Community surveys revealed a strong socio-economic connection between local communities and the Lake, with frequent engagement in birdwatching and tourism. To enhance the long-term sustainability of Lake Elementaita's water quality, fisheries, and socio-economic activities, the study recommends integrated watershed management, soil conservation, riparian buffer zones, public awareness campaigns, tree planting, and sustainable agricultural practices.

Keywords: water quality, *Alcolapia grahami*, fisheries, socio-economic dynamics, Lake Elementaita, wetland conservation

Introduction

Nestled in the Eastern arm of the Great Rift Valley within Nakuru County of Kenya, Lake Elementaita emerges as a prominent feature, characterized by its shallow, saline waters. Fed by a network of rivers including the Mbaruk, Chamuka, and Mereroni, with the Mereroni River playing a significant role due to Rift Valley faulting dynamics (Githae, 1998). This Lake also receives contributions from hot springs in its Southeastern region and subsurface flows from Lake Naivasha (Muno, 2002). However, the variability in water levels, sometimes leading to the drying up of both the Lake and its feeder rivers (Murimi *et al.*, 1993), underscores the dynamic nature of this ecosystem.

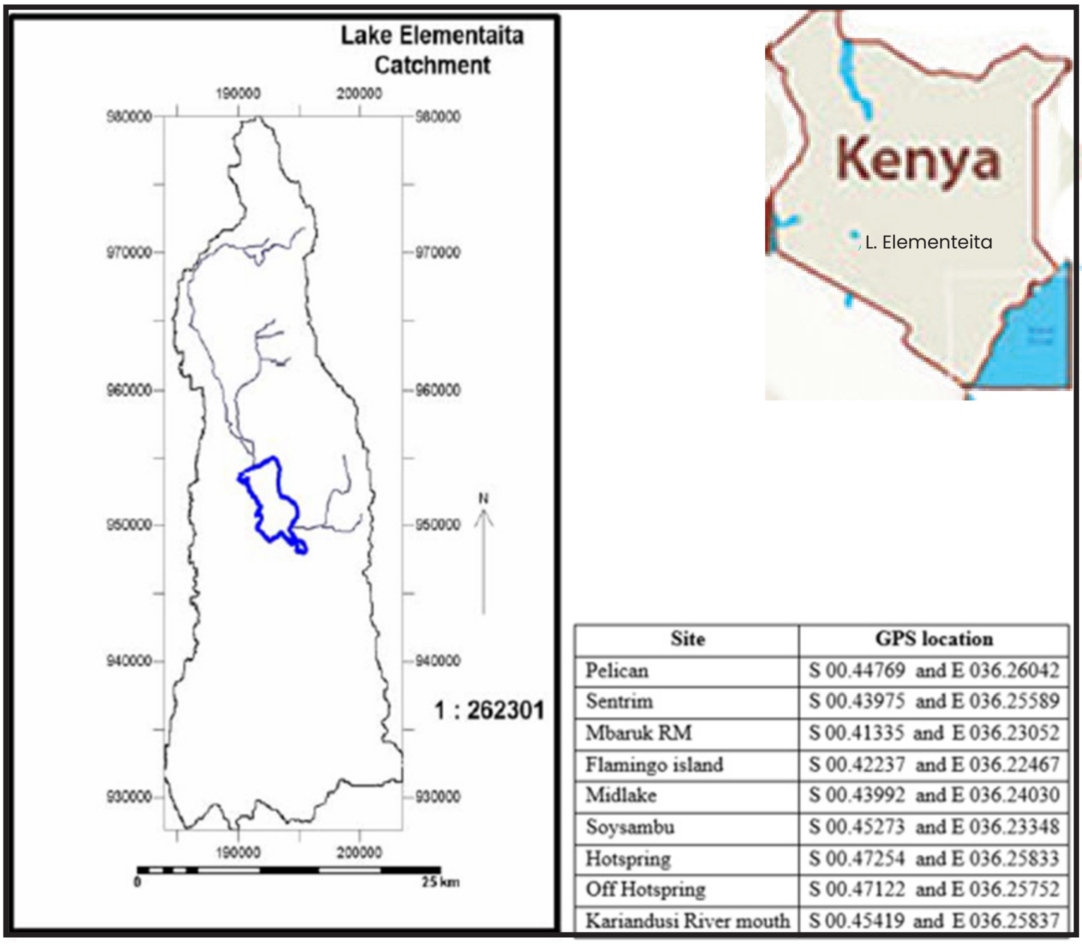
Lake Elementaita is not only a geographical feature but also a vibrant ecosystem, supporting a diverse array of flora and fauna. Its significance is exemplified by its role as a habitat for the pink-backed pelican breeding grounds and a feeding area for the lesser flamingo, which thrives on the blue-green algae *Arthrospira filiformis*. Moreover, human activities such as salt harvesting, game viewing, small-scale farming, and livestock rearing are intricately woven into the fabric of this ecosystem, potentially influencing its water quality and overall ecological health. In the late 1950s, *Alcolapia grahami* fish species was introduced into Lake Elementaita for mosquito control purposes. This species is adapted to the extreme conditions of highly alkaline waters and has thrived in various Rift Valley lakes, often becoming a dominant fish species (Wood *et al*., 2016; Maina *et al*., 2019). Lake Elementaita has drawn attention not only for its ornithological spectacle but also for its diverse vegetation. Acacia and Euphorbia trees dot its landscape alongside various bush and grassland species, although extensive deforestation and land use changes threaten these natural habitats.

The ecosystems of lakes like Elementaita are profoundly influenced by both natural processes and human activities. As societies become more interconnected with their environments, understanding this complex interplay becomes crucial (Mwendwa *et al*., 2015). Researchers such as Berkes and Folke (1998) advocate for integrating social and ecological systems to enhance resilience and sustainability. Carpenter (2008) stresses the importance of scientific knowledge in managing ecosystem services and promoting responsible stewardship. In the face of escalating human population, urbanization, and industrialization, lakes like Elementaita are under increasing pressure. This situation underscores the need for a comprehensive understanding of how ecological dynamics and human behaviors interact. Such understanding is essential for steering practices toward sustainability and ensuring the resilience of these ecosystems. Therefore, this study aimed to explore the interactions between ecological processes and human activities in Lake Elementaita, with the goal of providing insights for effective conservation and management by evaluating water quality, fish stock status, and socio-economic factors.

Materials and methods

Study area

Lake Elementaita is situated in Nakuru County, Gilgil Sub County, and lies between 0°27′ S and, 36°15′ E. Gilgil has a population of 152,102 with Kekopey Centre hosting a population of 15,624 (KNBS, 2009). It lies on the Eastern floor of the Great Rift Valley in Kenya. Geographically, it is surrounded by Nyandarua Hills to the Northeast and Eburru Hills to the South. The Lake is 1,772 m above sea level and is served by rivers Meroronyi, Mbaruk, and Kariandusi (Fig. 1).



Site	GPS location
Pelican	S 00.44769 and E 036.26042
Sentrim	S 00.43975 and E 036.25589
Mbaruk RM	S 00.41335 and E 036.23052
Flamingo island	S 00.42237 and E 036.22467
Midlake	S 00.43992 and E 036.24030
Soysambu	S 00.45273 and E 036.23348
Hotspring	S 00.47254 and E 036.25833
Off Hotspring	S 00.47122 and E 036.25752
Kariandusi River mouth	S 00.45419 and E 036.25837

Figure 1. Map of Lake Elementaita and the GPS points of study's sampling points (Modified from Adeka, et al., 2008).

Data collection

This study was conducted in October 2023. The study employed a mixed-methods approach, combining ecological field surveys, and socio-economic surveys. Quantitative data was gathered through water quality measurements, fisheries assessments, and socio-economic surveys.

Ecological Assessment

The *in situ* measurement of physicochemical parameters, including temperature, dissolved oxygen (DO), total dissolved solids (TDS), pH, conductivity, turbidity, and salinity, were taken using a portable multi parameter water quality meter. Transparency was measured with a Secchi disk. Water samples for nitrates, phosphates, chlorophyll-a (Chl-*a*), and total suspended solids (TSS) measurements were collected using a Van Dorn sampler and transferred into 1 L polyethylene bottles. The samples were then stored in cooler boxes at a temperature of approximately 4ºC pending further analysis in the laboratory. Chemical analyses for dissolved nutrients were carried out using photometric methods according to APHA (2005) standards. Samples for soluble reactive phosphorus (PO_4^{3-}) were filtered using 0.45 mm membrane filters, and the filtrate was analyzed using the molybdate assay method (APHA, 2005). Nitrate (NO^{3-}) analyses were performed using the palintest photometer 7500 bluetooth method. For the determination of Chl-a, water samples were filtered through glass fiber filters and extracted in 90% acetone. Chl-a concentration was measured in a 1 cm length cell at the absorbencies of 665 and 750 nm, respectively, using a spectrophotometer according to Pechar (1987). Total suspended solids (TSS) were determined using the gravimetric method as described by APHA (2005).

The membrane filtration technique was used to determine levels of coliforms. At each station, a sterile water sampling cup was used to collect surface water. Water samples were vacuum-filtered through 47 mm membrane filters with 0.45 mm porosity, trapping coliforms on the filter surface. The filter was then transferred into a petri dish containing an absorbent pad soaked in M-lauryl sulfate broth media and incubated for 24 hours at 37ºC and 44.7ºC for total coliforms and fecal coliforms respectively. Discreet yellow colony-forming units developed after incubation. They were counted manually with the help of the membrane grids for interpretation (US EPA, 2002).

Fisheries

Fish samples were collected using both multi and monofilament gill nets of various mesh sizes ranging from 2 - 4. The nets were set and lifted after 22 hours. Seines were also deployed (set of three seine with 3 hauls of 15 mins. Fish caught by the various nets were removed and sorted. The total length (TL), standard length (SL), and body depth (BD) for each fish caught was measured in millimetres while body weight was measured in grams. All fish samples were dissected and their gonads were examined for sex and maturity stages according to a classification modified by Lagler (1978).

Socio-economic Survey

Data collection was through a mixed sampling approach with structured questionnaires randomly administered to the community living in the vicinity of Lake Elementaita (n = 50). Quantitative data was collected on the community's Lake usage, conservation, ecosystem services, livelihoods, governance, and management of the Lake. Other aspects investigated included communication and awareness of management aspects of the Lake. Data on the demographic characteristics of the community was also collected.

Data analyses

Descriptive statistics were used to analyze water quality parameters, including measures of central tendency (means, standard deviations) to summarize key physicochemical variables. Fish size (total length, TL, cm) was analyzed using length-frequency plots to visualize size distribution, while the length-weight relationship was determined using the regression equation by Wootton (1990). The condition factor (K) was calculated using Fulton's formula (Froese, 2006) to assess fish health. For the socioeconomic survey, descriptive statistics such as frequencies and percentages were used to analyze demographic data, ecosystem services provided by Lake Elementaita, major activities around the Lake, and challenges affecting respondents' livelihoods. Responses on proposed measures for Lake conservation and community benefits were categorized into common themes for qualitative insights. All data were entered and processed using Microsoft Excel.

Results and discussion

Ecological Assessment

The average depth of Lake Elementaita was 0.65 m, with the deepest point being at the Midlake section. The Lake exhibited wide temperature ranges, spanning from 21°C to 43°C, with the highest temperatures recorded at the Hotspring point (Table 1).

The mean dissolved oxygen (DO) recorded was 12.99 ± 6.49 mg L^{-1} indicating adequate oxygen saturation to support aquatic life. Total dissolved solids values were high across all sampling stations with a high of 12704.0 ± 5352.53 mg L-1 at Soysambu. This high TDS values in all sites could be associated with high concentrations of dissolved minerals as a result of volcanic activities and high evaporation rates experienced in the Lake (Ondiere, *et al.,* 2017). Electrical conductivity levels were also high with mean value of 15292 ± 7265 µS cm^{-1} (Table 1). These recorded values are lower than values (39000 µS cm^{-1}) recorded by Odour and Schagerl (2007) and 61500 µS cm^{-1} Njenga (2004). This variation could be attributed to the dilution effect of the recent lake level rise of Rift Valley lakes. Heavy rainfall can also lead to runoff from surrounding land, carrying sediment, organic matter, and nutrients into the lake.

High levels of chlorophyll-a (Chl-a) concentrations were observed in Lake Elementaita, with mean values of 33.48 ± 13.01µg L^{-1}, indicating significant algal biomass in the Lake (Table 2). This is supported by the observed large number of lesser flamingo that feed on the *Spirulina*. Various factors, including nutrient availability, temperature, light availability, and water column stability could also contribute to the high concentrations (Schagerl *et al.*, 2015). The mean concentration of total suspended solids was 190.81 ± 90.76. These levels are above the permissible limits of the United States Environmental Protection Agency (US EPA) of < 30 mg L^{-1}.

Table 1. Physicochemical variables in Lake Elementaita. (Temp -Temperature; EC- Electrical conductivity; DO- Dissolved oxygen; TDS-Total dissolved solids; ORP- Oxidative reduction potential; SD - standard deviation) during sampling period.

Site	Depth (m)	Temp. °C	EC (µS/cm)	DO (mg/L)	pH	TDS (mg/L)	Salinity (ppt)	Turbidity (mg/L)	Secchi depth (cm)	Pressure (mm/Hg)	ORP (mv)
Pelican	0.7	25.35	18955.00	16.9	9.5	12216.8	11.1	317	8.0	594.5	47.3
Sentrim	1.0	23.50	18345.00	16.9	9.8	12232.5	11.2	276	7.25	594.5	32.4
Mbaruk RM	0.9	28.10	19645.00	19.6	10.0	12028.0	11.9	308	7.5	593.3	31.4
Flamingo Island	0.7	25.10	19290.00	16.6	9.9	12525.0	11.4	298	13.5	593.0	36.0
Midlake	1.2	21.85	17915.00	7.6	10.0	12398.8	11.4	276	10.0	592.7	44.8
Soysambu	1.0	21.40	18245.00	11.6	9.7	12704.0	11.6	286	9.0	595.5	27.2
Hotspring	0.07	43.10	4770.00	2.6	9.5	23.0	1.8	1.7	-	595.1	14.1
Off Hotspring	0.49	28.50	19910.00	20.0	9.9	12122.5	11.0	303	7.6	594.5	37.0
Kariandusi RM	0.01	26.30	560.00	5.2	8.3	357.5	0.3	38.7	-	593.9	82.9
MEAN	0.65	27.02	15292.78	12.99	9.60	9623.11	9.07	233.82	8.97	594.09	39.23
SD (±)	0.39	6.52	7265.86	6.49	0.53	5352.53	4.58	122.25	2.22	0.96	19.05

Table 2. Mean values of Chl-*a*-Chlorophyll-*a* (µg L^{-1}) and TSS - Total suspended solids (mg L^{-1}).

Site	Chl-*a* (µg L^{-1})	TSS (mg L^{-1})
Pelican	41.4	238
Sentrim	37.5	248
Mbaruk RM	37.8	242
Midlake	37.6	160
Soysambu	38.8	241
Hotspring	3.5	23.5
Kariandusi RM	27.5	92
Off Hotspring	43.9	282
Flamingo Island	-	250
Mean	33.48	190.81
SD (±)	13.01	90.76

Results of nitrates during the sampling period was 0.03 mg L^{-1}, suggesting a relatively low input of nitrogen-containing compounds into the lake (Table 3). Nitrogen is an essential nutrient for phytoplankton growth, and its availability can influence Chl-a concentrations and overall ecosystem productivity. The limited nitrate input may indicate a lower potential for nitrogen-driven eutrophication compared to lakes with higher nitrate levels. On the other hand, the average phosphate concentration was 0.09 ± 0.05 mg L^{-1} (Table 3). These values are lower compared to historical values recorded by Oduor and Schagerl (2007). The decrease in nitrates and phosphate concentrations compared to previous studies could be as a result of the existing management measures by Kenya Wildlife Service to ensure there are no human activities around the park.

Low phosphate levels are often desirable because they can help mitigate the risk of eutrophication, and excessive growth of algae and aquatic plants due to high nutrient levels. Studies by Adeka *et al.*, (2008) indicated that the hot spring is a major source of dissolved nitrogen, dissolved phosphorus, and total phosphorus in Lake Elementaita.

Table 3. Mean values of Nutrients Nitrates (NO^3); Soluble Reactive Phosphates (SRP).

Site	NO^{3-} (mg L^{-1})	SRP (mg L^{-1})
Pelican	0.05	0.12
Sentrim	0.03	0.11
Mbaruk RM	0.01	0.11
Midlake	0.04	0.14
Soysambu	0.05	0.09
Hotspring	0.01	0.03
Kariandusi RM	0.03	0.00
Off Hotspring	0.01	0.09
Flamingo Island	0.02	0.15
Mean	0.03	0.09
SD (±)	0.02	0.05

Total and fecal coliforms were observed in majority of the sampling points excluding Hotspring and Soysambu points, indicating a widespread distribution of these bacteria throughout the Lake (Table 4).

Table 4. Coliform forming units (cfu) of total and fecal coliforms in Lake Elementaita."-": not detected; tntc: too numerous to count.

Sampling point	Total Coli (cfu 100 ml^{-1})	Fecal coliforms (cfu 100 ml^{-1})
Midlake	100	-
Pelican	tntc	1333
Sentrim	40	40
Hotspring	-	-
Soysambu	-	-
Kariandusi R.M	-	-
Island	tntc	333
Mbaruk R.M	367	-

The areas where coliforms were observed are characterized by large populations of flamingoes and pelicans, which are known to inhabit shallow, nutrient-rich waters, which provide the ideal conditions for the proliferation of coliforms. Other factors such as agricultural runoff,and wildlife activities could contribute to the values recorded above. It's important to note that the presence of fecal coliforms in water poses a potential health risks to humans.

Fisheries

During the period of this study, only Magadi tilapia *(Alcolapia grahami)* fish species was caught with a total wet weight of 14 kg. The catch rates of this species was 0.4 kg hr^{-1} and 1.4 kg hr^{-1} using gill netting and seining respectively, yielding an average catch rate of 0.9 kg hr^{-1}. *A. grahami* is tolerant to very alkaline conditions (Maina *et al*., 2019), contributing to its abundance in Lake Elementaita. The alkaline nature of the lake influences habitat availability, food resources, and interspecific interactions, shaping the population dynamics of *A. grahami* within the ecosystem. The species' ability to thrive in such environments underscores its ecological resilience and evolutionary adaptations.

Analysis of mean length, weight, and condition factor provided valuable insights into the status and general well-being of *A. grahami* populations in Lake Elementaita (Table 5). The mean sizes and condition factor of this species in Lake Elementaita may indicate a relatively stable population structure, suggesting favourable environmental conditions and resource availability. However, variations in condition factors could be attributed to seasonal changes in food availability, environmental quality, and reproductive dynamics (Yongo *et al*., 2019).

Table 5. Morphometric parameters and condition factor of *A.grahami* in Lake Elementaita

Measure	Sample size	Range (cm)	Mean size (±SD)
Length	244	5 to 13	8.55 ± 1.55
Weight	244	2 to 48	13.03 ± 7.56
Condition factor (K)	244	0.02 to 2.73	1.78 ± 0.45

The length-frequency data for *A. grahami* revealed that most of the fish measured between 9 cm and 10 cm in total length(Fig. 2). These values recorded are slightly higher than those recorded in Lake Magadi by Maina *et al.,* (2019). However, total length of 20.0 cm have been recorded (Froese and Pauly, 2017).

Length weight relationship analysis of the combined sex revealed that *A. grahami* showed a positive allometric growth for width b = 3.1 implying that the fish increased its weight faster than its length.

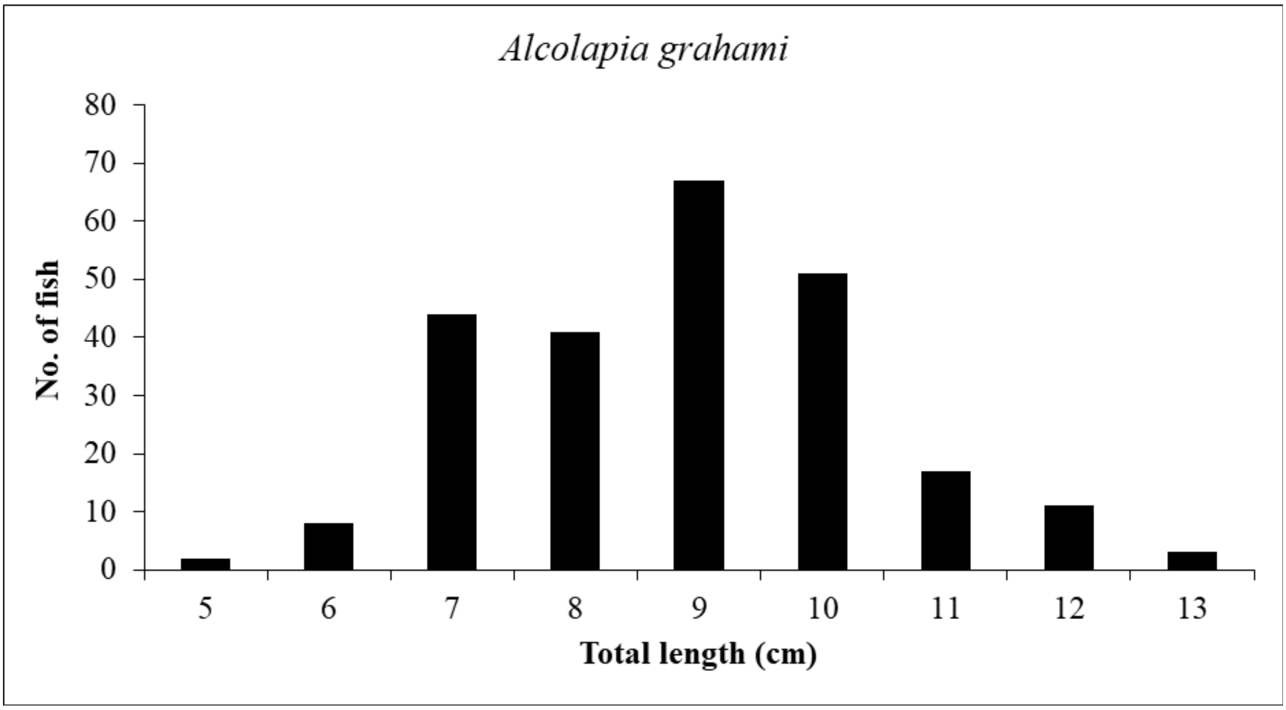


Figure 2. Length frequency structure of *A. grahami* in Lake Elementaita.

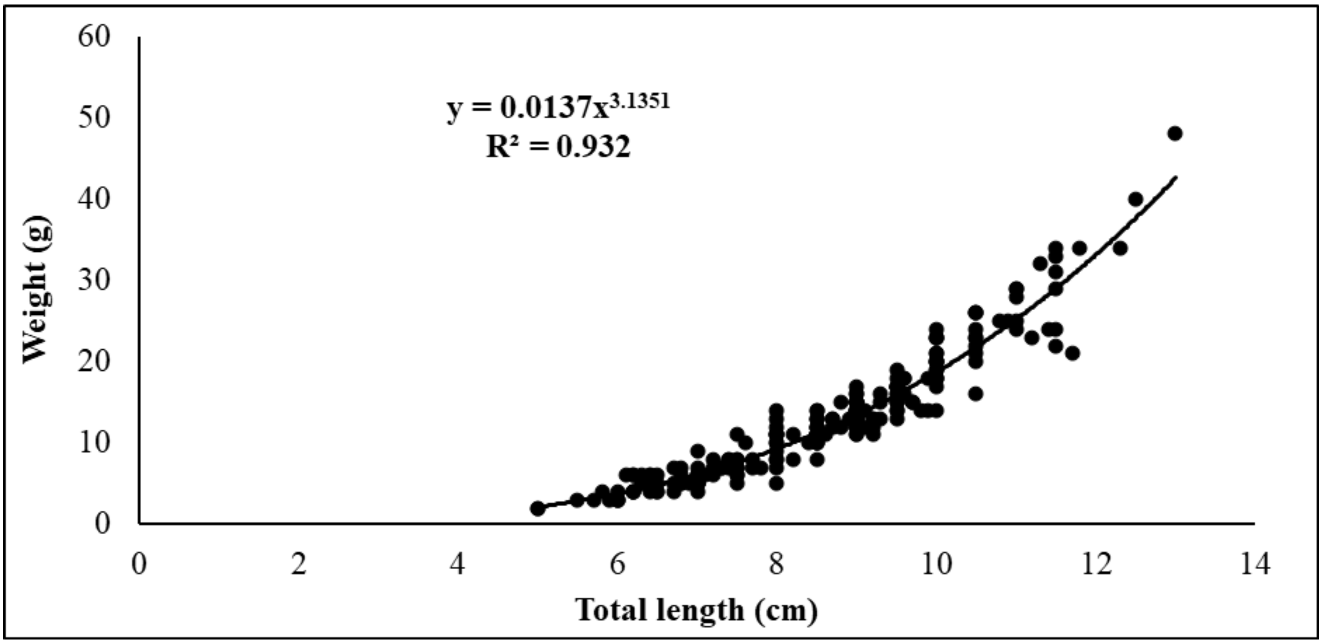


Figure 3. Length-weight relationship of *A. grahami* in Lake Elementaita.

(Fig. 3). Change of b values depends primarily on the shape and fatness of the fish species as well as physical, chemical, and biological factors such as temperature, salinity, food, stomach fullness, sex, and stage of maturity (Sparre and Venema, 1998; Sarkar *et al.,* 2013).

Sex ratio composition of the total catch comprised of 52% males, and 48% females (0.92:1) (Fig. 4), with a large proportion of this catch (80% of females and 89.8% of males) being mature. These results suggest a relatively balanced sex distribution within the fish population, indicating a stable self-replenishing stock.

Socio-economic survey

Sixty-four (64%) of the respondents in the study were male aged between 21 and 30, constituting the majority of the respondents. Other demographic characteristics are as shown in table 6.

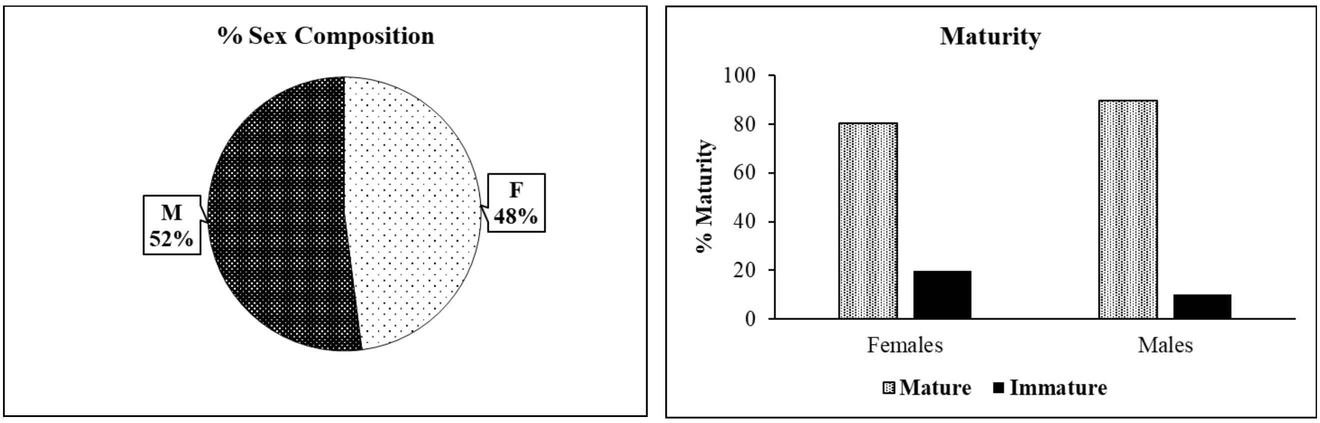


Figure 4. Percentage sex composition and maturity of *A. grahami* in Lake Elementaita.

Table 6. Summary of demographic data from the respondents.

Characteristics		N	Proportion (%)
	Female	18	36
Gender	Male	32	64
	n	50	100
	<20	11	22
	>50	4	8
Age	21_30	19	38
	31_40	11	22
	41_50	4	8
	N/A	1	2
	n	50	100
	Primary	9	18
	Secondary	30	60
Education level	Vocational training	6	12
	Degree	5	10
	n	50	100
	Divorced	1	2
	Married	20	40
Marital status	N/A	4	8
	Single	22	44
	Widow	2	4
	Widower	1	2
	n	50	100
	Students	10	20
	Self-employed/Business	9	18
	Employed	6	12
Occupation	Hustler	6	12
	Farmer	5	10
	N/A	14	28
	n	50	100

Survey findings point to a robust recognition among respondents of the ecosystem services provided by Lake Elementaita, with recreation and tourism emerging as the most prominently acknowledged ecosystem service that the community identify, with 67.1% of primary benefit. The Lake's scenic beauty, wildlife viewing opportunities, and cultural significance make it a popular destination for recreational activities and ecotourism ventures.

Furthermore, respondents also highlighted the importance of biodiversity conservation and ecological balance, recognizing the Lake's role in supporting diverse flora and fauna and maintaining a healthy ecosystem dynamic. Additionally, climate regulation was acknowledged as a critical service provided by Lake Elementaita, with respondents recognizing its role in moderating local climate conditions and mitigating the impacts of climate change. Table 7 outlines more services as cited by the respondents.

Table 7. Ecosystem services the Lake provides to the community.

Service	No. of respondents	Proportion (%)
Recreation and tourism	47	67.1
Biodiversity and ecological balance	10	14.3
Climate regulation	10	14.3
Fisheries and food resources	2	2.9
Freshwater for drinking and irrigation	0	0.0
Treatment of skin ailments	1	1.4
n	70	100.0

From the study, a significant proportion of respondents frequent Lake Elementaita weekly, with individuals citing engaging in various activities such as bird watching (49%) and tourism (25%). Other activities carried out around the lake are shown in figure 5.

Some of the challenges faced by the community members living near the Lake as cited by the respondents included park entry restrictions (28.3%), water pollution (21%), human wildlife conflict (13.3%)(Table 8).

Table 8. Major challenges related to the Lake that affect respondents' livelihoods.

Challenges	Respondents (%)
Restricted entry	28.3
N/A	25.0
Water pollution	21.7
Human-wildlife conflict	13.3
Encroachment	5.0
Mosquitoes infestation	3.3
Migration of birds	1.7
An increase in lake levels causes floods	1.7
Total	100

Some of the threats facing lake Elementaita based on the perceptions of the community are climate change (21%), pollution (19%), and deforestation (16%). These were deemed as urgent, requiring immediate interventions. To conserve the Lake Elementaita ecosystem, and based on the foregoing results, the community reported having engaged in interventions such as tree planting (30%), undertaking clean ups (25%), community awareness and patrols (10%), while the majority (35%) of the respondents were not cognizant of any community interventions.

On Lake Elementaita governance, resource and other legal frameworks, the study established that 60% of the respondents were familiar with

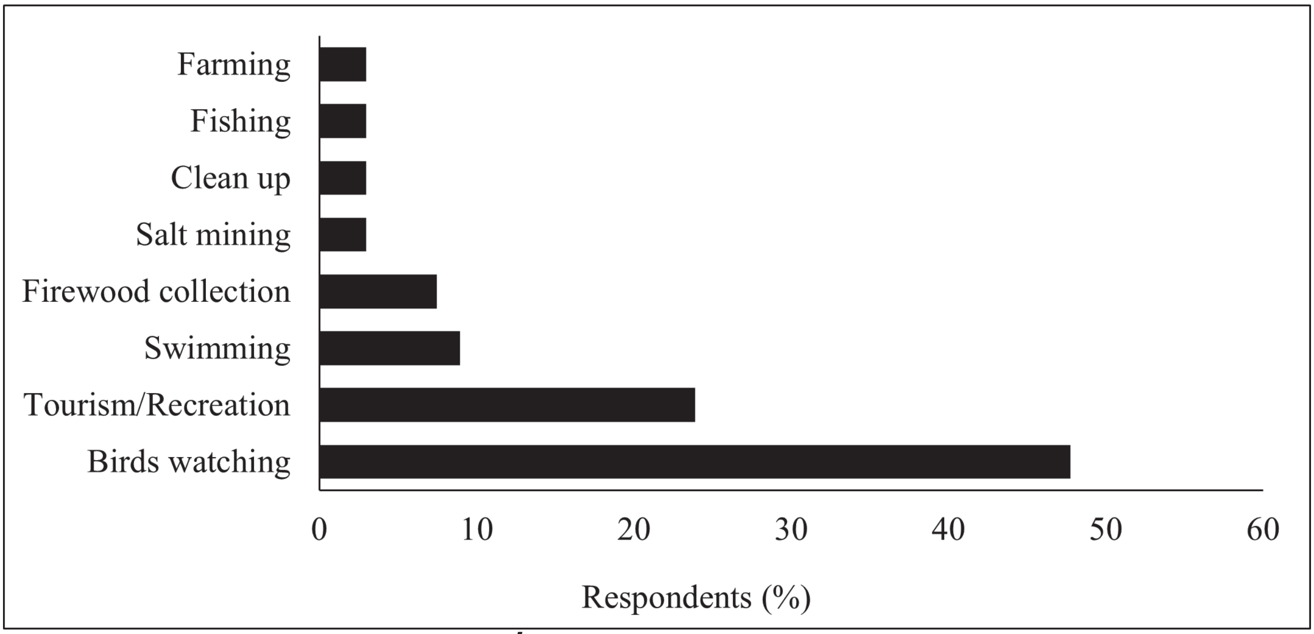


Figure 5. Major activities undertaken/ observed around Lake Elementaita.

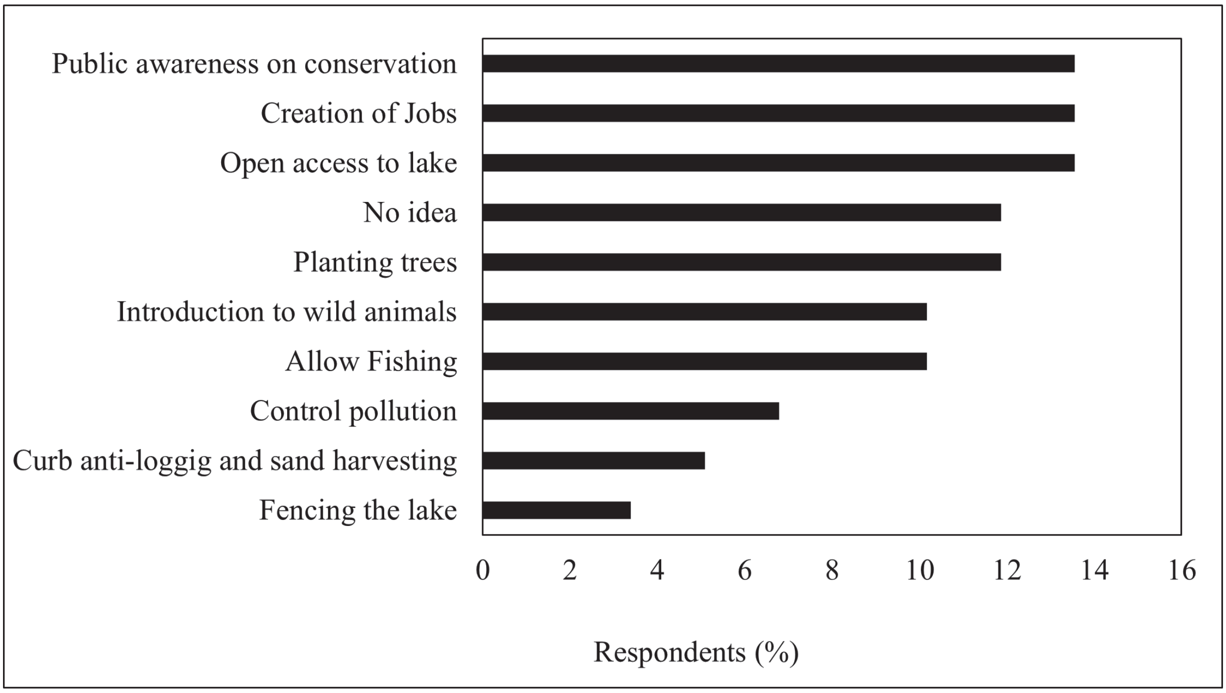


Figure 6. Measures to be implemented to improve the Lake's condition and benefit the local communities.

regulations and policies governing the use of the resource, indicating a relatively high level of awareness among the local population regarding the legal framework guiding Lake management and conservation efforts. However, 40% of respondents lacked awareness of any existing regulations, suggesting the need for community sensitization on the role of government agencies in resource conservation and management. The most cited legislation included restricted entry and access, anti-poaching, restrictions on water abstraction, restriction on fishing activities, and pollution control.

Several recommendations were proposed from this study, notably, allowing the Lake to be an open access system, exploring opportunities for income generation activities for instance eco-tourism, and other recreational activities, public awareness campaigns, and encouraging tree planting (Fig. 6).

Conclusions and recommendations

Lake Elementaita exhibits considerable physico-chemical variability, with wide temperature fluctuations, sufficient dissolved oxygen levels, and high total dissolved solids (TDS) concentrations. Elevated chlorophyll-a levels indicate significant algal biomass, likely driven by nutrient availability and environmental factors. *Alcolapia grahami* was the only recorded fish species, with a stable and well-adapted population. The local communities demonstrated a strong dependence on the lake for vital ecosystem services, including biodiversity conservation, tourism, and climate regulation. These findings highlight the need for integrated watershed management and targeted conservation strategies to safeguard Lake Elementaita's ecological integrity and sustain its socio-economic benefits. This includes implementing soil conservation measures, establishing riparian buffer zones, and promoting sustainable agricultural practices to minimize nutrient and sediment runoff. Additionally, enforcing existing regulations on lake use, such as entry restrictions and pollution control measures, is crucial for mitigating human-induced pressures.

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