



Effect of Human Activities on the Ecosystem of Areas Surrounding Lake Elementaita Naivasha Sub County Kenya

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Authors' contributions

This work was carried out by all authors. Authors EM, FKL, STK and AAS designed the study and wrote the protocol. All authors managed literature searches and analyses of the study. Authors AAS and NNA wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JSRR/2015/16074

Editor(s):

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Complete Peer review History: <http://www.sciencedomain.org/review-history.php?iid=968&id=22&aid=8753>

Original Research Article

Received 5th January 2015
Accepted 3rd March 2015
Published 10th April 2015

ABSTRACT

Aims: The paper aims at identifying human activities that cause environmental degradation around Lake Elementaita. This study focused on the potential role of local communities in addressing ecological problems around Lake Elementaita ecosystem.

Study Design: This study was a survey research design.

Place and Duration of the Study: The study was carried out from April to August 2011 around Lake Elementaita in Kenya.

Methodology: A structured questionnaire was administered to 183 households that were randomly selected. This data was analyzed using Statistical Package for Social Sciences (SPSS). Descriptive statistics was used to determine the mean and standard deviations,

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inferential statistics was used to determine the relationship among variables and between dependent and independent variables. A focus group discussion was conducted for different stakeholders who included: local community leaders, ranchers, conservation groups, community based organizations and Kenya Wildlife Services to share the research findings.

Results: The results from this research showed that rapid population growth, overstocking, poor farming practices and unsustainable resource exploitation practices resulted in increased soil erosion, pollution, loss of habitats and biodiversity around Lake Elementaita riparian zone. There was no significant association in the perceptions on conservation of the residents in the three sites ($X^2 = 5.881$, "d".f=4, $p = .208$). Implying similar perception amongst residents in the study sites. Results also revealed that it was only perception about importance of firewood that was significantly associated with the site of residence of the respondents with chi square results of 10.414 and p value of .034.

Conclusion: Rapid population growth, overstocking, poor farming practices and unsustainable resource exploitation practices resulted in increased soil erosion, pollution, loss of habitats and biodiversity around Lake Elementaita. It was noted that there is an urgent need for the government together with all stakeholders to come up with a comprehensive participatory management wetland policy. This would strengthen coordination among government and non-government agencies operating within this riparian zone. Alternative sources of livelihood should be provided for the communities living around Lake Elementaita.

Keywords: Lake Elementaita; riparian zone; biodiversity; livelihoods; sustainable development.

1. INTRODUCTION

Societies all over the world are closely linked to the natural environment in which they are embedded. Human productive and social activities are shaped to a significant degree by the available natural resources. Environmental degradation on both renewable and non-renewable resources may induce changes in settlement patterns and disrupt established social relations [1]. It is important therefore that communities are well informed about the consequences of unsustainable use of all forms of natural resources. The concerns are shared by people of different nations, cultures, religion and social classes.

Environmental degradation is a process induced by anthropogenic activities [2]. High human population growth rates and economic development have led to degradation of wetlands, forests, habitats and air quality [3]. High poverty levels amongst most developing countries have accelerated the rate of natural resources destruction, since the poor depend on natural resources directly for their livelihood [4].

Degradation of wetlands affects both developing and developed countries. Since 1990, half of the world's wetlands have disappeared. For example, in the United States, an estimated 54% of its original wetlands no longer exist [5]. There is evidence that a similar pattern of wetland degradation is taking place in developing

countries. Environmental degradation within the wetland ecosystems shows a diminishing natural resource base whose effect and impact is measured by the ever-increasing levels of poverty of the catchment and riparian communities [6]. This decline of wetlands globally and an appreciation of their ecological functions such as acting as carbon sinks, recycling of nutrients and human waste, climate regulation, removal of nonpoint sources of pollution, storm buffering and flood control and economic functions such as food provision, water, raw materials for building and clothing, has recently generated concern from international and regional communities [7].

In Kenya, the Ministry of Environment and Natural Resources (MENR) estimates that wetland ecosystems (freshwater and saline) cover only 2-3% of the country's surface area and are found mostly within the Great Rift Valley. They include: Lakes Nakuru, Elementaita, Baringo, Naivasha, Bogoria and Lake Magadi [8]. Research on the relationships between human activities and wetlands is nearly nonexistent in Kenya and rather limited internationally [9]. Similarly, quantitative analysis of the effects and impacts of agriculture on wetlands is limited [10] due to insufficient environmental monitoring.

Some authors note that modern approaches to natural resource conservation are simply conflicting with the survival strategies of the poor in developing world that are dependent on

wetland resources [11]. Application of chemicals like fertilizers and pesticides in agricultural activities in the catchment area are impacting negatively on the wetland ecosystems. Kenya Wildlife Service (KWS), World Wide Fund for Nature (WWF); independent researches carried out at different time spans on lesser flamingoes in Lakes Elementaita and Nakuru established that these lakes were threatened by sedimentation, livestock wastes and toxic wastes [12,13]. These are washed off the land through erosion and end up in rivers, streams, lakes and oceans causing eutrophication that interferes with food chains.

Reports by various authors' document that environmental degradation can be worsened in situations where ownership of natural resources is undefined. For example, Bromley, [14] states that ownership of natural resources such as freehold or free access leads to unsustainable exploitation of natural resources and hence degradation. More often, free access is a result of ineffective resource rights regime which claim rights over a resource but lack the means to fulfill the responsibilities involved. Lack of control and management leads to uncontrolled exploitation, which is highly threatening to sustainability [15]. This situation in Kenya's Rift Valley lakes that is home to flamingos is posing a serious threat to this rare bird's survival since they frequently come to these lakes in large numbers either to breed or feed. The lakes are also important stopovers for other migratory birds like African Spoon Bill (*Platalea alba*), Sand Piper (*Eurynorhynchus pygmeus*), Great White Pelican (*Pelecanus onocrotalus*) and the Eurasian Marsh Harrier (*Circus aeruginosus*) [16].

In industrialized countries, the consequences of loss and degradation of wetlands have often been mitigated with expensive artificial constructions, such as major flood protection schemes or water purification plants which is not the case in developing countries because mitigation measures may take too long to be implemented mostly due to financial and technical constraints [17]. It is from this background that this study was conducted to investigate the impact of human activities around Lake Elementaita ecosystem and look for feasible solutions for sustainable management of its riparian area as well as to seek possible livelihood alternatives for the adjacent community. The findings could provide long term

relieve for the other Rift Valley lakes facing similar challenges.

2. METHODOLOGY

2.1 The Study Area

Lake Elementaita is situated in Gilgil location, Naivasha Sub County and lies between 0° 27'S and, 36° 15E. Gilgil location has a population of 152,102 and Kekokey centre 15,624 (KNBS, 2009) [18]. It lies on the Eastern floor of the Great Rift Valley in Kenya. Geographically, it is surrounded by Nyandarua hills to the North East and Eburru hills to the south. The Lake (Fig. 1) is 1772 meters above sea level and is served by rivers Meroronyi, Mbaruk and Kariandusi. The Lake has a maximum depth of one metre and occupies an area of 36.5 sq. km [19]. Climatic conditions around Lake Elementaita are strongly influenced by altitude and other physical features. The maximum temperatures are about 30°C, December to January being the hottest months. The area receives an annual rainfall of less than 750 mm. Natural vegetation includes Acacia woodland, dry bush land, lake-side grasslands and swamps [20]. The woodland vegetation is concentrated around the rivers with the *Acacia xanthophloea* as the dominant species. The settlement area where the study was carried out Soysambu to the North, Kekokey to the south western and Kariandusi to the North East and south east. The major occupation of the residents here is sand/salt harvesting, land cultivation for agriculture and livestock rearing.

2.2 Data Collection

This was a survey research design conducted between April and August 2011. Data collection was through the administration of structured questionnaires and researcher's observation of human activities being carried out, evidence of degradation on land and settlement pattern in the area. The researcher made observations and analysed what was happening in the study area guided by a checklist. A transect from Lake Elementaita Lodge to the Lakeshore was followed. This helped in validating documented information as compared with actual occurrences in the study area. The questionnaire was administered to 183 household heads randomly selected within the three study sites shown on the map in Fig. 1. The area has in the recent had more people settling (returning absentees or new land buyers) thus opening more land for cultivation. There is also evidence of more trees

planted by the new or returning tenants in the area and new economic activities of tree nurseries established by the road reserves and an ecotourism activity as indicated by the new grass thatched office clearly labeled “Lake Elementaita Ecotourism Group”. There is also evidence of cleared areas within acacia woodland possibly as a result of increased logging and charcoal burning.

2.3 Data Analysis

The data was coded and analyzed using Statistical Package for Social Sciences (SPSS) version 17 and MS Excel packages. Descriptive statistics was used which included the use of

frequency tables, cross-tabulations and measures of central tendency and dispersion (means, modes, medians, standard deviations, percentages and variances). A chi square test was carried out to determine whether there was any association between the three study locations and the perception about conservation (degradation) of the Lake Elementaita riparian area. Socioeconomic aspects of the households such as sources of their livelihoods and resources within the ecosystem, degradation trends and resources, mitigation measures proposed by the community for conservation of ecosystem among others were analyzed using inferential statistics.

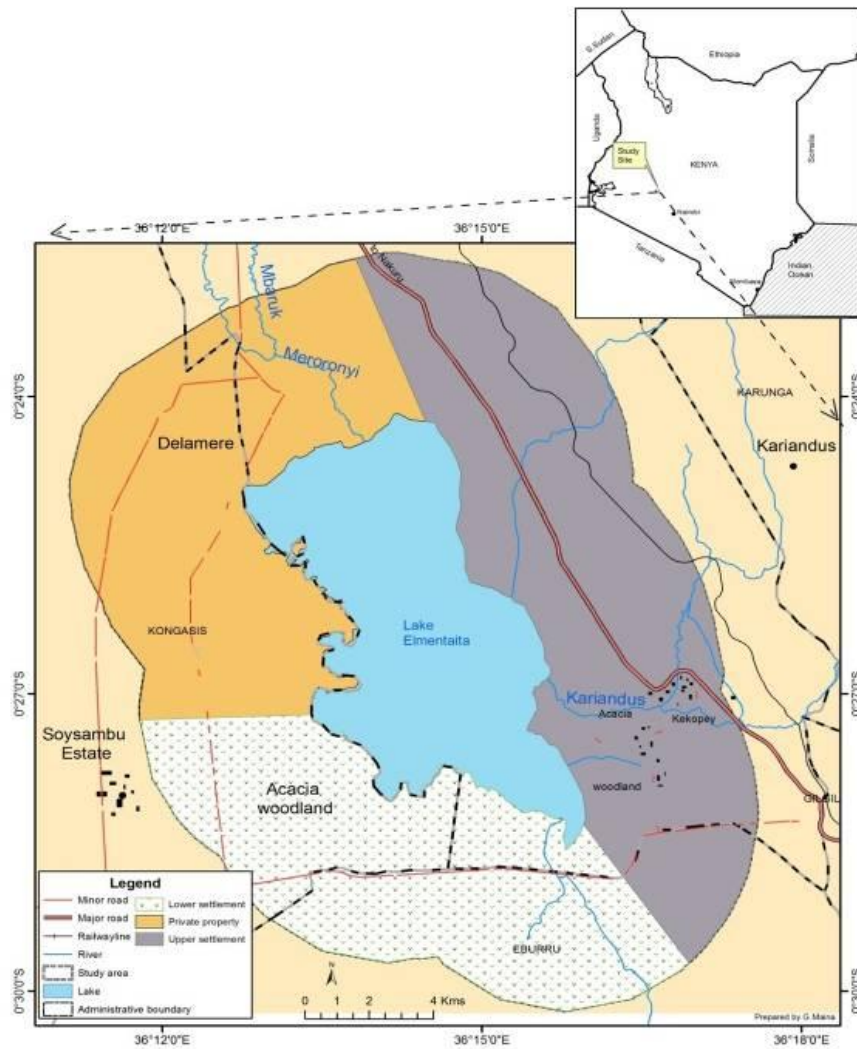


Fig. 1. Map of Lake Elementaita showing the study site
 Source: Maina, G. GIS. Geography Department, Egerton University, 2011 [21]

3. RESULTS AND DISCUSSION

3.1 Human Activities

Grazing and farming were the major human activities carried out by respondents in the entire study area. This concurs with the findings by [22] who realized that the common property resources around the rural landscape within developing countries are a set of dependable resources, which provide a variety of economic and environmental security for the whole community. In common property regimes, the community or state have the option of putting in place rules of how to use the resource. There is always a problem of enforcement of conservation measures. The common property resources and especially those with free open access are at the risk of degradation and overuse [23,24]. Although other human activities were minimal, the harvesting of firewood and other natural products without recourse for direct consumption and income generation exacerbates environmental degradation [4].

3.1.1 Resource utilization around Lake Elementaita Riparian Zone

The most important resources utilized by majority of respondents in the study area were farmland, grazing land and water as shown in Fig. 2. According to UNEP and World Conservation Monitoring Centre (WCMC) 2011 report, terrestrial vegetation around Lake Elementaita consists of upland forest, woodland, dry bush land dominated by *Acacia xanthophloea* and *Eurphobia candelabrum*, scrubland dominated by *Olea europea* subsp. *Africana* sp. and

Tarchonanthus camphorates and grassland of *Cynodon dactylon*, *Chloris gayana* and *Panicum* spp. Marshes located in the southern part of the lake are dominated by *Cyperus laevigatus* and *Typha* spp. These are now threatened by human activities taking place within the areas surrounding the Lake.

The human activities carried out around Lake Elementaita have far reaching effects on the survival of the fragile ecosystem. The land degradation and soil erosion around the ecosystem have been enhanced by the residents carrying out agricultural activities such as maize and horticultural growing that are incompatible with the climatic conditions that prevail in the area. The situation has been made worse by overgrazing as a result of large herds of livestock brought in by pastoralists who come from as far as Narok County and the mining of salt and sand. Potential impacts related to livestock grazing may include, overgrazing, and trampling of soils and plants. The significance of these impacts would depend upon the timing, duration, and intensity of grazing. A decrease in the abundance, distribution, and vigor of plant species resulting from livestock overgrazing may, in turn, decrease the amount of ground-cover (vegetation and litter) and soil organic matter, and increase the amount of bare soil. This would inevitably accelerate soil erosion leading to a change in the water quality of the lake [25]. The loss of woody riparian species (cottonwoods and willows) by livestock is particularly detrimental. The loss of these species that stabilize river banks [26] end up decreasing the areas of Lake Ecosystems such as Elementaita.

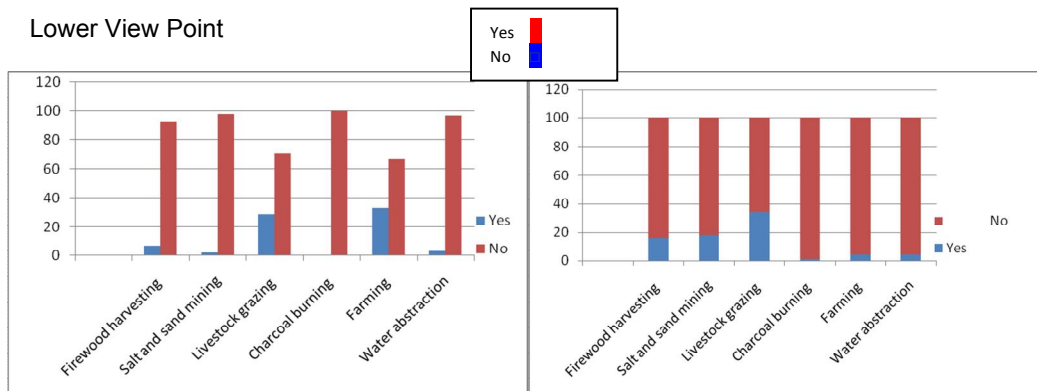


Fig. 2. Resources around Lake Elementaita
 Lower view point (n=72); Upper view point (n=113)
 Y axis- number of respondents with regard to resource utilization

The high demand for charcoal by the nearby community of Kekopey and Gilgil town has led to overexploitation of acacia woodlands. This has led to loss of habitats for woodland birds like the ground hornbills, the rich flora and fauna that epitomizes biodiversity of the Great Rift Valley. These findings are consistent with a report by the World Resources Institute [27] that states that as early as 1993 one –quarter of the vegetated land area of the earth had been highly disturbed by unsustainable and uncontrolled exploitation of natural resources through anthropogenic activities.

3.1.2 Pollution in the Lake Elementaita Riparian Zone

Most wetlands are being affected by increasing human population which leads to more land being opened up for cultivation which then necessitates increased use of pesticide and other agrochemicals which are eventually washed down through surface run-off leading to pollution in wetlands [28]. This affects drinking water sources and biological diversity. Drainage and run-off from fertilized crops and pesticides used in industry introduce nitrogen and phosphorous nutrients and other toxins like mercury to water sources. These chemicals can affect the health and reproduction of species, posing a serious threat to biological diversity. From the results, upper view point was overgrazed and high levels of agrochemical use observed (Figs. 3 and 4). This results concurs with the findings of Mennonite, [3] who attests that in many parts of the world, overgrazing has

resulted in wide spread soil erosion especially in places of high human population growth and economic development compounding degradation of wetlands, forests habitats and air quality.

As resources are being used in the study area, the effects of degradation in the area are aggravated, especially pollution from agrochemicals waste and soil erosion. The Lakes riparian ecosystems are rich in biodiversity and provide essential livelihood products to their riparian communities [8]. Vegetation around the riparian zone plays an important role in intercepting surface runoff and store non point pollutants like sediments, nutrients and certain heavy metals that would otherwise end up in the lake. The overstocking and the resultant overgrazing from livestock leaves the ground bare. Surface runoff water from agrochemicals used on crops and pesticides used on livestock are easily washed down to Lake Elementaita as a result of soil erosion. These pollutants end up distorting the food chain and reproduction of species within and around the ecosystem thus destroying biodiversity [13]. This ecosystem is faced with rising demand for food, energy and other supplies to sustain the increasing population within and adjacent to these area. This has led to a situation where acacia forests are cleared for charcoal burning to make room for agricultural activities and settlement. Siltation and pollution of the wetlands is a critical problem in this lake, due to change in hydrological regime within the catchment confirming the work of Kimani [29].

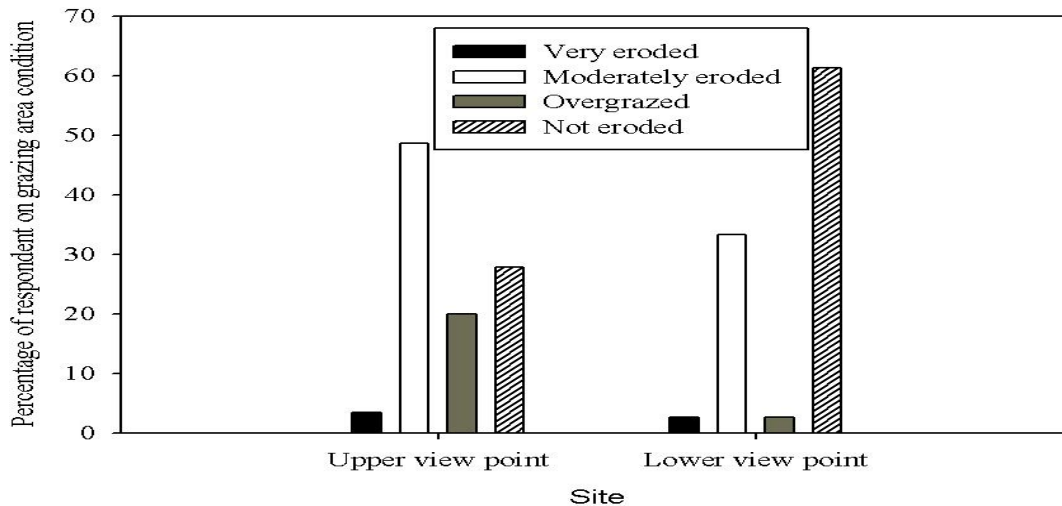


Fig. 3. Respondents' perception on soil erosion

3.1.3 Perception on conservation issues in the Lake Elementaita riparian zone

More than 72% of respondents were of the opinion that there has been decrease in land productivity, while about 67% believed that soil erosion has increased over the years. The fact that the community members have noted evidence of environmental degradation around Lake Elementaita and the fact that there is a decline of ecosystem services both in quality and quantity as shown by their perceptions results is a clear indicator of their concern.

The community living around is willing to conserve Lake Elementaita as shown by more than 79% of the respondents, a demonstration of their awareness of the need to do something to arrest further decline. This positive perception of the community towards environmental issues is important since they can help in environmental conservation programs, once government and stakeholders come in to agree on sustainable ways of addressing environmental degradation [30].

A chi-square test was carried out to determine whether there was any association between the three study locations which were the study sites for data collection (Kariandusi settlement as shown with purple shading to the north east (Fig. 1), Kekopey settlement as shown by the dotted shading to the south west as acacia woodlands (Fig. 1) and Soysambu settlement as shown by brown shading to the north west (Fig. 1) and the perception about conservation (degradation) of the community. As shown in the Table 1, there was no significant association in the perceptions on conservation of the residents in the three sites ($X^2 = 5.881$, "d".f=4, $p = .208$). This means that perception about conservation in the study area were similar amongst residents of the three sites.

Chi-square test for association between perception about the importance of resources for residents in the three sites. Table 2 shows that it is only perception about importance of firewood that was significantly associated with the site of residence of the respondents.

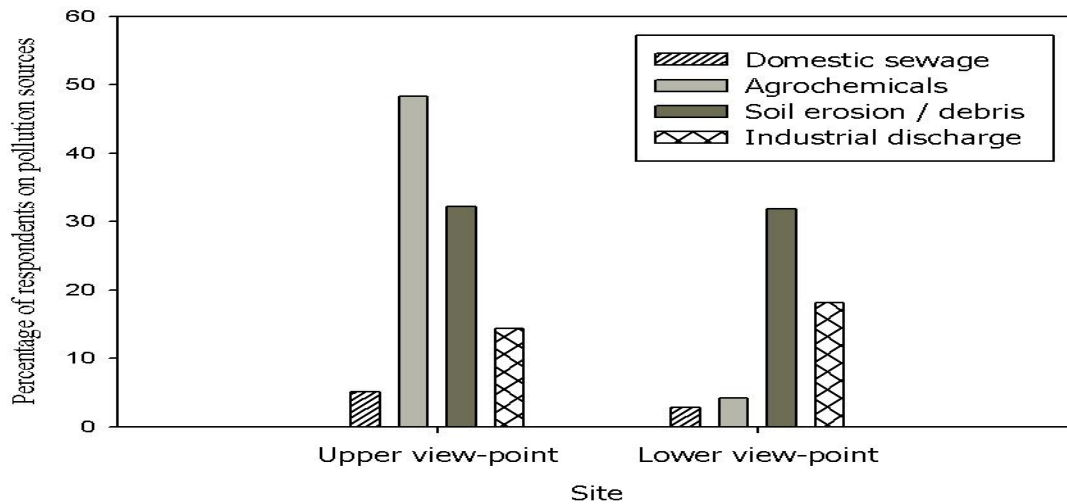


Fig. 4. Pollution sources

Table 1. Firewood as important resource derived from L. Elementaita

Respondent site of residents	Firewood as important resource derived from L. Elementaita and its environs			Total
	Most important	Important	Not important	
Upper-view point	24	48	14	86
Lower-view point	17	30	27	74
Soysambu	4	16	6	26
Total	45	94	47	186

$X^2 = 5.881$, "d".f=4, $p = .208$

Table 2. Perception about Importance of Resources

Dependent	Independent	Chi-square value	DF	Asymp. sig. (2-sided)(p-value)
Firewood	The three sites	10.414	4	.034
Grazing land		7.910	4	.095
Farmland		4.920	4	.296
Water		8.282	4	.082

Note: Significant association is present when the p-value is less than 0.05

4. CONCLUSION

Rapid population growth, overstocking, poor farming practices and unsustainable resource exploitation practices resulted in increased soil erosion, pollution, loss of habitats and biodiversity around Lake Elementaita. There was no significant association in the perceptions on conservation of the residents in the three sites ($X^2 = 5.881$, "d".f=4, p=.208. Perception about importance of firewood was significantly associated with the site of residence of the respondents with chi square results of 10.414 and p value of .034. It was noted that there is an urgent need for the government together with all stakeholders to come up with a comprehensive participatory management wetland policy. This would strengthen coordination among government and non-government agencies operating within this riparian zone. It was also noted that the communities living here need some alternative sources of livelihood such as, beekeeping and ecotourism. In order to minimize water pollution in the lake, organic farming needs to substitute inorganic production systems.

ACKNOWLEDGEMENTS

The authors would wish to thank the people around Lake Elementaita for actively participating in the study. Their responses were invaluable without which the study could not have been possible.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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