Kabarak Journal of Research & Innovation Volume 16 Number 3 (2026)
ISSN 2305-784X (print) ISSN 2410-8383
(online)https://journals.kabarak.ac.ke/index.php/kjri/

Community Perceptions, Pollution Pathways, and Governance Factors Influencing Microplastic Pollution Management in Lake Naivasha Basin, Kenya

Authors

Nicodemus O. Omwancha, Eliud G. Michura and Rose N. Sagwe

Affiliation

[1]Kabarak University, Department of Physical and Biological sciences, Private bag 20157, Kabarak, *Nakuru, Kenya.*

Corresponding Author: Nicodemus O. Omwancha - *nomwancha@kabarak.ac.ke*

Article History: *Submitted: 26th July 2026; Accepted: 20th October 2026; Published (online): 18th November 2026*

Abstract

Microplastic pollution is an emerging environmental concern in freshwater ecosystems, yet its effective management depends not only on understanding pollution pathways but also on community awareness and institutional governance. This study examined community perceptions, perceived pollution pathways, and governance factors associated with microplastic pollution management in the Lake Naivasha Basin, Kenya. A cross-sectional mixed-methods design was employed, combining structured questionnaires with semi-structured key informant interviews. Of the 288 questionnaires distributed, 245 were completed and analyzed, representing a response rate of 85.1%. An additional 33 key informants were purposively selected for interviews. Quantitative data were analyzed using descriptive statistics, Pearson's correlation and multiple linear regression, while qualitative data were subjected to thematic analysis. Inadequate waste-management facilities emerged as the leading perceived contributor to plastic pollution (mean = 4.48 ± 0.781), followed by the use of polythene bags (4.40 ± 0.691), household wastewater discharge (4.36 ± 0.745) and poor management of household plastic waste (4.33 ± 0.764). Respondents demonstrated relatively high awareness of the dangers of microplastic pollution (mean = 4.25 ± 0.806) and strong willingness to reduce plastic use (4.52 ± 0.668). However, recycling and reuse practices received a comparatively low rating (3.58 ± 1.145), while concerns were raised about the effectiveness of existing environmental policies and their implementation. Multiple regression analysis showed that perceived pollution pathways ($\beta = 0.428$), policy and governance factors ($\beta = 0.315$), and community awareness ($\beta = 0.291$) were significant positive predictors of microplastic pollution management ($p < 0.001$), with the model explaining 52.0% of the variation in the outcome ($R^2 = 0.520$). The findings highlight the importance of strengthening waste-management infrastructure, promoting environmental education, improving regulatory enforcement and enhancing institutional coordination. An integrated, community-centered

approach is therefore essential for improving plastic pollution management in the Lake Naivasha Basin.

Keywords
Community perceptions; Environmental governance; Lake Naivasha Basin; Microplastic pollution; Pollution pathways.

Introduction

Plastic production has increased substantially over the past several decades due to the versatility, durability, and relatively low production cost of plastic materials. Global plastic production exceeded 400 million tonnes annually by 2022, with packaging accounting for a significant proportion of plastic consumption worldwide (OECD, 2022; UNEP, 2023). Although plastics have contributed significantly to economic development and improved living standards, inadequate collection, recycling, and disposal systems have resulted in widespread environmental contamination. Once released into the environment, plastic materials undergo physical, chemical, and biological degradation, generating smaller particles known as microplastics, which are generally defined as plastic particles measuring less than 5 mm in diameter (Andrady,2017; UNEP, 2021).

Despite increasing scientific attention to the occurrence and ecological impacts of microplastics, comparatively less emphasis has been placed on the social, behavioral, and governance dimensions influencing their management. Recent studies have shown that public perceptions and awareness play a critical role in shaping responses to environmental pollution. While members of the public generally recognize plastic pollution as a visible environmental problem, their understanding of microplastics, their sources, environmental persistence, and potential impacts remains comparatively limited (Nguyen et al., 2022; Shi et al., 2023). Public awareness has been found to influence environmentally responsible behavior, including waste segregation, recycling practices, support for environmental policies, and participation in pollution control initiatives (Nguyen et al., 2022; Shi et al., 2023).

Communities living within freshwater catchments interact closely with aquatic ecosystems through activities such as agriculture, fishing, tourism, domestic water use, and commercial enterprises. These activities may contribute directly or indirectly to the generation and movement of plastic waste within the environment. Understanding community perceptions regarding the sources, pathways, and impacts of microplastic pollution is therefore essential for developing practical, socially acceptable, and locally relevant interventions for pollution prevention and management.

In Kenya, plastic pollution remains a significant environmental challenge despite the implementation of various regulatory measures aimed at reducing plastic waste. Notable interventions include the national ban on plastic carrier bags introduced in 2017 and subsequent restrictions on selected single-use plastic products. Nevertheless, rapid population growth, urbanization, agricultural intensification, tourism development, and changing consumption patterns continue to increase pressure on existing waste management systems (NEMA, 2021;

UNEP, 2023). Inadequate waste collection services, indiscriminate disposal of plastic waste, open burning, and weak enforcement of environmental regulations facilitate the movement of plastic debris into rivers, wetlands, and lakes, where it may fragment into microplastics and persist in the environment (UNEP, 2021).

Lake Naivasha is one of Kenya's most important freshwater ecosystems and provides critical ecological, economic, and social benefits. The lake supports fisheries, floriculture, irrigated agriculture, livestock production, tourism, wildlife conservation, and domestic water supply. As a Ramsar Wetland of International Importance, Lake Naivasha contributes significantly to biodiversity conservation and local livelihoods (Ramsar Convention Secretariat, 2016). Freshwater ecosystems are increasingly recognized as important receiving environments for plastic pollution. Plastic waste generated from households, agricultural activities, tourism facilities, commercial establishments, and urban settlements can enter aquatic systems through stormwater runoff, wastewater discharge, drainage networks, and river transport pathways (Windsor et al., 2019; Wang et al., 2022). Rivers have been identified as major conduits for transporting plastic debris from terrestrial environments into freshwater ecosystems (Dris et al., 2016; Wang et al., 2022). Within the Lake Naivasha Basin, the Malewa and Gilgil Rivers serve as important hydrological connections between the surrounding catchment and the lake and may facilitate the transport of plastic waste into the aquatic environment.

Modern agricultural production relies heavily on plastic materials such as mulch films, irrigation pipes, greenhouse coverings, and packaging materials. When improperly managed, these materials can degrade and fragment into microplastics that accumulate in soils and may subsequently be transported into rivers and lakes through runoff and drainage processes (Qiang et al., 2023; Shen et al., 2023). Similar concerns have been reported in East African freshwater ecosystems, where agricultural plastics have been identified as emerging sources of environmental contamination (Biginagwa et al., 2022).

Although previous research in the Lake Naivasha ecosystem has provided valuable insights into environmental degradation, water quality and ecosystem pressures, limited attention has been given to the social and institutional dimensions of microplastic pollution management. In particular, there is insufficient understanding of how community awareness, perceptions of pollution sources and pathways, and institutional governance interact to shape pollution-management practices. It is also important to establish how community knowledge and risk perceptions relate to public participation and support for environmental management interventions. Addressing these gaps is essential because effective microplastic pollution management requires more than scientific evidence alone; it also depends on informed communities, active public participation and effective institutional coordination and enforcement.

This study aimed to examine community perceptions, pollution pathways, and governance dimensions of microplastic pollution in the Lake Naivasha Basin, Kenya. Specifically, the study sought to: (i) identify the perceived pathways through which plastic waste enters the Lake Naivasha ecosystem; (ii) assess community awareness and perceptions regarding the sources of microplastic pollution; (iii) evaluate waste management practices and governance challenges

influencing microplastic pollution management; and (iv) examine the relationship between pollution pathways, community awareness, governance factors, and microplastic pollution management. The findings contribute to the growing body of knowledge on the social and governance dimensions of microplastic pollution and provide evidence to support community-centered interventions, strengthened environmental governance, and sustainable strategies for reducing plastic pollution in freshwater ecosystems in Nakuru County, Kenya.

Materials and Methods

Study area

The study was conducted in the Lake Naivasha Basin in Nakuru County, Kenya, focusing on communities living around Lake Naivasha and along the Malewa and Gilgil Rivers (Figure 1). The study area was chosen because it is a freshwater lake located within Kenya's Eastern Rift Valley and is recognized as a Ramsar Wetland of International Importance with ecological, economic, and biodiversity significance (Ramsar Convention Secretariat, 2016). The basin has experienced rapid population growth, urban expansion, agricultural intensification, and increasing commercial activities, resulting in higher levels of plastic consumption and waste generation (NEMA, 2021; UNEP, 2023). The Malewa and Gilgil Rivers, together with stormwater runoff and drainage systems, serve as major pathways through which plastic waste from surrounding settlements, agricultural areas, and commercial activities is transported into the lake (Wang et al., 2022; Ross et al., 2023). These characteristics make the Lake Naivasha Basin an appropriate setting for examining community perceptions, pollution pathways, and governance challenges associated with microplastic pollution.

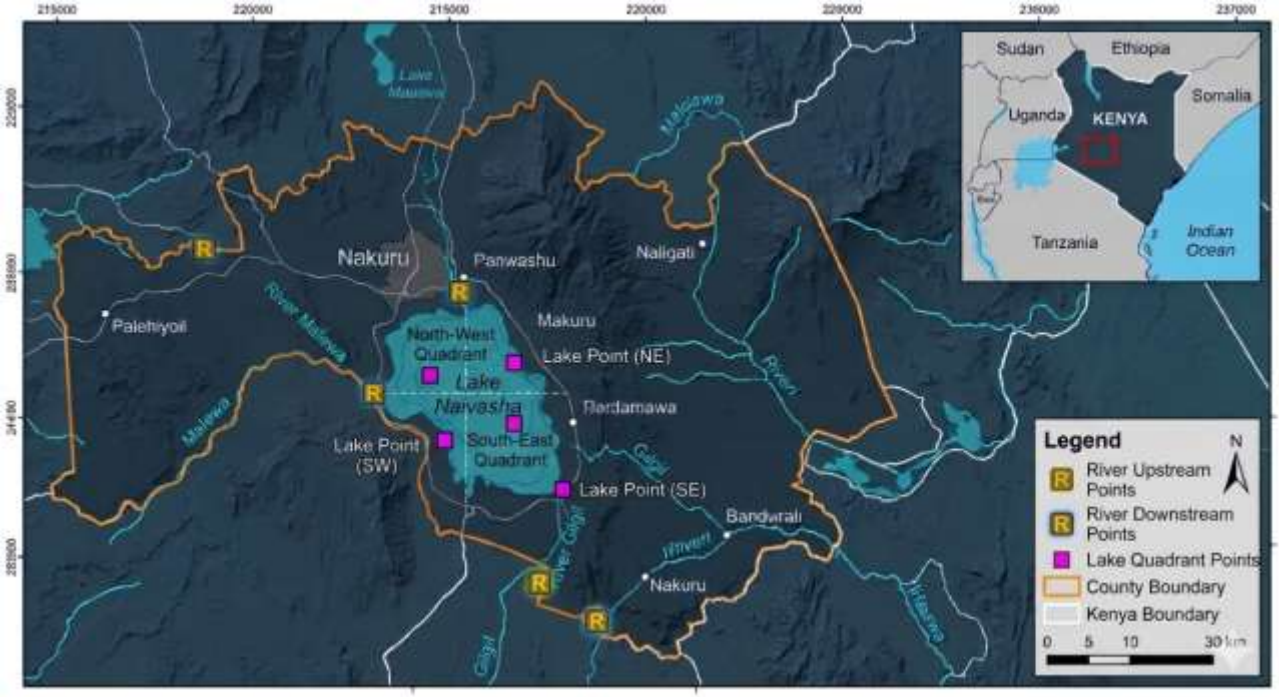


Figure 1: Map showing study area

Research design

The study employed a cross-sectional mixed-methods design that integrated quantitative and qualitative approaches to examine community perceptions, pollution pathways, and governance dimensions of microplastic pollution in the Lake Naivasha Basin. Mixed-methods designs are widely recommended in environmental management research because they combine numerical evidence with contextual and experiential insights, thereby enabling a more comprehensive understanding of complex issues (Creswell & Plano Clark, 2018). The quantitative component involved structured questionnaires administered to community members and other stakeholders, generating standardized data on awareness of microplastic pollution, perceived pathways, waste management practices, and governance-related issues, and supporting descriptive and inferential statistical analyses of relationships among key variables. The qualitative component comprised semi-structured key informant interviews with representatives of government agencies, environmental management institutions, community-based organizations, and other actors involved in environmental governance and natural resource management; such interviews are well suited to environmental governance research because they elicit detailed accounts of institutional experiences, policy implementation challenges, and management practices while maintaining consistency across interviews (Braun & Clarke, 2006). A cross-sectional design was appropriate because the study sought to capture prevailing perceptions, practices, and institutional experiences at a single point in time rather than track change over an extended period, an approach that has been applied in comparable studies of environmental awareness, community perceptions, and governance of environmental management (Nguyen et al., 2022; Shi et al., 2023). Integration of the two data strands enhanced credibility through methodological triangulation and provided a broader understanding of the environmental, social, and governance dimensions of microplastic pollution in the basin.

Target population and sampling procedure

The study targeted adult residents of the Lake Naivasha Basin together with key stakeholders engaged in environmental management, natural resource conservation, and waste management. The target population therefore comprised household members, community leaders, representatives of community-based organizations, and personnel from institutions responsible for environmental governance within the basin. Plastic-producing industries were excluded from this sampling frame because they are not located within the Lake Naivasha Basin; manufacturing is done in Nairobi and Mombasa industrial hubs.

To determine the number of human participants needed to ensure statistically representative results, this study utilized Cochran's (1977) formula for estimating a population proportion.

The formula is expressed as:

$$n = z^2 * \mathrm{p} * (1 - \mathrm{p})/d^2$$

Where:

n = required sample size
Z = Z-score corresponding to the confidence level (e.g., 1.96 for 95%)
d = margin of error (precision, usually 0.05 or 5%)

p = estimated proportion of the population exhibiting the characteristic of interest (taken as 0.25)

In this study, an anticipated proportion (p) of 0.25 (25%) was chosen as a planning estimate of the percentage of respondents likely to be aware of or affected by plastic pollution in Lake Naivasha Basin. A confidence level of 95% (with Z = 1.96) was selected because it provides a widely putative level of statistical confidence for population estimates in survey research (Ahmed, 2024). A margin of error (d) of 0.05 (5%) was assumed to deliver practical precision in estimating population features while sustaining a manageable sample size and is normally used in survey research, with smaller margins requiring larger samples and subsequently greater data collection resources (Hasan & Kumar, 2024; Althubaiti, 2023). Further, recent methodological guidance underscores that the confidence level, satisfactory margin of error, variability in population and available resources, should be key in the determination of sample size (Ahmed, 2024; Althubaiti, 2023). Based on these assumptions, the calculated sample size yielded 288 respondents.

For the quantitative component, a total of 288 participants were targeted for the questionnaire survey. The sample was distributed across different stakeholder groups and geographical locations within the basin. These included 90 farmers from the Malewa and Gilgil river catchments, with 45 participants selected from each river. For each river, 15 farmers were selected from the upstream, midstream and downstream sections. Additionally, 60 farmers and 60 fishermen were selected from the four lake quadrants, comprising 15 participants from each quadrant for each stakeholder category. Other targeted participants included 15 fish vendors, 15 administrative officers, 15 policymakers and 33 representatives from different institutions involved in environmental management, conservation and natural resource governance within the basin. The planned allocation therefore comprised 255 participants from the farming, fishing, fish-vending, administrative and policymaking categories, together with 33 institutional respondents, giving a total of 288 questionnaire participants. Stratified sampling was used to ensure representation across the different geographical zones and stakeholder categories. Where household respondents were selected, simple random sampling was applied to provide eligible households with an equal opportunity for inclusion and minimize selection bias. The selection of study locations prioritized areas considered vulnerable to plastic pollution because of their proximity to the lake and its tributaries, intensive agricultural activities, urban settlements and commercial operations. Out of the 288 questionnaires distributed, 245 were completed and returned, representing a response rate of 85.1%. The quantitative analysis was therefore based on the 245 completed questionnaires.

For the qualitative component, an additional 33 key informants were selected separately through purposive sampling. The key informants comprised government officers involved in environmental conservation and policy administration, representatives of environmental regulatory and water-resource management institutions, and representatives of community-based organizations (CBOs) and non-governmental organizations (NGOs) actively engaged in conservation and natural resource management within the Lake Naivasha Basin. Their selection was based on their professional experience, specialized knowledge and direct involvement in environmental management, conservation activities and policy implementation within the basin

and its inflowing rivers. Purposive sampling was considered appropriate for the qualitative component because it enabled the identification and selection of individuals with relevant knowledge and practical experience concerning pollution management and environmental governance. The 33 key informants participated in semi-structured interviews designed to obtain detailed institutional perspectives on pollution sources and pathways, waste-management practices, regulatory enforcement, institutional coordination and potential interventions.

Data collection methods

Data were collected using structured questionnaires and key informant interviews to generate complementary quantitative and qualitative information on community perceptions, pollution pathways, waste-management practices, and governance issues related to microplastic pollution in the Lake Naivasha Basin. Data collection was conducted concurrently, with the qualitative and quantitative strands gathered during the same cross-sectional timeframe to facilitate methodological triangulation. Ultimately, the qualitative evidence from key informant interviews was integrated to contextualize the quantitative survey results, providing depth to the statistical trends by embedding them within the lived institutional experiences and policy implementation realities of the basin.

Quantitative data were obtained through a structured questionnaire administered to household respondents. The instrument combined closed-ended and Likert-scale items designed to assess awareness of microplastic pollution, perceptions of sources and pathways, waste-management practices, and views on policy and governance. To ensure reproducibility, management performance was assessed using the following indicators: waste collection frequency, regulation enforcement strength, and institutional coordination dynamics, while support for interventions was evaluated using indicators measuring willingness to participate in community cleanups and approval of industrial labeling requirements and packaging penalties.

Questionnaires enabled the collection of standardized responses from a relatively large sample, thereby facilitating statistical analysis and comparison across the study population. Qualitative data were gathered through semi-structured key informant interviews with individuals possessing knowledge and experience in environmental management, waste management, water-resource conservation, and environmental governance. Participants included representatives of government agencies, environmental regulatory institutions, community-based organizations, and other relevant stakeholders. The interviews yielded detailed insights into institutional challenges, policy implementation, pollution-management practices, and potential interventions.

Before the main survey, both the questionnaire and the interview guide were pre-tested to evaluate clarity, relevance, and suitability. Feedback from the pilot was used to refine the instruments and enhance data quality. Data collection proceeded only after the necessary research approvals had been obtained and informed consent secured from all participants. Respondents were informed of the study purpose and assured that the information they provided would remain confidential and be used solely for research purposes.

Data analysis

Quantitative data obtained from the structured questionnaires were coded, entered and analyzed using Statistical Package for the Social Sciences (SPSS), version 26. Descriptive statistics, including frequencies, percentages, means and standard deviations, were used to summarize respondents' demographic characteristics, levels of awareness, perceptions of pollution sources and pathways, waste-management practices, and views on environmental policy and governance. The results were presented using tables, figures and appropriate descriptive summaries.

Inferential statistical analyses were conducted to examine the relationships between the independent variables and microplastic pollution management, which was the dependent variable in the study. The independent variables comprised perceived pollution pathways, community awareness, and policy and governance factors. Pearson's correlation analysis was used to establish the direction and strength of the associations between these variables and microplastic pollution management. Multiple linear regression analysis was subsequently performed to assess the combined and individual predictive contributions of the three independent variables to microplastic pollution management. Standardized regression coefficients (β) were used to compare the relative contributions of the predictors. Statistical significance was evaluated at the 5% significance level ($p < 0.05$).

Qualitative data obtained from the 33 key informant interviews were transcribed and analyzed thematically following the approach described by Braun and Clarke (2006). The analysis involved familiarization with the interview data, generation of initial codes, identification and review of recurring themes, and interpretation of the findings. The emerging themes were organized around pollution sources and pathways, community awareness, waste-management practices, institutional and governance challenges, and potential management interventions. Findings from the qualitative interviews were integrated with the quantitative results to provide contextual explanations, identify areas of convergence and divergence, and strengthen the interpretation of the factors associated with microplastic pollution management in the Lake Naivasha Basin

Validity and reliability of research instruments

Content validity of the questionnaire and interview guide was established through expert review by specialists in environmental management and research methodology. Their feedback improved the clarity, relevance, and adequacy of the instruments in addressing the study objectives. A pilot study was also conducted to assess suitability and identify any ambiguities or inconsistencies before the main survey. Reliability of the questionnaire was evaluated using Cronbach's alpha coefficient. A value of 0.70 or higher was adopted as the threshold for acceptable internal consistency. Pilot results confirmed that the questionnaire items met this criterion and were suitable for the main survey. The concurrent use of quantitative and qualitative methods further strengthened trustworthiness through triangulation, allowing findings from one approach to be corroborated by evidence from the other.

Ethical considerations

Ethical approval was obtained from the Kabarak University Institutional Scientific and Ethics Review Committee (reference number KABU01/KUREC/001/25/02/26), and a research permit

was secured from the National Commission for Science, Technology and Innovation (NACOSTI) (Permit reference number 462082). Further, permission to conduct the study was also obtained from the relevant national and local administrative authorities within the Lake Naivasha Basin. Participation was voluntary, and informed consent was obtained from all respondents prior to data collection. Participants were informed of the study purpose, procedures, and their right to withdraw at any stage without penalty. Confidentiality and anonymity were maintained throughout by ensuring that individual identities were not disclosed in the analysis or reporting of findings. All data were used solely for academic and research purposes and handled in accordance with established ethical principles governing social and environmental research.

Results

Response rate and socio-demographic characteristics of respondents

A total of 288 questionnaires were distributed to respondents within the Lake Naivasha Basin, of which 245 were successfully completed and returned, yielding a response rate of 85.1% (Figure 2a). The high response rate indicates strong participation and enhances the reliability of the study findings. The distribution and return rates of the questionnaires are presented in Figure 2a. The respondents comprised various stakeholder groups whose livelihoods and activities are closely associated with Lake Naivasha and its catchment. These included farmers (n = 70), household and community members (n = 50), fishermen (n = 55), fish vendors (n = 40), and other local stakeholders (n = 30). In addition, 33 key informants representing government agencies, environmental management institutions, community-based organizations, and local administrative structures participated in the qualitative component of the study.

The age distribution of respondents indicates that the study largely captured the views of economically active individuals. The largest proportion of respondents (38%) were aged between 26 and 35 years, followed by those aged 36-45 years (27%). Respondents aged over 45 years accounted for 20% of the sample, while those below 25 years represented 15% (Figure 2b). The predominance of respondents within the working-age population suggests that the findings reflect perspectives of individuals who regularly interact with the lake ecosystem through economic and social activities and are therefore likely to possess relevant knowledge and experience regarding environmental issues affecting the basin.

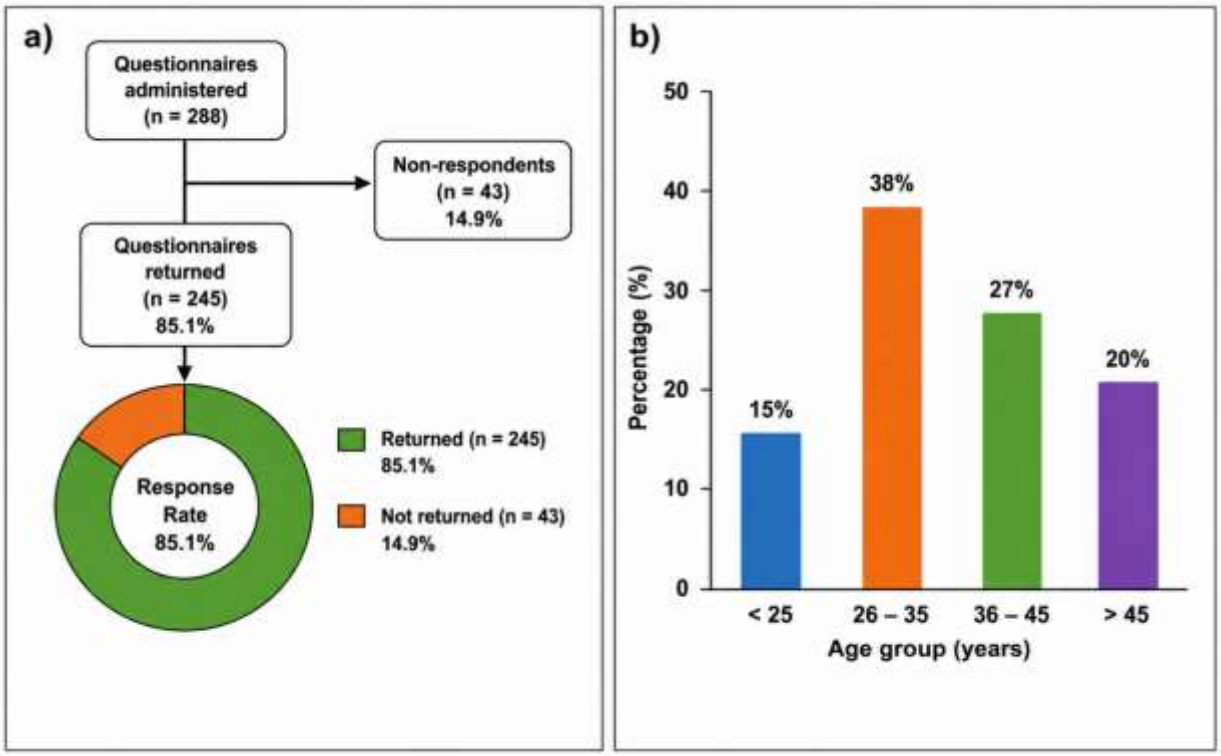


Figure 2: Response rate and age distribution of respondents participating in the Lake Naivasha Basin study: (a) questionnaire response rate showing the number of questionnaires administered, returned, and non-responses; and (b) age distribution of respondents.

The gender distribution of respondents (Figure 3a) showed that males constituted 61% of the study population, while females accounted for 39%. This indicates that both male and female respondents were represented in the survey, providing perspectives from different gender groups on environmental management, natural resource utilization and pollution-related challenges within the Lake Naivasha Basin.

Regarding educational attainment (Figure 3b), the largest proportion of respondents (42%) had attained secondary education, followed by those with college or university-level education (31%). Respondents with primary-level education accounted for 15%, while 9% had postgraduate qualifications. Only 3% reported having no formal education. Overall, the findings indicate that the majority of respondents had attained at least secondary-level education, suggesting a relatively high level of formal educational attainment within the study sample.

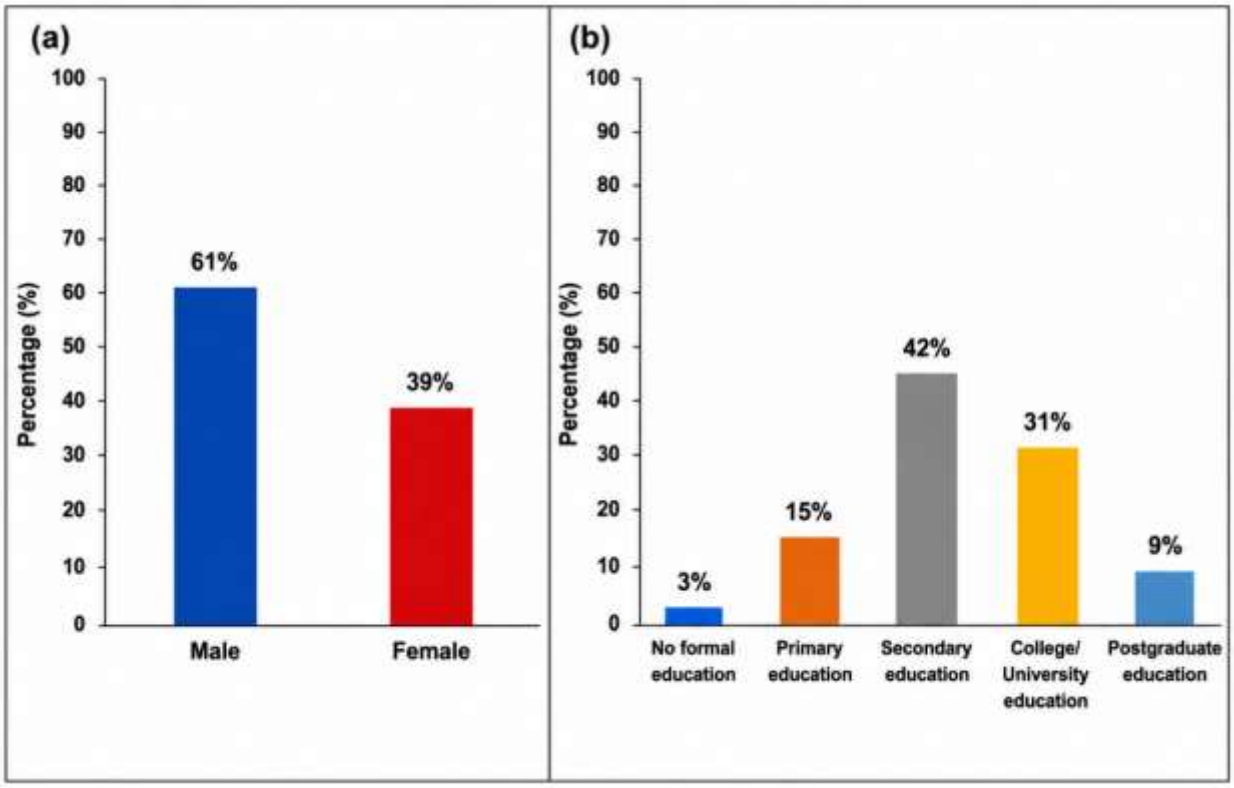


Figure 3: Distribution of respondents by (a) gender and (b) educational attainment in the Lake Naivasha Basin study (n = 245).

With regard to the duration of residence or work within the basin, more than half of the respondents (52%) reported having lived or worked around Lake Naivasha for more than ten years. A further 31% had resided or worked in the area for between five and ten years, while only 17% had lived or worked in the basin for less than five years. These findings indicate that the majority of respondents had substantial experience and familiarity with environmental conditions, resource use practices, and pollution-related challenges within the Lake Naivasha Basin. Additionally, these long-term historical observations revealed a clear consensus among participants that plastic pollution within the basin has steadily and significantly worsened over the years. Their long-term interaction with the lake ecosystem provides a valuable basis for understanding community perceptions of pollution pathways, waste management practices, and environmental governance issues affecting the basin.

Perceived Pathways of Plastic Waste into the Lake Naivasha Ecosystem

Community perceptions were assessed using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The results presented in Table 1 indicate that respondents generally agreed that several human activities and inadequate waste-management practices contribute to plastic pollution within the Lake Naivasha Basin. Mean scores for the identified sources and pathways ranged from 4.05 to 4.48.

Inadequate waste-management facilities were identified as the most important perceived contributor to pollution (mean = 4.48 ± 0.781). This was followed by the use of polythene bags (mean = 4.40 ± 0.691), household wastewater discharge (mean = 4.36 ± 0.745), and poor management of household plastic waste (mean = 4.33 ± 0.764). These findings highlight concerns about inadequate waste collection and disposal systems, the widespread use of plastic packaging materials, and the potential movement of improperly disposed household waste into the aquatic environment.

Stormwater runoff during rainy seasons was also identified as an important pathway (mean = 4.29 ± 0.812). This suggests that respondents recognized the potential for rainfall to transport plastic waste from settlements and other land-based sources into the lake. Respondents also associated plastic pollution with areas close to human settlements (mean = 4.21 ± 0.876) and fishing activities, particularly the disposal of fishing nets and gear (mean = 4.18 ± 0.842). Agricultural activities (mean = 4.11 ± 0.913) and tourism-related activities (mean = 4.07 ± 0.936) were also perceived as contributors. Industrial activities near the lake recorded a mean score of 4.05 ± 0.885.

From the findings respondents therefore, perceived inadequate waste-management facilities, polythene bags, household wastewater and poorly managed household plastic waste as the leading contributors to plastic pollution in Lake Naivasha. The findings further demonstrate that agricultural, fishing, tourism and industrial activities are also perceived as relevant sources of plastic waste within the catchment. These perceptions highlight the importance of strengthening waste collection and disposal systems, improving wastewater management, promoting responsible plastic use, and enhancing community participation in pollution prevention and environmental management.

Table 1

Community Perceptions of Pollution Pathways contributing to Microplastic Pollution in Lake Naivasha (n = 245)

Pollution pathway	Mean	Standard deviation	Rank
Inadequate waste-management facilities	4.48	0.781	1
Use of polythene bags	4.40	0.691	2
Household wastewater discharge	4.36	0.745	3
Poor management of household plastic waste	4.33	0.764	4
Stormwater runoff during rainy seasons	4.29	0.812	5
Plastic pollution more severe near settlements	4.21	0.876	6
Discarded fishing nets and gear	4.18	0.842	7

Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

Community Awareness and Perceptions of Microplastic Pollution Sources

The findings indicated relatively high awareness of the dangers of microplastic pollution, with a mean score of 4.25 ± 0.806 (Table 2). Respondents also expressed strong support for individual and institutional actions to reduce plastic pollution. Personal willingness to reduce plastic use recorded the highest mean score (4.52 ± 0.668), followed by agreement that strict enforcement of plastic bans could reduce pollution (4.41 ± 0.722). Respondents also recognized the contribution

of non-governmental organizations to plastic-waste reduction (mean = 4.01 ± 0.915) and the importance of community participation in conservation Programmes (mean = 3.97 ± 0.886).

Nevertheless, respondents expressed comparatively moderate views regarding the adequacy of existing community-awareness Programmes (mean = 3.71 ± 1.004), government involvement in pollution management (mean = 3.88 ± 0.972), and the promotion of environmentally friendly alternatives (mean = 3.89 ± 0.943). The lowest mean scores were recorded for the adequacy of policies regulating plastic disposal (mean = 3.64 ± 1.107) and the prevalence of recycling and reuse practices (mean = 3.58 ± 1.145). These findings point to gaps in the implementation of awareness initiatives, waste-management practices, and institutional interventions. Although respondents demonstrated awareness of the dangers of microplastic pollution and willingness to adopt measures to reduce plastic use, challenges remain in translating awareness into consistent environmental-management practices. Strengthening environmental education, expanding recycling and waste-recovery opportunities, promoting environmentally friendly alternatives, and improving enforcement of existing plastic-waste regulations are important for enhancing community participation in pollution management within the Lake Naivasha Basin.

Table 2.
Community awareness and mitigation strategies (n = 245)

Statement	Mean	Standard deviation
Awareness of dangers of microplastic pollution	4.25	0.806
Community awareness Programmes are adequate	3.71	1.004
Government agencies actively manage pollution	3.88	0.972
NGOs play a key role in reducing plastic waste	4.01	0.915
Policies regulating plastic disposal are adequate	3.64	1.107
Recycling and reuse practices are common	3.58	1.145
Communities participate in conservation Programmes	3.97	0.886
Environmentally friendly alternatives are encouraged	3.89	0.943
Strict enforcement of plastic bans can reduce pollution	4.41	0.722
Personal willingness to reduce plastic use	4.52	0.668

Waste Management Practices and Governance Challenges

The results in Table 3 indicate strong support for evidence-based policy development and enhanced environmental governance. Respondents agreed that scientific research can inform county-level environmental policies (Mean = 4.39±0.742) and strengthen environmental regulations by providing credible evidence (Mean = 4.31±0.798). The highest level of agreement was recorded for the statement that community awareness is important for effective policy implementation (Mean = 4.51±0.648), suggesting that public participation and environmental education are regarded as essential elements of successful governance. Respondents also strongly agreed that waste-management policies should integrate research findings (Mean = 4.45±0.693), reflecting confidence in the value of scientific evidence for improving environmental decision-making.

Although respondents acknowledged the existence of policies addressing environmental pollution, the relatively lower rating for policy effectiveness (Mean = 3.42±1.033) points to concerns about implementation and enforcement. This is reinforced by the high level of agreement regarding the existence of policy-implementation gaps (Mean = 4.27±0.811). The findings therefore indicate that the principal challenge for microplastic pollution management in the Lake Naivasha Basin is not the absence of environmental policies, but limitations in their implementation, enforcement, institutional coordination, and public engagement. Strengthening these governance dimensions would enhance efforts to reduce plastic pollution and improve environmental-management outcomes.

Table 3

Respondents' Perceptions of Policy and Governance Issues related to Microplastic Pollution Management (n = 245)

Statement	Mean	Standard deviation
Community awareness is important for effective policy implementation	4.51	0.648
Waste management policies should integrate research findings	4.45	0.693
Research findings can inform county policies	4.39	0.742
Research contributes to evidence-based regulations	4.31	0.798
Gaps exist in policy implementation	4.27	0.811
Government agencies can adopt research findings	4.18	0.866
Current policies are effective	3.42	1.033

Relationships between Pollution Pathways, Community Awareness, Governance and Microplastic Pollution Management

Multiple linear regression analysis was conducted to examine the relationships between perceived pollution pathways, community awareness, policy and governance factors, and microplastic pollution management in the Lake Naivasha Basin. Microplastic pollution management was treated as the dependent variable, while perceived pollution pathways, community awareness, and policy and governance factors were included as independent variables. The model summary is presented in Table 4.

Table 4

Model Summary for Factors Influencing Microplastic Pollution Management

Statistic	Value
R	0.721
R^2	0.52
Adjusted R^2	0.497
F-statistic	20.448
p-value	<0.001

The regression model produced a correlation coefficient (R) of 0.721 and an R^2 value of 0.520, indicating that the three independent variables collectively explained 52.0% of the variation in microplastic pollution management. The adjusted R^2 was 0.497, while the overall regression model

was statistically significant ($F = 20.448$, $p < 0.001$). These findings indicate that perceived pollution pathways, community awareness, and policy and governance factors collectively provide important explanatory information regarding microplastic pollution management within the study area.

The standardized regression coefficients (Table 5) further showed that perceived pollution pathways had the strongest positive predictive association with microplastic pollution management ($\beta = 0.428$, $p < 0.001$). This was followed by policy and governance factors ($\beta = 0.315$, $p < 0.001$) and community awareness ($\beta = 0.291$, $p < 0.001$). The positive coefficients indicate that higher scores for each of these factors were associated with higher scores for microplastic pollution management, holding the other predictors constant. The findings therefore suggest that pollution pathways, institutional and policy-related factors, and community awareness are important considerations in efforts to improve the management of microplastic pollution in the Lake Naivasha Basin.

Table 5
Regression Coefficients for Factors Influencing Microplastic Pollution Management

Predictor Variable	**β**	**p-value**
Pollution pathways	0.428	<0.001
Policy and governance	0.315	<0.001
Community awareness	0.291	<0.001

Key informant interview findings

Qualitative data from key informant interviews complemented the questionnaire results by providing deeper insight into the drivers of microplastic pollution in the Lake Naivasha Basin. Four principal themes emerged: sources of pollution, transport pathways, institutional and management challenges, and priority interventions. Key informants consistently identified domestic solid waste (100%), agricultural plastics (especially from floriculture 81.8%), fishing gear (66.7%), tourism-related single-use plastics (60.6%), and industrial discharges (54.5%) as the main sources of microplastic pollution. The extensive use of greenhouse covers, irrigation pipes, fertilizer bags, and packaging materials in commercial agriculture was highlighted as a major contributor, alongside discarded fishing nets and recreational plastics. These activities collectively increase the volume of plastic waste entering the lake and its tributaries. Stormwater runoff and river systems were described as the dominant transport pathways of the microplastics as established from 87.9% of the respondents.

The Malewa and Gilgil Rivers were singled out as primary conduits carrying plastic debris from upstream settlements, agricultural lands, markets, and urban centers into the lake, particularly during heavy rainfall when accumulated waste is mobilized downstream. This observation aligns with the quantitative finding that stormwater runoff ranks among the most important perceived pathways. Institutional and management constraints were widely cited. Informants pointed to inadequate waste-collection and disposal infrastructure, pressure from rapid population growth

and expanding commercial activity, weak enforcement of existing regulations, limited financial and technical resources, and poor inter-institutional coordination. Although relevant policies exist, inconsistent implementation was viewed as a critical barrier to effective control of plastic waste.

Priority interventions proposed by informants included stricter enforcement of environmental regulations and by-laws, expanded public-awareness and education Programmes, investment in recycling and plastic-recovery infrastructure, and stronger multi-stakeholder collaboration among government agencies, research institutions, community organizations, the private sector, and local communities. Continuous environmental monitoring and research were also emphasized as essential for generating reliable data to support evidence-based policy and adaptive management. Taken together, the interviews indicate that microplastic pollution in the basin arises from the interplay of environmental, socioeconomic, and institutional factors. Addressing it effectively requires integrated, multi-stakeholder strategies that combine improved waste-management infrastructure, consistent policy enforcement, public engagement, institutional coordination, and ongoing scientific monitoring.

Discussion

This study examined community perceptions, pollution pathways, and governance issues associated with microplastic pollution in the Lake Naivasha Basin. Respondents regarded plastic pollution as a growing environmental challenge driven primarily by human activities within the catchment. Poor solid waste management and stormwater runoff emerged as the most important pathways through which plastic waste enters the lake, while community awareness and governance factors were shown to influence microplastic pollution management significantly. Evidence from both the questionnaire survey and key informant interviews points to the need for integrated interventions that combine improved waste-management systems, environmental education, effective policy implementation, and stronger institutional collaboration.

Community Awareness and Perceptions of Microplastic Pollution Sources

Respondents viewed plastic pollution as a significant environmental concern affecting the Lake Naivasha ecosystem. Most associated its occurrence with improper disposal of plastic materials, rising consumption of plastic products, agricultural activities, tourism, fishing, and household waste generation. These results indicate that communities within the basin recognize the close link between human activities and the accumulation of plastic waste in freshwater environments.

The findings align with those of Nguyen et al. (2022) and Shi et al. (2023), who noted that members of the public are generally more familiar with visible plastic pollution than with microplastics, which are difficult to detect without specialized techniques. Akindele et al. (2020) similarly reported that increasing plastic consumption combined with inadequate waste-management systems contributes substantially to plastic contamination in African freshwater ecosystems. Although general awareness of plastic pollution is relatively widespread in the Lake Naivasha Basin, understanding of microplastics and their environmental implications remains limited. This gap underscores the value of targeted environmental-education Programmes that clarify microplastic sources, pathways, persistence, and potential effects on ecosystem and human health, thereby encouraging greater community participation in waste-reduction initiatives.

Respondents regarded public awareness as an important element of efforts to reduce and manage microplastic pollution, noting that environmental education can improve understanding and encourage responsible waste practices. They also observed, however, that existing awareness initiatives remain insufficient and that inappropriate disposal practices continue to contribute to contamination. Awareness alone is therefore unlikely to produce lasting change unless accompanied by practical measures that support behavioral shifts. These observations are consistent with UNEP (2021), which stresses the role of environmental education in promoting responsible consumption and improved waste management, and with Dube and Okuthe (2024), who reported that limited environmental awareness contributes to improper disposal of plastics and lower participation in recycling, particularly in developing countries. Strengthening education and community engagement Programmes is consequently an essential component of broader plastic-pollution strategies.

Strengthening waste-management systems throughout the basin, through source segregation, improved collection and transport, expanded recycling capacity, and control of open burning, could substantially reduce plastic leakage into the environment. When combined with sustained education and active community participation, these measures offer a practical route to lowering plastic pollution in Lake Naivasha.

Perceived Pathways of Plastic Waste into the Lake Naivasha Ecosystem

Respondents identified poor solid waste management, stormwater runoff, household wastewater discharge, agricultural activities, tourism, and river systems as major pathways through which plastic waste reaches Lake Naivasha. These perceptions highlight the central role of land-based activities in generating and transporting plastic waste into the freshwater ecosystem. Stormwater runoff is particularly relevant in the Lake Naivasha Basin, where the Malewa and Gilgil Rivers form the principal inflow systems. During rainfall events, plastic waste generated in residential areas, agricultural fields, commercial centers, and drainage networks is carried through these rivers into the lake.

Comparable processes have been documented by Browne et al. (2011), who showed that urban runoff and wastewater systems facilitate the movement of plastic contaminants from terrestrial to aquatic environments, and by Dris et al. (2016), who identified rivers as major conduits for land-based plastic waste. Windsor et al. (2019) further demonstrated that rainfall and surface runoff substantially increase the transport of plastic debris from urban and agricultural landscapes into rivers and lakes.

Agricultural activities were also recognized as important contributors. Modern farming relies heavily on plastic materials such as greenhouse covers, irrigation tubing, mulch films, fertilizer bags, and pesticide containers. These materials can degrade and fragment under environmental conditions, generating microplastics that accumulate in soils and may subsequently enter aquatic systems through runoff (Qiang et al., 2023; Shen et al., 2023). Biginagwa et al. (2022) likewise identified agricultural plastics as a significant source of freshwater plastic pollution in East Africa. Plastic pollution in Lake Naivasha therefore originates from multiple interconnected sources and transport pathways operating across the catchment. Management efforts must address both the generation of plastic waste and the environmental processes that carry it into the lake.

Inadequate waste management was identified as a major driver of microplastic pollution. Respondents cited open dumping, limited collection services, insufficient recycling facilities, and uncontrolled burning of plastic waste. Such practices increase the likelihood that plastic materials remain in the environment, fragment into smaller particles, and are transported into the lake via runoff and drainage systems. Similar pressures on waste-management infrastructure have been noted by NEMA (2021) in the context of rising waste generation across Kenya.

Waste Management Practices and Governance Challenges

Governance and institutional factors critically shape the effectiveness of microplastic pollution management in the Lake Naivasha Basin. Although Kenya has established policies and regulatory frameworks for environmental protection, respondents identified persistent constraints: inadequate policy implementation, weak enforcement of regulations, limited institutional coordination, and insufficient monitoring of plastic-waste activities. These constraints echo UNEP (2023), which emphasizes that addressing plastic pollution requires coordinated action among governments, environmental agencies, private-sector actors, research institutions, and local communities, and OECD (2022), which notes that environmental policies are most effective when supported by strong institutional capacity, adequate financing, robust monitoring, and consistent enforcement. Strengthening implementation and institutional capacity is therefore as important as formulating additional regulations.

Key informant interviews further revealed that limited collaboration among institutions responsible for environmental management constitutes a significant barrier. Informants stressed the need for closer coordination among county governments, the National Environment Management Authority (NEMA), the Water Resources Authority (WRA), the Kenya Wildlife Service (KWS), the Kenya Fisheries Service, research institutions, community-based organizations, and private-sector stakeholders. Enhanced collaboration would improve information sharing, strengthen monitoring and enforcement, and facilitate coordinated pollution-control measures. The significant influence of governance factors in the regression analysis reinforces the importance of institutional effectiveness. Improving inter-agency collaboration, regulatory enforcement, resources for environmental monitoring, and stakeholder participation would strengthen the implementation of existing policies and support more sustainable management of plastic pollution in the basin.

Relationships between Pollution Pathways, Community Awareness, Governance and Microplastic Pollution Management

Multiple linear regression showed that pollution pathways, community awareness, and policy and governance factors significantly influence microplastic pollution management in the Lake Naivasha Basin. Pollution pathways exerted the strongest effect ($\beta = 0.428$), followed by policy and governance ($\beta = 0.315$) and community awareness ($\beta = 0.291$). Effective management therefore requires simultaneous attention to pollution sources and transport mechanisms, human behavior, and institutional capacity. The dominant influence of pollution pathways indicates that interventions targeting the generation and movement of plastic waste improved waste collection, proper disposal, wastewater management, and runoff control are likely to yield the greatest environmental benefits by reducing the quantity of plastic entering the lake (Migwi et al., 2023). The significant contribution of policy and governance underscores the need for effective regulatory

frameworks, institutional capacity, enforcement mechanisms, and stakeholder coordination. Community awareness remains an important complementary factor, reflecting the value of public understanding and participation in environmental management.

These results are consistent with the Integrated Environmental Management framework, which recognizes that environmental problems arise from interactions among ecological, social, and institutional systems and therefore require coordinated rather than isolated interventions. Rochman et al. (2024) similarly emphasizes that sustainable solutions to plastic pollution depend on the integration of scientific knowledge, behavioral change, and effective governance. Reducing microplastic pollution in the Lake Naivasha Basin consequently calls for a comprehensive approach that combines environmental education, practical improvements in waste-management infrastructure, stronger policy implementation, effective monitoring systems, and enhanced institutional collaboration. Such integrated action offers the most promising route to lowering plastic pollution and safeguarding the long-term ecological health of the lake and its associated freshwater ecosystems.

Conclusion

This study shows that communities within the Lake Naivasha Basin regard microplastic pollution as an emerging environmental challenge driven primarily by human activities in the catchment. Poor solid-waste management, agricultural plastics, tourism-related waste, domestic wastewater discharge, and stormwater runoff were identified as the principal sources and pathways through which plastic material enters the lake, with rivers and surface runoff especially during heavy rainfall serving as key transport mechanisms from surrounding settlements and agricultural areas. Although general awareness of plastic pollution is relatively widespread, understanding of microplastics, their persistence, and their potential ecological and human-health implications remains limited, while inadequate waste-management infrastructure, weak enforcement of environmental regulations, limited institutional coordination, and insufficient community engagement continue to constrain pollution-control efforts. Statistical analysis confirmed that pollution pathways, community awareness, and policy and governance factors significantly influence microplastic pollution management, with pollution pathways exerting the strongest effect, underscoring the need to reduce plastic inputs at source while strengthening public awareness, institutional capacity, and environmental governance. An integrated, multi-stakeholder approach is therefore required, combining improved waste-collection and recycling systems, sustained environmental education, consistent policy implementation and enforcement, continuous environmental monitoring, and closer collaboration among government agencies, research institutions, local communities, and other actors. By examining the social, institutional, and environmental dimensions of microplastic pollution, the study advances understanding of the factors that shape pollution management in freshwater ecosystems and supplies evidence to guide more effective and sustainable strategies for Lake Naivasha and comparable freshwater environments.

Recommendations

The findings of this study highlight the need for an integrated and preventive approach to microplastic pollution management within the Lake Naivasha Basin. Priority should be given to

strengthening environmental education and public awareness Programmes to improve understanding of microplastic pollution, promote responsible plastic consumption, and encourage proper waste management practices among households, farmers, fishers, tourism operators, and other stakeholders. At the same time, county governments and relevant institutions should improve solid waste management systems through expanded waste collection services, waste segregation at source, enhanced recycling infrastructure, and environmentally sound disposal of plastic waste. These interventions would reduce the quantity of plastic materials entering rivers, drainage channels, and ultimately Lake Naivasha, while supporting resource recovery and circular economy initiatives.

Effective management of microplastic pollution will also require stronger environmental governance, institutional collaboration, and long-term monitoring. National and county governments should strengthen the implementation and enforcement of existing environmental policies, enhance institutional capacity, and provide adequate financial and technical resources for pollution control activities. Greater collaboration among government agencies, research institutions, civil society organizations, private sector actors, and local communities is essential for addressing pollution sources and transport pathways across the catchment. Specifically, there is an urgent need to directly engage plastic manufacturing industries on taking active responsibility for the collection and recycling of their own products. Furthermore, microplastic pollution should be incorporated into existing environmental monitoring Programmes to facilitate continuous assessment of pollution trends and management outcomes. Future research should focus on the socio-economic and behavioral factors influencing plastic consumption, disposal, and recycling practices, as well as the effectiveness of community-based waste management interventions, to provide evidence for the development of sustainable and context-specific pollution management strategies.

Declarations

Acknowledgements
The authors gratefully acknowledge the research assistants for their professionalism, commitment, and diligence during data collection; their efforts were essential to the successful gathering of the required information. We also thank the respondents and key informants who generously shared their time, experiences, and insights, thereby providing the empirical foundation for this study. Finally, we express our appreciation to the local stakeholders and institutions within the Lake Naivasha Basin for their cooperation and support, which facilitated the smooth conduct and completion of the research.

Competing Interests

The authors declare that they do not have known competing financial interests or personal relationships that could influence the work reported in this paper.

Authorship Statement

Material preparation, data collection, data analysis, and the writing of the first draft of the manuscript were performed by the corresponding author, Nicodemus Omwancha. The co-authors;

Dr. Eliud Michura and Dr. Rose Nyakemiso Sagwe, supervised the entire study, reviewed the manuscript, and approved the final version for publication.

Funding

We declare that no funds, grants, or other support were received during the preparation of this manuscript.

Research Approval

Prior to data collection exercise, ethical approval and a research permit were obtained from the Kabarak University Scientific and Ethics Review Committee and the National Commission for Science, Technology and Innovation (NACOSTI), respectively, under the broader parent research project. Local authorities were notified, and all respondents provided voluntary informed consent. Throughout the study, participant anonymity, strict data confidentiality, and respectful conduct were maintained.

Licensing Statement
© 2026 The Author(s). This article is published by *Kabarak Journal of Research & Innovation (KJRI)* under the **Creative Commons Attribution 4.0 International (CC BY 4.0) License**, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and source are credited.

References

Akindele, E. O., Ehlers, S. M., & Koop, J. H. E. (2020). Freshwater microplastics in Africa: Current knowledge and research priorities. *Environmental Toxicology and Chemistry*, *39*(8), 1519–1531.

Ahmed, S. K. (2024). How to choose a sampling technique and determine sample size for research: A simplified guide for researchers. *Oral Oncology Reports*, *12*, 100662. https://doi.org/10.1016/j.oor.2024.100662

Althubaiti, A. (2023). Sample size determination: A practical guide for health researchers. *Journal of General and Family Medicine*, *24*(2), 72–78. https://doi.org/10.1002/jgf2.600

Andrady, A. L. (2017). The plastic in microplastics: A review. *Marine Pollution Bulletin*, *119*(1), 12–22.

Biginagwa, F. J., Mayoma, B. S., Shashoua, Y., Syberg, K., & Khan, F. R. (2022). First evidence of microplastics in African freshwater ecosystems and implications for environmental management. *Environmental Science and Pollution Research*, *29*, 17624–17639.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Browne, M. A., Crump, P., Niven, S. J., Teuten, E., Tonkin, A., Galloway, T., & Thompson, R. (2011). Accumulation of microplastic on shorelines worldwide: Sources and sinks. *Environmental Science & Technology*, *45*(21), 9175–9179.

Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

Dris, R., Gasperi, J., Mirande, C., Mandin, C., Guerrouache, M., Langlois, V., &Tassin, B. (2016). A first overview of textile fibers, including microplastics, in indoor and outdoor environments. *Environmental Pollution*, *221*, 453–458.

Dube, E., &Okuthe, G. E. (2024). Plastic and micro/nanoplastic pollution in Sub-Saharan Africa: Challenges, impacts, and solutions. *World*, *5*(2), 325–345. https://doi.org/10.3390/world5020018

Hasan, M. K., & Kumar, L. (2024). Determining adequate sample size for social survey research. *Journal of the Bangladesh Agricultural University*, *22*(2), 146–157. https://doi.org/10.3329/jbau.v22i2.74547

Migwi, F. K., Ogunah, J. A., & Mwangi, J. K. (2023). Decadal assessment of microplastics, pharmaceuticals, and emerging chemical contaminants in Kenyan freshwater wetlands. *Environmental Toxicology and Chemistry*, *42*(9), 1845–1856. doi.org

National Environment Management Authority (NEMA). (2021). *National Sustainable Waste Management Policy*. Ministry of Environment and Forestry, Republic of Kenya.

Nguyen, X. P., et al. (2022). Public awareness and perception of microplastic pollution: A systematic review. *Science of the Total Environment*, *806*, 150567.

Organization for Economic Co-operation and Development (OECD). (2022). *Global plastics outlook: Economic drivers, environmental impacts and policy options*. OECD Publishing.

Qiang, L., Hu, H., Li, G., Xu, J., Cheng, J., Wang, J., & Zhang, R. (2023). Plastic mulching, and occurrence, incorporation, degradation, and impacts of polyethylene microplastics in agroecosystems. *Ecotoxicology and Environmental Safety*, *263*, 115274.

Omondi, E. O., Osano, O., &Gitonge, J. M. (2020). Occurrence and spatial distribution of microplastics in the surface waters of Lake Naivasha, Kenya. *Environmental Toxicology and Chemistry*, *39*(4), 765–774. doi.org

Ramsar Convention Secretariat. (2016). *The Ramsar Convention Manual* (6th ed.). Ramsar Convention Secretariat.

Rochman, C. M., et al. (2024). Sustainable solutions to plastic pollution require the integration of scientific knowledge, behavioural change, and effective governance. *Environmental Science & Technology* (or update with the exact published title/year once confirmed).

Ross, M. S., Loutan, A., Groeneveld, T., Molenaar, D., Kroetch, K., Bujaczek, S., Kolter, S., Moon, S., Huynh, A., Khayam, R., Franczak, B. C., Camm, E., Arnold, V. I., &Ruecker, N. J. (2023). Estimated discharge of microplastics via urban stormwater during individual rain events. *Frontiers in Environmental Science*, *11*, 1090267.

Shen, W., et al. (2023). Effects of irrigation on the fate of microplastics in typical agricultural soil and freshwater environments in the upper irrigation area of the Yellow River. *Journal of Hazardous Materials*, *459*, 130766.

Shi, H., et al. (2023). Public perception and awareness of microplastic pollution: Current status and future directions. *Journal of Hazardous Materials*, *451*, 131149.

United Nations Environment Programme (UNEP). (2021). *From pollution to solution: A global assessment of marine litter and plastic pollution*. United Nations Environment Programme.

United Nations Environment Programme (UNEP). (2023). *Turning off the tap: How the world can end plastic pollution and create a circular economy*. United Nations Environment Programme.

Wang, J., Peng, J., Tan, Z., Gao, Y., Zhan, Z., Chen, Q., & Cai, L. (2018). Microplastics in the aquatic environment: Sources, transport and ecological risks. *Marine Pollution Bulletin*, *137*, 181–193.

Wang, J., Bucci, K., Helm, P. A., Hoellein, T., Hoffman, M. J., Rooney, R., &Rochman, C. M. (2022). Runoff and discharge pathways of microplastics into freshwater ecosystems: A systematic review and meta-analysis. *FACETS*, *7*(1), 1473–1492.

Windsor, F. M., Tilley, R. M., Tyler, C. R., & Ormerod, S. J. (2019). Microplastic ingestion by riverine macroinvertebrates. *Science of the Total Environment*, *646*, 68–74.