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Influence of land use on pesticide use knowledge, attitudes and practices among urban farming households in the Murchison Bay catchment, Uganda

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Abstract

Background

Inappropriate pesticide use can undermine human health, ecosystem integrity and the sustainability of urban food production, particularly in intensively farmed catchments. This study assessed knowledge, attitudes and practices (KAP) related to pesticide use among farming households across three land-use types in the Murchison Bay catchment of the Lake Victoria Basin, Uganda.

Methods

A cross-sectional survey was conducted among 248 farming households in wetland, forest and open-land systems using a pre-tested, interviewer-administered questionnaire. Data on sociodemographic characteristics, pesticide-use knowledge, attitudes, practices and risk perceptions were collected. KAP scores were classified as good or poor using predefined cut-offs. Binary logistic regression identified predictors of good knowledge, while correlation and multivariable linear regression examined relationships among knowledge, attitude and practice scores.

Results

Respondents had a median age of 32 years; 62.9% were male, 81.5% had tertiary education and 42.7% had received training in pesticide use. Good knowledge, attitude and practice were observed in 45.6%, 60.5% and 24.2% of participants, respectively. KAP outcomes varied across land-use types, and open-land households reported particularly poor pesticide-use practices. Predictors of good knowledge included prior training (adjusted odds ratio [aOR] = 2.89, 95% confidence interval [CI] 1.41–5.90), moderate-to-high concern about contamination (aOR = 2.15, 95% CI 1.47–3.13) and willingness to modify habits (aOR = 1.68, 95% CI 1.23–2.30). Knowledge scores were positively, but modestly, associated with practice scores.

Conclusion

Pesticide-use knowledge and practices differed across land-use contexts, while safe practices remained uncommon overall. Land-use-sensitive extension, practical risk communication and stronger stewardship across the pesticide life cycle are needed to translate awareness into safer behaviour, protect the Murchison Bay catchment and support sustainable urban agriculture.

1 Introduction

Lake Victoria is a major transboundary freshwater resource in East Africa and supports farming, fishing, transport and other livelihoods across its catchment [1]. The basin is therefore both a critical ecological

system and an important socioeconomic landscape in which environmental degradation can affect food security, income and public health. In Uganda, the Murchison Bay catchment drains parts of Kampala and surrounding urban areas into Lake Victoria. The study area includes wetland, open upland agricultural and community forest land-use systems along the Nakivubo channel.

Rapid land-use and land-cover change in Ugandan catchments has increased pressure on wetlands, drainage channels, soils and aquatic resources [2]. In the Lake Victoria Basin, agricultural intensification in environmentally sensitive areas may increase reliance on agrochemicals, including pesticides, particularly where pests and diseases constrain yields.

Pesticides can reduce crop losses when they are appropriately selected, applied, stored and disposed of. Unsafe dosage, limited use of personal protective equipment, inappropriate container disposal and washing of equipment near water sources, however, can create occupational and environmental risks. The FAO and WHO International Code of Conduct on Pesticide Management therefore promotes stewardship throughout the pesticide life cycle while protecting human, animal and environmental health [3]. These risks are especially important in the Murchison Bay catchment, where farming occurs near drainage channels, wetlands, homes and water resources. Understanding pesticide use in this setting is essential for designing practical risk-reduction interventions that support safe food production and catchment sustainability.

Appropriate pesticide use is influenced not only by regulation, product labels and extension messages but also by users' knowledge, attitudes, risk perceptions, training, access to agronomic information, economic pressures and willingness to adopt safer behaviour [4, 5]. KAP studies can therefore identify behavioural and informational gaps that contribute to unsafe exposure and environmental contamination.

Studies in agricultural settings have documented unsafe pesticide handling and contamination risks [6–9]. However, evidence is limited on how pesticide-use knowledge, attitudes and practices vary among land-use systems within urban catchments of the Lake Victoria Basin. Wetland, open-land and forest-land farming systems may differ in cropping intensity, extension exposure, pesticide access, disposal behaviour and proximity to vulnerable ecological receptors. This study assessed pesticide-use KAP among urban farming households across these three land-use systems in the Murchison Bay catchment and considered the implications for sustainable urban agriculture and catchment management.

Pesticide pollution has become a sustainability concern because residues can move through soil, runoff, drainage networks and food chains. Global assessments identify extensive pollution risk and connect pesticide exposure with adverse environmental and human-health outcomes [13–20]. In densely settled urban and peri-urban catchments, these risks can be amplified by the close proximity of farms, homes, markets and receiving waters.

Aquatic and terrestrial evidence shows that agricultural insecticides frequently occur at concentrations that threaten surface-water organisms, reduce stream-invertebrate diversity and contribute to wider

declines in non-target insects [21–25]. This evidence strengthens the need to examine farmer practices within the land-use context through which pesticides are transported, retained or released into sensitive ecosystems.

Studies among farmers in Ethiopia, Tanzania, Nepal, Kuwait and Iran consistently report gaps in hazard knowledge, personal protection, storage, application and container disposal [26–32]. They also show that education, training, access to advice and perceived risk influence safer practice. However, the strength and direction of these relationships vary across settings, supporting locally grounded KAP assessment rather than direct transfer of conclusions between production systems.

2 Methodology

2. 1 Study design and setting

A cross-sectional analytical study was conducted from 2 December 2018 to 4 February 2019 among urban farming households in wetland, forest and open-land systems in the Lake Victoria Basin (Fig. 1).

Murchison Bay is an extension of Lake Victoria southeast of Kampala, between 00°10'00"–00°30'00" N and 32°35'00"–32°50'00" E, at an average elevation of 1,224 m above sea level. The catchment contributes water to Kampala and has experienced substantial land-use and land-cover change. The study area was stratified into three land-use systems along the Nakivubo channel: (i) wetland, (ii) community open upland bordering the wetland and (iii) community forest land. Study communities were located in Luzira, Nakawa, Butabika, Bugolobi and Kiswa (Fig. 1).

2.2 Study participants, sampling procedure and sampling framework

The study population comprised farming households engaged in urban agriculture within three distinct ecosystem types of the Lake Victoria Basin: wetlands, forested areas, and upland agricultural zones. To ensure adequate representation of each ecosystem, a stratified random sampling design was employed. The three ecosystem types were treated as separate strata, and households within each stratum were randomly selected from community registers and local council listings.

The sample size was determined using Cochran's formula for large populations: $n_o = Z^2p(1 - p)/e^2$.

Here, Z is the standard normal deviate at the 95% confidence level (1.96), p is the estimated proportion of households with the attribute of interest (0.50, selected to maximise variability) and e is the margin of error (0.05). The sample size was adjusted for a finite population using $n = n_o/[1 + (n_o - 1)/N]$, where N is the total number of eligible farming households across the three strata.

where N is the total number of farming households across the three ecosystems.

The final sample of 248 households was allocated across the land-use strata as follows: wetland, 139; forest land, 52; and open land, 57. Within each stratum, households were randomly selected from the sampling frame. When a selected household did not respond, the next eligible household on the list was approached to maintain the required sample size.

This approach was intended to capture variation in farming practices and environmental conditions across the three land-use systems.

2.3 Data collection

Trained research assistants administered a standardised questionnaire to consenting respondents (Appendix 1). They explained the purpose of the study and obtained written informed consent before each interview. The questionnaire was pre-tested among 15 farming households to assess feasibility, clarity and interpretation. Pre-test participants were excluded from the main study, and questions were revised or removed where necessary.

The revised questionnaire comprised four sections: sociodemographic and occupational characteristics; pesticide-use knowledge; attitudes; and practices. It included closed- and open-ended questions on label instructions, spraying, adverse effects, risk reduction and the management of pesticide residues and containers.

The questionnaire was informed by international pesticide-management guidance [3] and published pesticide KAP studies [6, 7, 10–12]. Internal consistency across the three KAP components was acceptable (Cronbach's alpha = 0.73).

2.4 Data analysis

Correct and incorrect responses were scored 1 and 0, respectively. Ordered responses were assigned scores of 0, 1, 2 or higher according to the direction and degree of correctness. Open-ended items and items without objectively correct answers, such as demographic characteristics and information sources, were not scored.

Concern about environmental pesticide contamination was rated from 0 (no concern) to 10 (very high concern) and was categorised as little or no concern (0–3) or moderate-to-high concern (4–10). Percentage KAP scores were calculated from maximum possible scores of 68 for knowledge, 7 for attitude and 32 for practice.

Data were entered in Microsoft Excel, checked and analysed in Stata version 11.0 (StataCorp, College Station, TX, USA). Knowledge, attitude and practice were classified as good at scores of ≥ 80%, ≥ 90% and ≥ 70%, respectively [4, 5]. Continuous variables were summarised using means and standard deviations or medians and interquartile ranges, as appropriate; categorical variables were summarised using frequencies and percentages. Groups were compared using Student's t test for continuous variables and the chi-square or Fisher's exact test for categorical variables. Variables associated with good knowledge at $p < 0.20$ in bivariable analysis were entered into a multivariable logistic-regression

model. Backward selection was guided by the likelihood-ratio test. Associations are reported as odds ratios with 95% confidence intervals. Pearson's correlation and multivariable linear regression were used to examine relationships among continuous KAP scores. Statistical significance was set at $p < 0.05$.

3 Results

3.1 Study population and demographic characteristics

Of 280 administered questionnaires, 32 were excluded because of non-response (n = 12) or missing data (n = 20), leaving 248 respondents. These comprised 139 (56.0%) from wetland, 52 (21.0%) from forest land and 57 (23.0%) from open land. As shown in Table 1, 156 respondents (62.9%) were male and 128 (51.6%) were single or had never married.

The median age was 32 years (range 15–69 years). The age distribution was 15–19 years, 15 (6.0%); 20–24 years, 41 (16.5%); 25–29 years, 40 (16.1%); 30–34 years, 61 (24.6%); 35–39 years, 30 (12.1%); and ≥40 years, 61 (24.6%).

3.2 Distribution of pesticide-use knowledge, attitudes and practices

Among the 248 respondents, 202 (81.5%) had attained tertiary education and 106 (42.7%) reported training in pesticide use.

Table 1: Demographic Characteristics of Study Participants by Land Cover Type

Demographic Variable	Wetland (n = 139)	Open Land (n = 52)	Forest Land (n = 57)
Age (years), M ± SD	29.47 ± 9.30	36.39 ± 9.26 ***	38.78 ± 8.75 ***
Gender, n (%)			
• Male	96 (69.06)	25 (48.07) *	35 (61.40) **
• Female	43 (30.94)	27 (51.93)	22 (38.60)
Marital status, n (%)			
• Single	72 (51.79)	17 (32.69) *	39 (68.42) *
• Ever married	67 (48.21)	35 (67.31)	18 (31.58)
Education, n (%)			
• **Tertiary**	97 (69.78)	52 (100) *	53 (92.98) *
• Non-tertiary	42 (30.22)	0 (0)	4 (7.02)
Training in pesticide use, n (%)			
• Yes	7 (5.03)	7 (13.47)	4 (7.01)
• No	132 (94.97)	45 (86.53) *	53 (92.98) *

Note.*Statistically significant difference at p<0.0001 in chi-square or fisher's exact test compared to wetland

**Statistically significant difference at p<0.05 in chi-square or fisher's exact test compared to wetland

*** Statistically significant difference at p<0.0001 in student t-test compared to wetland

sd-standard deviation

Percentage scores for knowledge, attitude and practice were calculated and classified using cut-offs of 80%, 90% and 70%, respectively. Table 2 presents the mean KAP scores and the proportions classified as having good knowledge, attitude and practice.

Differences in participant characteristics according to knowledge category are presented in Table 3.

Most respondents in the wetland, open-land and forest-land groups identified prolonged excessive pesticide use as a cause of environmental contamination (Table 4).

Only 7/57(12.2%) from open land agreed with Open disposal of used container as the cause of environmental contamination compared to 58/137(42.3%) and 2/5(40.0%) from wetland and Forestland respectively.

Majority of the respondents 109/137(79.6%), 31/43(72.1%) and 35/41(85.4%) respectively from wetland, open land and forestland agreed that pesticide contamination is a serious problem yet a large number 115/138(83.3%), 28/44(63.6%) and 39/41(95.1%) agreed that it can be prevented.

Most of the respondents from wetland, 125/136(91.9%) and Forestland, 50/56(90.1%) said they understand and follow instructions on the labels of pesticide containers, while only 19/48(39.5%) of respondents from open land could understand and follow instructions, while majority of the respondents from open land 32/45(71.1%)) said they were not willing to change their habits in relation to pesticide use.

Good knowledge was observed among 63 (45.3%) wetland, 7 (13.5%) open-land and 43 (75.4%) forest-land respondents. Good attitude was observed among 96 (69.1%), 28 (53.8%) and 26 (45.6%), respectively, while good practice was observed among 34 (24.5%), 1 (1.9%) and 25 (43.9%), respectively.

Good knowledge was more common among respondents who had received pesticide-use training than among those without training (53/106 [50.0%] versus 60/142 [42.3%]; $\chi^2 = 5.60$, $p = 0.018$). Good practice was reported by 29/106 (27.4%) trained and 31/142 (21.8%) untrained respondents ($\chi^2 = 1.99$, $p = 0.159$). In contrast, good attitude was less common among trained respondents than among untrained respondents (43/106 [40.6%] versus 97/142 [68.3%]; $\chi^2 = 139.4$, $p < 0.001$).

Table 2. Knowledge, Attitude and Practice Percentage Scores by Land Use cover type

KAP Scores		Land cover type	
	Wetland	Open land	Forest land
Mean knowledge score±sd % (range)	76.47±11.39 (19.18-93.16)	71.92±10.16(23.63-8.17)	85.94±13.10(13.32-99.9)
*Proportion with good knowledge n (%)	63(45.3)	7(13.5)	43(75.4)
**Proportion with good attitude n (%)	96(69)	28(53.8)	26(45.6)
Mean practice score ±sd % (range)	53.48±24.10(0-100)	33.15±14.26(0-1.81)	64.25±22.90(0-99.90)
Proportion with good practice n (%)	34(24.5)	1(2.0)	25(43.8)
Overall	**n=139 (56%)**	**n=52 (21%)**	**n=57 (23%)**

*Knowledge score cut-off of ≥80% used to define good knowledge

**Attitude score cut-off ≥ 90% used to define good attitude

 Practice score cut-off≥70% used to define good practice

sd-standard deviation

In multivariable logistic regression, prior training in pesticide use or agronomic practice, moderate-to-high concern about environmental pesticide contamination and willingness to modify habits independently predicted good knowledge (Table 5). Being single and having tertiary education were significant in bivariable analysis but not after adjustment.

Table 3: Comparison of Study Variables in Relation to Level of Knowledge of Pesticide Use

Characteristic	Good Knowledge (n, %)	Poor Knowledge (n, %)	Test Statistic	p Value
Age (years), M ± SD	33.5 ± 9.6	32.7 ± 10.6	t = −1.19	0.234
Gender (Male)	70 (61.9)	86 (63.7)	χ^2 = 0.46	0.497
Marital status (Single)	65 (57.5)	62 (45.9)	χ^2 = 13.50	0.0002
Tertiary education	95 (84.1)	107 (79.3)	χ^2 = 4.30	0.0382
Training in pesticide use	53 (49.6)	53 (39.2)	χ^2 = 5.60	0.018
Land cover type			χ^2 = 167.02	<0.0001
• Wetland	63 (55.7)	76 (56.3)		
• Open land	7 (6.2)	45 (33.3)		
• Forest land	43 (38.0)	15 (11.1)		
Moderate to high concern about EC	96 (84.9)	93 (68.8)	χ^2 = 31.46	<0.0001

Note. M = mean; SD = standard deviation. χ^2 = chi-square test. EC = environmental contamination. Percentages are based on column totals.

Table 4: Selected Knowledge, Attitudes, and Practices (KAP) Responses by Land Cover Type

KAP Attribute	Wetland n (%)	Open Land n (%)	Forest Land n (%)
Knowledge			
Understanding and following instructions	39/138 (28.2)	26/36 (72.2)	55/56 (98.2)
Knowledge of banned pesticides	58/137 (42.3)	2/5 (40.0)	7/57 (12.2)
Excessive use of pesticide	112/122 (91.8)	27/28 (96.4)	57/57 (100)
Spraying in the morning	124/138 (89.8)	27/28 (96.4)	34/37 (81.8)
Awareness of short- and long-term environmental effects	109/138 (78.9)	46/49 (93.8)	32/37 (86.5)
Attitude			
Fear of contamination	108/138 (78.2)	28/44 (63.6)	32/39 (82.1)
Belief that contamination can be prevented	115/138 (83.3)	28/44 (63.6)	39/41 (95.1)
Contamination is a serious problem	109/137 (79.6)	31/43 (72.1)	35/41 (85.4)
Family fear of contamination	113/134 (84.3)	31/45 (68.9)	40/42 (95.2)
Practice			
Willingness to modify behavior/habit	54/123 (43.9)	13/45 (28.9)	32/55 (58.1)
Open disposal of used containers	125/136 (91.9)	19/48 (39.5)	50/56 (90.1)
Washing and burying containers	91/138 (65.9)	41/52 (78.8)	29/37 (78.4)
Washing containers in open water	106/135 (78.5)	40/50 (80.0)	22/25 (88.0)

Note. Percentages are based on valid responses within each land cover type.

Knowledge was weakly positively correlated with attitude ($r = 0.137$, $p < 0.001$) and with practice ($r = 0.276$, $p < 0.001$). In multivariable linear regression, practice scores were positively associated with knowledge and attitude scores, while marital status was also associated with practice (Table 6).

Table 5: Predictors of Good Knowledge of Pesticide Use in Multivariate Logistic Regression Analysis

Predictor	Crude Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)
Marital status		
•Ever married (reference)	1.0	1.0
• Single	1.60 (1.24–2.05)	1.36 (0.94–1.97)
Age groups		
• 15–19 years (reference)	1.0	1.0
• Each increasing age group	1.02 (1.00–1.04)	1.01 (0.99–1.04)
Education level		
• Non-tertiary (reference)	1.0	1.0
• Tertiary	1.41 (1.02–1.94)	1.38 (0.91–2.08)
Training in pesticide use		
• Non-trained (reference)	1.0	1.0
• Trained	1.35 (1.05–1.73)	2.89 (1.41–5.90)
Environmental contamination (EC) concern		
• Little or no concern (reference)	1.0	1.0
• Moderate to high concern	2.54 (1.81–3.56)	2.15 (1.47–3.13)
Willingness to change behavior		
• Not willing (reference)	1.0	1.0
• Willing	2.32 (1.76–3.04)	1.68 (1.23–2.30)
Land cover type		
• Wetland (reference)	1.0	1.0
• Open land	0.20 (0.13–0.31)	0.06 (0.03–0.14)
• Forest land	3.54 (2.51–5.03)	1.12 (0.52–2.41)

Note. CI = confidence interval. Odds ratios greater than 1 indicate increased likelihood of good knowledge of pesticide use. Likelihood ratio = 472.06; R^2 = 17.36.

Table 6: Multiple Linear Regression Model of Good Pesticide Use Practice Scores

Variable	β Coefficient	t	p Value
Training (trained vs. non-trained)	−1.33	−0.72	0.473
Marital status (single vs. ever married)	3.85	2.38	0.017
Age group	0.16	1.43	0.153
Educational level (tertiary vs. non-tertiary)	−2.16	−1.04	0.298
% of appropriate knowledge score	0.50	8.15	< .0001
% of appropriate attitude score	0.08	3.26	0.001
Constant	−1.89	—	—

Note. $F(6, 1028) = 18.16$, $p < .0001$; $R^2 = 9.58\%$; adjusted $R^2 = 16.6\%$. Negative β coefficients indicate inverse associations with good practice scores.

4 Discussion

Pesticide-dependent crop production can support yields, but unsafe use threatens occupational health, food safety and ecosystem integrity. Waste disposal, application decisions, production pressure and limited risk controls can sustain hazardous exposure even where technical guidance exists [33–36]. Behavioural research further shows that pesticide decisions reflect perceived efficacy, convenience, local production conditions and access to credible advice [37]. Previous detection of organochlorine pesticide residues in Ugandan Lake Victoria sediments underscores the relevance of human practices to catchment contamination [9].

Unlike many pesticide KAP studies conducted within a single production setting [4–7, 10–12], this study compared farming households across wetland, open-land and forest-land systems. KAP scores varied markedly by land use: wetland respondents recorded mean knowledge, attitude and practice scores of 76.47, 90.54 and 53.48; open-land respondents recorded 71.92, 54.59 and 33.15; and forest-land respondents recorded 85.94, 74.18 and 64.25, respectively. Studies among pesticide applicators and farm workers likewise show that knowledge and safety practices vary with education, crop system, training and access to protective resources [38–41]. The absence of a uniform pattern indicates that intervention design should account for land use, farmer characteristics and exposure pathways rather than assume that one extension package will work equally well in all settings.

Differences in knowledge may partly reflect variation in education, training and access to credible advice. Agro-input dealers can be influential information sources, yet evidence from Uganda shows that point-of-sale advice may be incomplete or inconsistent [7]. Educational interventions can improve pesticide safety, but their effects depend on practical delivery and reinforcement [42]. Studies in Ethiopia, Tanzania and other smallholder settings similarly link education, advisory support and production context with

pesticide-management practice [43–46]. Regulators and extension services should therefore strengthen dealer stewardship, improve the clarity and accessibility of label information and provide locally relevant demonstrations of safe handling.

Knowledge of banned or highly hazardous pesticides was limited across land-use systems. This is important because farmers may recognise trade names without knowing active ingredients, toxicity classes or regulatory status. Comparable KAP studies in Lebanon, Palestine, China and Iran report gaps in hazard knowledge, label interpretation, protective practice and pesticide-waste management [47–50]. Recent evidence from northeastern Ethiopia also links poor knowledge and inadequate safety practice with acute pesticide poisoning [51], while a mixed-methods study in eastern Uganda documented unsafe pesticide use and health concerns among farmers [52]. Routine market surveillance, accessible lists of authorised and prohibited products, labels in locally understood languages and stronger retailer accountability are therefore needed.

Training, concern about contamination and willingness to modify established habits independently predicted good knowledge. Nevertheless, good knowledge was observed in fewer than half of respondents and was only modestly related to practice. Training was associated with better knowledge but not with better attitude, indicating that training content, delivery and follow-up matter. Intervention evidence supports repeated, practical education rather than one-off awareness sessions [4, 5, 42]. Such coaching should address dosage, protective equipment, storage, disposal, label comprehension and safer pest-management alternatives.

The positive association between knowledge and practice supports education as one component of risk reduction, but the modest effect indicates that knowledge alone is insufficient. Costs, product availability, social norms, retailer incentives, weak enforcement and limited access to protective equipment can constrain behaviour even when hazards are understood [33–37, 43–46, 49, 50]. Interventions should therefore combine education with reliable advisory services, affordable protective equipment, safer pest-management options, responsible retailing and enforcement against mislabelled or unauthorised products.

The strong recognition of contamination risks in some groups did not consistently translate into safe practice. Similar knowledge–practice gaps have been reported among farmers and pesticide workers in several low- and middle-income settings [38–41, 43–52]. Participatory risk communication should therefore involve farmers, local leaders, extension officers, agro-input dealers, health workers and environmental regulators, while practical monitoring should assess whether recommended behaviours are feasible and sustained.

The low prevalence of good practice, especially in open-land systems, raises concerns for household exposure, food safety and the movement of pesticide residues through runoff into wetlands and Lake Victoria. Evidence reviewed in the background shows that pesticide pollution can exceed aquatic safety thresholds, reduce stream-invertebrate diversity and harm non-target organisms [13–25]. Because these

risks connect agricultural productivity with human and ecosystem health, pesticide stewardship should be integrated into urban land-use planning, catchment management and sustainable food-system policy.

The cross-sectional design limits causal inference, and self-reported practices may have been affected by recall or social-desirability bias. The study nevertheless provides land-use-disaggregated evidence from a sensitive urban catchment. Future research should combine KAP surveys with structured observation, pesticide-product inventories, residue monitoring, biomonitoring and longitudinal assessment of behaviour after training.

5 Conclusion

Pesticide-use knowledge, attitudes and practices varied across land-use systems in the Murchison Bay catchment, while safe practice remained uncommon overall. Training, concern about contamination and willingness to change were associated with better knowledge, but the modest relationship between knowledge and practice shows that information alone will not ensure safer behaviour. Land-use-sensitive extension, dealer stewardship, regulatory enforcement and access to practical risk-reduction options are required to protect farmers, consumers and aquatic ecosystems. These measures would contribute to sustainable urban agriculture and more resilient management of the Lake Victoria catchment.

Declarations

Ethical approval and consent to participate

Ethical approval was obtained from the Gulu University Research Ethics Committee (GUREC), and the study was registered with the Uganda National Council for Science and Technology under reference NS 631. All prospective participants received information about the study and provided written informed consent before interview. Responses were handled confidentially. All methods were performed in accordance with the relevant guidelines and regulations of the GUREC.

Clinical Trials

Not applicable

Competing interests

The authors declare that they have no competing interests.

Consent to publish

Not applicable

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Author Contribution

R.O.L. contributed to conceptualization, data analysis, investigation, methodology, visualization, manuscript writing, and content review. E.A contributed to content review. L.O. contributed to writing the manuscript and reviewing content. S.P.A. contributed to content review and supervision. D.O. contributed to conceptualization, investigation, methodology, supervision, and review of the content.All Authors contributed to the review of the manuscript

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Data Availability

The data supporting the findings of this study are available within the article and its Supplementary Information.

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Figures

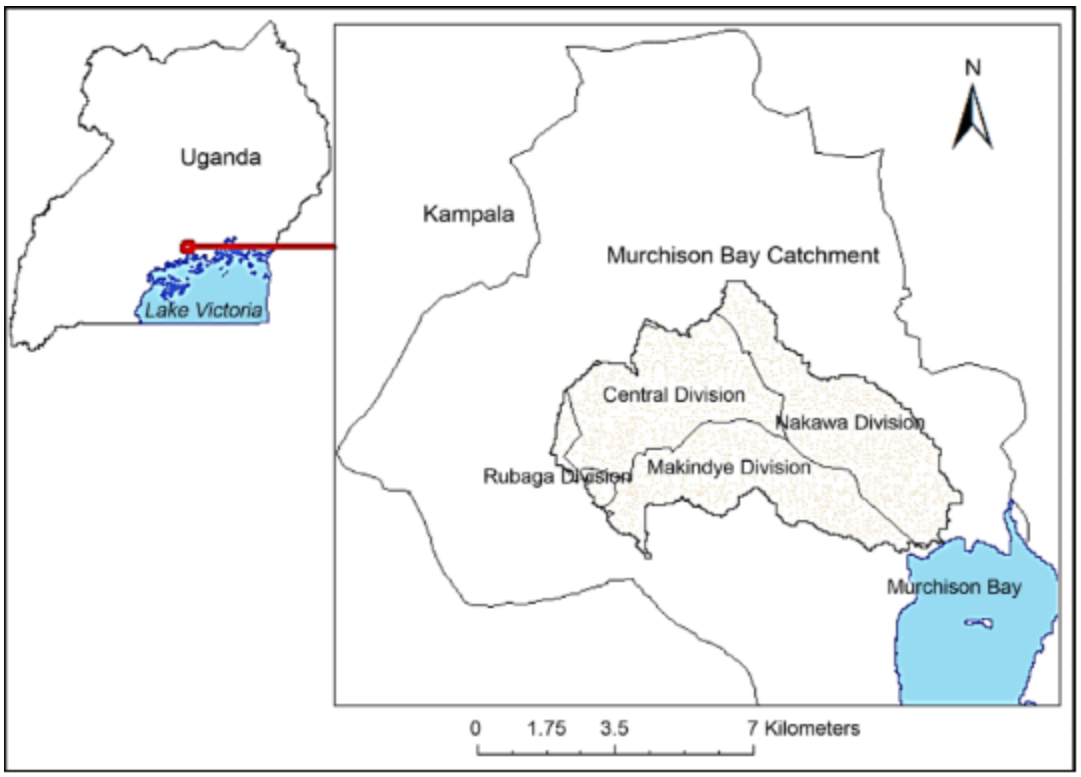


Figure 1

Map of Uganda showing the Murchison Bay catchment