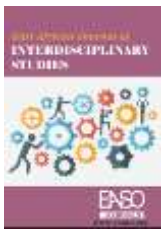

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Original Article

Effect of Human Settlement on the Sustainability of Lake Kenyatta Wetland in Lamu County

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ABSTRACT

The wetland ecosystem represents a crucial ecological resource, supporting diverse flora and fauna while providing essential services to the local communities. However, rapid human settlement within its environment has raised concerns to play it important functions. The study assessed the effect of human settlement on wetland ecosystem sustainability at Lake Kenyatta Wetland in Lamu West Sub-County. This study adopted descriptive research design. The target population of the study was 2750 persons comprising of households from Lamu West Sub-County, three chiefs, and three sub-chiefs surrounding Lake Kenyatta Wetland Ecosystem and four environmental officers from Lamu County. The sample size of the study was 185 respondents; it was determined using Krejcie & Morgan (1970) formulae. Primary data was collected using questionnaires and interview guides. Quantitative data was analyzed using descriptive statistics in the form of means, and percentages and presented in tables and figures. The study findings on effect of human settlement showed that majority of the respondents 93.8% agreed that human settlement practices have hindered the long-term sustainability and resilience of Lake Kenyatta wetland, and thus human activities can introduce invasive plant and animal species into wetlands. In conclusion, human settlement has affected the ecological health and balance of the wetland ecosystem. The impact of human activities has led to degradation, habitat destruction, and hindered long-term sustainability of the lake. The study recommended that stakeholders engage in comprehensive community consultations and awareness programs. Collaborative efforts involving local authorities, environmental agencies, and community leaders are crucial for implementing sustainable policies that balance economic opportunities with environmental preservation.

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INTRODUCTION

Human settlements in wetland ecosystems have been a global phenomenon for centuries, driven by the availability of water resources, fertile soils, and diverse ecosystems that support various livelihoods (Appiah-Opoku *et al.,* 2023). While wetlands offer numerous benefits, including water purification, flood control, and habitat for biodiversity, human settlements in these areas can have significant environmental, social, and economic implications. Climate change poses an additional threat, with rising sea levels and altered precipitation patterns affecting wetland ecosystems. Balancing the needs of growing populations with the conservation of wetlands requires integrated and sustainable planning approaches (Kadoma *et al.,* 2023).

Wetlands are vital environments that should be conserved in order to promote sustainable development. They are known to possess specific habitats and important biodiversity. Over the last a hundred years, it is estimated that almost 50% of the world's wetlands have been lost and hence necessitating efforts of rehabilitating them (Macreadie *et al.,* 2021). Marine and coastal wetlands include estuaries, inter-tidal marshes, brackish, saline and freshwater lagoons, mangrove swamps, as well as coral reefs and rocky marine shores such as sea cliffs. Inland wetlands refer to such areas as lakes, rivers, streams and creeks, waterfalls, marshes, peat lands and flooded meadows. Man-made wetlands include canals, aquaculture ponds, water storage areas and even waste-water treatment areas (Sharma *et al.,* 2021).

In Europe, human settlements in wetland ecosystems have a long history, dating back to ancient civilizations. Many major European cities, such as Venice and Amsterdam, were established in wetland areas for strategic and economic reasons (Ciampa *et al.,* 2021). However, the historical drainage and reclamation of wetlands for agriculture and urban development have led to significant ecological changes. Today, European countries are increasingly recognizing the importance of wetland conservation. The European Union has implemented directives and policies, such as the Water Framework Directive and the Natura 2000 network, to protect and restore wetland ecosystems. Efforts are being made to balance the needs of human settlements with the conservation of these vital habitats (Newton *et al.,* 2020).

Nigeria, Africa's most populous country, is grappling with the consequences of rapid urbanization. With an urban growth rate of around 4.3%, wetlands are under threat from expanding human settlements, resulting in habitat degradation and loss of ecosystem services (Alemu, 2022). The Niger Delta region, characterized by extensive wetlands, faces threats from oil exploration, urbanization, and industrialization. These activities not only disrupt the fragile ecosystems but also affect local communities dependent on wetland resources. Addressing the challenges posed by human settlement in Nigerian wetlands is crucial for sustainable development and biodiversity conservation (Okonkwo et al., 2018).

In Kenya, the Ministry of Environment and Natural Resources (MENR) estimates that wetland ecosystems, encompassing both freshwater and saline varieties, constitute a mere 2-3% of the country's total land area,

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predominantly concentrated within the Great Rift Valley (Deichsel, 2019). These ecosystems include notable bodies of water such as Lakes Nakuru, Elementaita, Baringo, Naivasha, Bogoria, and Lake Magadi (Renner-Mugono, 2022). The exploration of connections between human activities and wetlands is notably lacking in Kenya and is relatively constrained on a global scale, as highlighted by Wilson (Gesora *et al.*, 2022). Similarly, the comprehensive assessment of the effects and consequences of agriculture on wetlands faces limitations due to inadequate environmental monitoring.

Statement of the Problem

In Lamu County, human settlement on wetland ecosystems has intensified significantly since 2008, particularly around Lake Kenyatta (Kinyariro *et al.,* 2020). The population in the region has tripled in the last five years (Brooks *et al.,* 2020), leading to the conversion of wetland areas for residential, agricultural, and industrial purposes. This conversion results in the loss of critical habitats for various plant and animal species, disrupting the ecological balance of the wetland.

Economically, the growing population and associated activities such as farming, grazing, and sand harvesting are driven by the pursuit of livelihoods, yet they strain the wetland's resources and undermine its capacity to sustain these very activities long-term. Socially, the influx of people seeking better living conditions and economic opportunities has led to increased pressure on the wetland, affecting its ability to provide essential services to the community, such as clean water and flood protection.

Ecologically, Lake Kenyatta, Lamu's only freshwater lake, continues to face declining water levels despite rehabilitation efforts (Kipkemoi, 2018). Intense human activities are not only depleting the lake's water levels but also hindering any progress towards its recovery (Mumina & Bourne, 2020). Between 2016 and 2017, the lake's water levels dramatically shrunk from 12 meters to only 1.5 meters due to prolonged drought, with vast sections drying up completely (Mumina & Bourne, 2020). Despite efforts to restore the lake, the water level remains at less than three meters from the original 12 meters.

These economic, social, and ecological pressures highlight the urgent need for a comprehensive understanding of the impact of human settlement on the wetland's sustainability. However, there is a notable research gap in understanding the site-specific impacts on the health of the Lake Kenyatta wetland in Lamu County. This study seeks to fill this gap by determining the effect of human settlement on the sustainability of Lake Kenyatta Wetland in Lamu County.

Objective of the study

To determine the effect of human settlement on the sustainability of Lake Kenyatta Wetland in Lamu West Sub-County

Research Question

What is the effect of human settlement on sustainability of Lake Kenyatta Wetland in Lamu County?

Research Hypothesis

H01: Human settlement has no significant effect on the wetland ecosystem sustainability of Lake Kenyatta Wetland in Lamu County

LITERATURE REVIEW

Ecological Resilience Theory

Ecological Resilience Theory was developed by Canadian ecologist C.S. Holling articulated in the 1970s, with influential publications such as "Resilience and Stability of Ecological Systems" (1973) and "Resilience and Stability: Some Basic Conceptions" (1978). The theory is a conceptual framework that seeks to understand how ecosystems respond to disturbances and maintain their essential functions over time. At its core, resilience refers to the capacity of a system to absorb shocks, adapt to changing conditions, and undergo reorganization to sustain its identity and functions. This theory challenges the traditional ecological paradigm that often viewed ecosystems as stable and predictable, emphasizing instead the

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dynamic and adaptive nature of natural systems (Battisti *et al.,* 2016).

The theory introduces the concept of the adaptive cycle, which consists of four phases; exploitation, conservation, release, and reorganization. Ecosystems continually move through these phases, adapting to disturbances and evolving over time. The adaptive cycle is nested within the broader framework of panarchy, illustrating the hierarchical and interconnected nature of ecosystems at different scales. This hierarchical structure recognizes that smaller, faster cycles operate within larger, slower cycles, influencing each other in a dynamic and evolving pattern (Kinchin, 2022).

Ecological Resilience Theory emphasize on identifying critical thresholds and regime shifts. Thresholds represent points at which a system may undergo a qualitative change, leading to a shift in its state or function. Recognizing and understanding these thresholds are crucial for anticipating and managing changes in ecosystems. Overall, Ecological Resilience Theory provides a comprehensive lens for studying the complex dynamics of ecosystems, offering insights into their adaptive capacities and informing strategies for sustainable resource management and conservation (Baho *et al.,* 2017).

The theory offers a holistic perspective, considering the dynamic interactions between components of an ecosystem, which is crucial for understanding the complex relationships within wetland. Resilience theory is adaptable to various ecosystems and stressors, providing a flexible framework that can be applied to different contexts and environmental challenges. The theory has practical implications for ecosystem management, emphasizing the importance of maintaining or enhancing resilience to promote the long-term sustainability of ecosystems (Cere *et al.,* 2017).

The complexity of the theory can make it challenging to operationalize and apply in specific empirical studies. Determining the resilience of an ecosystem involves numerous interacting factors. Resilience is often context-dependent and may vary across different temporal and spatial scales. This can complicate the application of the theory to specific ecosystems. Some critics argue that the focus on stability and the return to equilibrium in resilience theory may oversimplify the dynamics of ecosystems, especially in the face of long-term or irreversible changes (Chambers *et al.,* 2019).

Critics note that resilience theory traditionally places more emphasis on ecological aspects and may not adequately consider the social dimensions of human-environment interactions. Resilience theory might not capture the unique characteristics and complexities of Lake Kenyatta Wetland comprehensively. Its application may need to be supplemented with site-specific data and context. The theory's primary emphasis on ecological dynamics may limit its ability to fully address the socio-economic aspects of human settlement and their impacts on wetland ecosystems (Falk *et al.,* 2019).

Ecological Resilience Theory has significantly contributed to the understanding of ecosystems and their response to disturbances. Its application to the study of Lake Kenyatta Wetland can provide valuable insights into the wetland's ability to withstand and recover from the impacts of human settlement, guiding conservation efforts for the sustainable management of this vital ecosystem.

The Effect of Human Settlement on Sustainability of Wetland

Mugo et al., (2020) examined the impact of human settlement on the sustainability of wetlands, highlighting socio-economic activities such as increased water pollution, habitat destruction, and a decline in fishing. The Lake Victoria Basin (LVB) is experiencing similar changes in land use driven by both anthropogenic and natural factors, which are critical to the sustainability of resources and livelihoods in the area. The study notes that large groups of people often migrate to resource-rich areas, and migrate away from resource-scarce locations. This migration, coupled with natural birth rates, has led to population booms and the expansion of human

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settlements. This study effectively outlines the socio-economic activities that contribute to wetland degradation. However, it could benefit from a more detailed quantitative analysis of the specific impacts of these activities on wetland ecosystems. Future research should include remote sensing data to quantify these changes and assess their environmental impacts.

Liu *et al.,* (2022) reported that over 70% of the population in the catchment area of the three riparian countries around Lake Victoria is engaged in agricultural production, mostly as small-scale farmers. The people of the LVB are involved in various occupational activities such as fishing, farming, trading, quarrying, sand mining, and extracting gold and other minerals. Both human migration and natural birth contribute to population increases and the expansion of human settlements. The Misungwi district in the Mwanza region is experiencing rapid population growth driven by both natural births and migration, which is impacting the area's natural resources and ecosystem. This study provides a comprehensive overview of the socio-economic activities in the LVB and their impacts on wetlands. However, it would benefit from a more detailed analysis of how these activities specifically contribute to wetland degradation. Future research should integrate remote sensing data to quantify the impacts of these activities on wetland ecosystems.

Hopkinson *et al.,* (2019) evaluated the direct impacts of human settlement on wetlands, including development for various purposes which often involve dredging, filling, and draining the area. These activities alter the wetland boundary and include draining wetlands for agricultural use by constructing drainage ditches or installing underground drainage tiles, and filling wetlands to create usable land for construction. This study effectively highlights the direct impacts of human activities on wetlands. However, it could benefit from a more detailed analysis of the long-term environmental impacts of these activities. Future research should include longitudinal studies to assess the long-term effects of these activities on wetland ecosystems.

Hanford, Webb, and Hochuli (2020) stated that rapid and unplanned land reclamation for city development has been achieved by infilling swamps and floodplains. This has not only impacted wetland biodiversity but also reduced the flood storage capacity of the land, resulting in increased flooding. McGranahan *et al.,* (2018) noted that while economic activity and urban development often increase environmental pressures leading to flooding, it is usually the low-income settlements and poorest groups within urban areas that are most vulnerable. This study effectively links urban development and environmental pressures to increased flooding. However, a more detailed analysis of the specific impacts of these activities on wetland ecosystems would enhance the study's findings. Future research should integrate socio-economic data to better understand the human activities contributing to wetland degradation.

Alam *et al.,* (2023) stated that the relatively flat terrain of river floodplains and estuarine wetlands is easier to urbanize than upland areas, resulting in a concentration of human developments on these lands. This has led to a progressive loss of coastal and floodplain wetlands globally through activities such as drainage or infilling, and indirect degradation through activities away from these areas such as water abstraction or conversion to agricultural and settlement lands. Historically, most wetland loss has occurred in freshwater wetlands. This study provides valuable insights into the global loss of coastal and floodplain wetlands due to urbanization. However, a more detailed analysis of the specific impacts of these activities on wetland ecosystems would strengthen the study's conclusions. Future research should integrate remote sensing data to quantify these changes and assess their environmental impacts.

Newton *et al.,* (2020) evaluated anthropogenic pressures on coastal wetlands, stating that these pressures originate outside the wetlands through the alteration of the hydrological system. Land development compounds hydrologic changes by removing vegetation, compacting soil, creating impervious surfaces, and installing drainage

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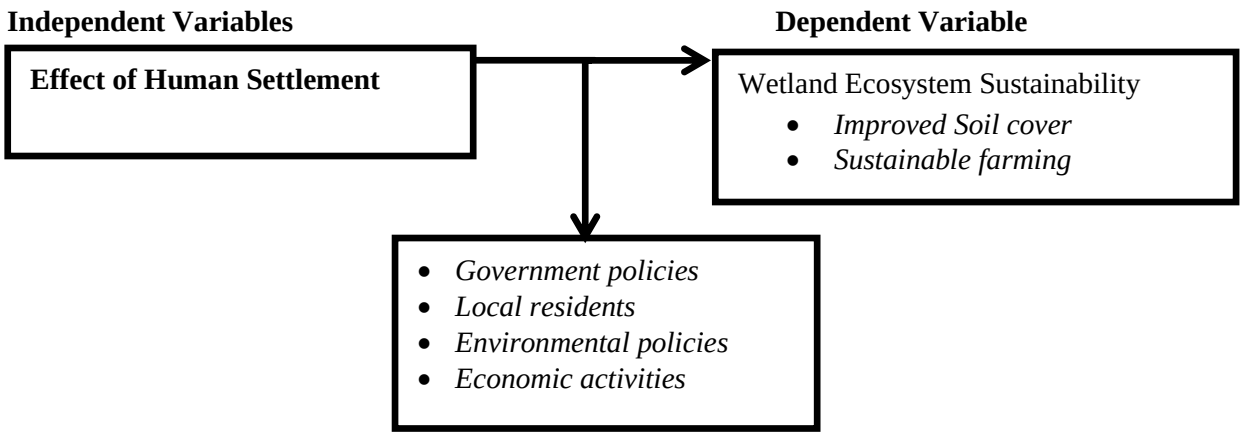
systems. However, it could benefit from a more detailed analysis of the long-term environmental impacts of these stressors. Future research should include longitudinal studies to assess the long-term effects of these activities on wetland ecosystems.

Merem *et al.*, (2019) assessed issues in Wildland Habitat Management in the State of Mississippi, noting significant wetland losses across the conterminous U.S. between the 1970s and the 1980s. Alaska experienced the least impact, with only 1% loss of its 170 million acres of wetland resources. Ohio and California experienced the most significant losses at 90% and 91%, respectively. In Canada, a study by the National Wetlands Working Group in 1988 reported significant losses of tidal and salt marshes, shoreline marshes and swamps, and estuarine wetlands due to agriculture, urban, and industrial expansion. This study provides a comprehensive overview of wetland losses in the U.S. and Canada. However, it could benefit from a more detailed analysis of the specific impacts of these activities on wetland ecosystems. Future research should integrate remote sensing data to quantify these changes and assess their environmental impacts.

Hu *et al.*, (2017) found that in Europe, overall wetland loss exceeds 50% of the original area, with significant losses in countries like the Netherlands, Germany, Spain, Greece, France, Italy, and parts of Portugal. In Africa, there is a lack of published quantitative studies on wetland losses, possibly due to lower rates of wetland losses and the lack of capacity to undertake such studies. In South Africa, over 90% of wetland resources in parts of the Tugela Basin and 58% in the Mfolozi catchment have been lost. Tunisia reports an overall loss of 15% of its wetland area. This study highlights significant wetland losses in Europe and Africa, emphasizing the need for more quantitative studies in Africa. However, it could benefit from a more detailed analysis of the specific impacts of these losses on wetland ecosystems. Future research should integrate remote sensing data to quantify these changes and assess their environmental impacts.

Whitelaw and Mazel (2023) reviewed wetland inventories in South Africa and Tunisia, noting significant losses of wetland resources. The Tugela Basin in South Africa has lost over 90% of its wetlands, while the Mfolozi catchment has lost 58%. Tunisia reports an overall loss of 15% of its wetland area. These losses are attributed to factors such as agriculture, urbanization, and industrial expansion. This study provides valuable insights into wetland losses in South Africa and Tunisia. However, a more detailed analysis of the specific impacts of these activities on wetland ecosystems would strengthen the study's conclusions. Future research should integrate remote sensing data to quantify these changes and assess their environmental impacts.

Figure 1: Conceptual Framework



Source: (Researcher, 2024)

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RESEARCH DESIGN AND METHODOLOGY

Research Design

This study used descriptive research design. The choice of a descriptive research design was motivated by its capacity to generalize findings to a broader population, offering precision and accuracy through the meticulous portrayal of events (Nayak, & Singh, 2021). The types of data collected are both primary and secondary data.

The target population of the study is 2750 households living around Lake Kenyatta in Lamu West Sub-County since they have an impact on wetland ecosystem sustainability of the Lake Kenyatta wetland (KNBS, 2023). The study also targets government officials comprising of six administrative officers (three chiefs, and three sub-chiefs) as well as four environmental officers within the Lamu County (Khamila et al., 2019).

The sample was selected from the households living around Lake Kenyatta in Lamu West Sub-County as well as key informants that included the 3 chief and 3 sub-chiefs representing each of the sub-locations extending to the lake region. Additionally, four (4) environment officers were also sampled purposively from the Lamu County Government to form part of the Key Informants in the study.

To determine the sample size from the households, the study made use of Krejcie & Morgan (1970) formulae.

$$n = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

Where: n = required sample size.

χ^2= the table value of chi-square for 1 degree of freedom at the desired confidence level (2.706025) (χ=1.645).

N = the population size (2750).

P = the population proportion (assumed to be .50 since this would provide the maximum sample size).

d = the degree of accuracy expressed as a proportion (.06).

$$n = \frac{2.706025 \text{ x } 2750 \text{ x } 0.5 \text{ x } 0.5}{0.06^2(2749) + 1.645^2 \text{x} 0.5(0.5)}$$

$$n = \frac{1860.392188}{9.8964 + 0.67650625}$$

$$n = \frac{1860.392188}{10.57290625}$$

$$n = 175$$

Using the formulae, a sample size of 175 respondents was arrived at. The primary data collection tools were questionnaires and interviews.

The quantitative data obtained from completed questionnaires were inputted into SPSS for additional descriptive statistical analysis. Descriptive statistics, including means, standard deviation, and percentages, were employed to analyze the data, and the results were presented through tables and figures. For qualitative data gathered through interviews, thematic interpretation was applied. In addition, inferential statistics were conducted to ascertain the correlation and multiple linear regressions among the study variables.

RESULTS AND DISCUSSIONS

Effect of human settlement on sustainability of Lake Kenyatta Wetland

Data was sought from residents of Lamu West Sub-County, Lamu County using a questionnaire to determine the effect of human settlement on the sustainability of Lake Kenyatta Wetland in Lamu County. Residents were asked to give their opinions whether they Strongly Disagreed (SD), Disagreed (D), Undecided (U), Agreed (A) or Strongly Agreed (SA) on the statements provided, while Chiefs, Sub-Chiefs and Environmental officers were interviewed to gain a deeper understanding of the issue. Data obtained from the respondents was analysed and the results are shared. The descriptive statistics are shown in table 1.

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Table 1 Effect of human settlement on sustainability of Lake Kenyatta Wetland

Existing Legislation and Policies		SD	D	U	A	SA
Human settlement has significantly degraded the ecological health of Lake Kenyatta Wetland.	P	14	14	0	74	58
	%	8.8	8.8	0.0	46.3	36.3
The presence of human settlements has led to a decline in water quality within Lake Kenyatta Wetland. Human activities in the vicinity of Lake Kenyatta Wetland have negatively impacted biodiversity and ecosystem balance.	P	14	0	10	40	96
	%	8.8	0.0	6.3	25.0	60.0
Human activities in the vicinity of Lake Kenyatta Wetland have negatively impacted biodiversity and ecosystem balance.	P	7	15	14	36	88
	%	4.4	9.4	8.8	22.5	55.0
The expansion of human settlements around Lake Kenyatta Wetland has contributed to habitat destruction for native flora and fauna. Human activities in the vicinity of Lake Kenyatta Wetland have negatively impacted biodiversity and ecosystem balance.	P	1	10	4	56	89
	%	.6	6.3	2.5	35.0	55.6
Human settlement practices have hindered the long-term sustainability and resilience of Lake Kenyatta Wetland's ecosystem.	P	3	5	2	83	67
	%	1.9	3.1	1.3	51.9	41.9

Source: Field data, 2024

Table 1 shows responses on effect of human settlement on the sustainability of Lake Kenyatta Wetland in Lamu County. Majority of the respondents 132(82.6%) agreed with the statement that human settlement has significantly degraded the ecological health of Lake Kenyatta Wetland, while 28(17.4%) of the respondents disagreed. Also majority of the respondents 136(85.0%) agreed that the presence of human settlements has led to a decline in water quality within Lake Kenyatta Wetland, while 10(6.3%) were undecided and 14(8.8%) of the respondents disagreed with the statement that the presence of human settlements has led to a decline in water quality within Lake Kenyatta Wetland.

Another response on human activities showed that majority of the respondents 124(77.5%) agreed that human activities in the vicinity of Lake Kenyatta Wetland have negatively impacted biodiversity and ecosystem balance. While 14(8.8%) were undecided, 22(13.8%) of the respondents disagreed with the statement. Also another response on the expansion of human settlements around Lake showed that majority of the respondents 145(90.6%) agreed, while 4(2.5%) were undecided and 11(6.9%) of the respondents disagreed with the statement that the expansion of human settlements around Lake Kenyatta Wetland has contributed to habitat destruction for native flora and fauna. Findings are in agreement with Hammer and Bastian (2020) that wetlands are often drained or filled for agriculture, urban development, or infrastructure projects. This destruction directly eliminates the habitat for numerous plant and animal species that depend on wetlands for survival.

Further, majority of the respondents 150(93.8%) agreed that human settlement practices have hindered the long-term sustainability and resilience of Lake, while 2(1.3%) were undecided, 8(5.0%) of the respondents disagreed with the statement that human settlement practices have hindered the long-term sustainability and resilience of Lake Kenyatta Wetland's ecosystem. The findings concurred with Lázaro-Lobo, and Ervin (2021) that human activities can introduce invasive plant and animal species into wetlands, which can outcompete native species for resources, disrupt food chains, and alter the structure and function of the ecosystem.

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In interviews conducted with local Chiefs, Sub-Chiefs and Environmental Officers, noted that rapid human settlement has severely degraded the wetland ecosystem. Chief [1] emphasized the increasing population around Lake Kenyatta Wetland has resulted in unsustainable land use practices such as deforestation and overgrazing, exacerbating environmental degradation. Chief [2] pointed out the, *"Decline in water quality due to uncontrolled waste disposal, stress the importance of stricter zoning laws and public awareness efforts for conservation"* (Personal communication, June 15, 2022).

Environmental Officer [1] reported that, "*Biodiversity in Lake Kenyatta Wetland has been severely impacted by human settlement. The introduction of invasive species, habitat destruction, and agricultural encroachment has disrupted the ecosystem's balance. While policies to protect the wetland exist, they mentioned that enforcement is weak and suggested that conservation efforts need to focus on strengthening community involvement and restoring degraded areas"* (Personal communication, June 20, 2022).

Inferential Analysis

The study tested hypothesis and the regression equation was first obtained using the B coefficients on the line of best fit. The decision rule was that if the p –value is less than conventional 0.05 the null hypothesis was rejected and when its above 0.05 we fail to reject the null hypothesis. Hypothesis was tested at 5% alpha level of significance (Di Leo, & Sardanelli, 2020). The findings of hypothesis testing were presented in Table 2.

Correlation Analysis Results

Table 2: Overall Correlation Analysis Results

		Human settlement	Wetland ecosystem sustainability
Human settlement	Pearson Correlation	1	
	Sig. (2-tailed)		
Wetland ecosystem sustainability	Pearson Correlation	.779**	1
	Sig. (2-tailed)	.000	
	N	160	160

***. Correlation is significant at the 0.01 level (2-tailed)*

Table 2 demonstrates that the human settlement have a statistically significant positive effect on the sustainability of the Wetland ecosystem in Lake Kenyatta Wetland, Lamu West Sub-County, Lamu County (r=0.779; p=0.00). This implies that human settlement around the lake greatly affects the sustainability of Lake Kenyatta Wetland in Lamu County.

Multiple Regression Analysis

The study used multiple linear regression analysis to determine the combined linear relationship between the dependent variable and the independent variables. Table 3 show results of model summary.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.826[a]	.683	.677	.33115

The model summary of the study shows coefficient results from correlation coefficient (R) and determination (R^2), which is the degree of association between product promotion strategy and organizational performance. According to the results in Table 3 ($R^2 = 0.683$), the effect of human settlement on wetland ecosystem have a negative impact on sustainability of Wetland. As a result, 68.3% of the variation in the sustainability of

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Wetland is attributed by the effect of human settlement on wetland.

Fitness of Regression Model

The analysis of variance (ANOVA) was used to determine if the simple regression model was fit for the data. The results were as shown in table 4.

Table 4: ANOVA for Testing Multiple Regression Model

	Model	Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	36.870	3	12.290	112.072	.000[b]
	Residual	17.107	156	.110		
	Total	53.978	159			

Findings in Table 4 shows that the dependent variable's influence was statistically significant (F=112.072; p=0.00). This implied that the multiple regression models was fit for the data, therefore the overall regression model for all the variables were statistically significant on the effect of human settlement on wetland ecosystem sustainability at Lake Kenyatta Wetland.

Regression Coefficients

The T-test of statistical significance of each regression coefficient was conducted in order to determine the beta (β) which shows how strongly each independent variable influences the dependent variable. Table 5 shows the regression analysis results.

Table 5: Regression Analysis

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	.944	.212		4.455	.000
Human settlement	-.405	.032	.616	8.898	.000

The study findings in table 5 shows the regression coefficients results whereby human settlement had a negative and statistically significant impact on wetland ecosystem sustainability at Lake Kenyatta Wetland (β=0.313, p<0.05). The multiple regression equation for impact of human settlement was as shown below:

$Y_i = 0.944 - 0.405X_1$

This implied that at constant the effect of human settlement and sustainability of the lake wetland ecosystem is at 0.944 units. The study coefficient of 0.405 showed that, reduction of human settlement by one unit boosts the sustainability of the lake wetland ecosystem of Lake Kenyatta by 40.5%.

Hypotheses Testing

The study hypothesis stated that human settlement has no significant effect on the wetland ecosystem sustainability of Lake Kenyatta Wetland in Lamu County. However, the study results revealed that human settlement has significant effect on the wetland ecosystem sustainability of Lake Kenyatta Wetland in Lamu County (β=0.405, p=0.000). The study rejected the null hypothesis, signifying that human settlement has a significant negative effect on the wetland ecosystem sustainability of Lake Kenyatta Wetland in Lamu County. The findings indicate that the more extensive the human settlement, the more it impacts the sustainability of the wetland ecosystem, as reflected by the significant beta coefficient (β = 0.405, p = 0.000). This suggests that human activities associated with settlement are strongly influencing the health and sustainability of the wetland.

CONCLUSIONS OF THE STUDY

Human settlement has affected the ecological health and balance of the wetland ecosystem. The impact of human activities have led to degradation, habitat destruction, and hindered long-term sustainability of the lake. This consensus highlights the urgent need for effective conservation measures to mitigate further

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deterioration and promote the resilience of Lake Kenyatta Wetland. The study's conclusion also emphasizes the negative relationship between human settlement and wetland ecosystem sustainability, emphasizing the destructive consequences of human activities on the natural environment.

Recommendations of the Study

Considering the diverse opinions expressed in the survey, the study recommended that stakeholders engage in comprehensive community consultations and awareness programs. Collaborative efforts involving local authorities, environmental agencies, and community leaders are crucial for implementing sustainable policies that balance economic opportunities with environmental preservation. This approach aligns with the survey's insights and supports a holistic strategy for wetland management that respects both community perspectives and ecological conservation goals.

Suggestions for Further Research

Conduct a detailed analysis of the effectiveness of current sustainable resource management practices within the wetland. Explore the ecological outcomes and socio-economic implications of these practices on fisheries, agriculture, and tourism.

Limitations of the study

This study is specific to Lake Kenyatta Wetland and may not be generalizable to other wetlands with differing ecological, social, and legal contexts. It focuses on the impact of human settlement but does not explore socio-economic factors, cultural influences, or individual environmental perceptions in depth. Additionally, while climate change may affect wetland health, the study does not examine its direct effects on Lake Kenyatta, concentrating instead on human settlement impacts.

Theoretical implications and practical applications of the study

Theoretically, this study reinforces existing ecological and environmental management theories that emphasize the detrimental effects of human settlement on natural ecosystems. It underscores the importance of applying ecological sustainability frameworks to mitigate human-induced environmental degradation. The findings align with concepts from the tragedy of the commons, where overuse of shared resources, such as wetlands, leads to depletion and long-term harm.

Practically, the study offers valuable insights for policy-makers, conservationists, and local authorities. The demonstrated link between human settlement and ecological degradation provides a basis for developing targeted interventions, such as stricter land-use regulations and sustainable resource management policies. Additionally, it calls for community-based conservation initiatives that incorporate local stakeholders in decision-making processes to ensure effective wetland preservation while addressing socio-economic needs. The study's conclusions also emphasize the need for educational programs to raise awareness about the environmental impacts of settlement activities and encourage sustainable practices at the grassroots level.

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