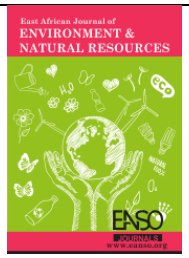

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Original Article

Thirty Years of Wetland Transformation: Socio-Ecological Drivers of Degradation in Kiborgoch, Kenya

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Wetland Degradation, Community Perceptions, Ecosystem Services, Land Tenure, Conservation Strategies.

ABSTRACT

Wetlands in arid and semi-arid regions are increasingly threatened by human activities, leading to the disruption of their ecological functions. This study investigates the socio-ecological dynamics of Kiborgoch Wetland, Kenya, over a 30-year period (1994–2024), focusing on institutional factors, land tenure, livelihood practices, and community perceptions of degradation. A mixed-methods approach was employed, combining structured household surveys (n=132) with qualitative data from focus group discussions and key informant interviews. The findings reveal that overgrazing (17.9%) is the most significant driver of degradation, alongside agricultural expansion, water overextraction, population growth, and overharvesting of wetland vegetation. While Prosopis juliflora, an invasive species, was noted as a concern by community members, it was a relatively less emphasised factor compared to direct land use pressures. Inheritance-based tenure dominates land access in the region, shaping how resources are used and managed. The wetland historically provided vital ecosystem services, including water, pasture, materials for basketry, and cultural space, but has suffered biodiversity loss, water scarcity, and soil degradation. Community narratives indicate a decline in traditional governance and ecological knowledge-sharing, weakening local conservation capacity. The study recommends integrated, community-led management strategies that merge traditional ecological knowledge with scientific practices to ensure the wetland's long-term sustainability and the protection of dependent livelihoods.

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INTRODUCTION

Wetlands are among the most productive ecosystems on earth, offering a wide range of ecological, economic, and socio-cultural services. These include water purification, flood mitigation, groundwater recharge, carbon sequestration, biodiversity conservation, and the provision of livelihood resources for rural communities (Mitsch & Gosselink, 2015; Skeie et al., 2023). However, the degradation of wetlands has become a global concern, particularly in arid and semi-arid lands (ASALs), where population pressure, land use change, and climate variability increasingly threaten their structure and function (Chen et al., 2023; Grenfell et al., 2019).

In dryland regions, wetlands are vital ecological buffers and serve as lifelines for both people and wildlife. They provide seasonal water, pasture during droughts, and wild food and medicinal plants, particularly for marginalised groups. Yet, wetlands in ASALs are under mounting pressure from unregulated agricultural expansion, overgrazing, invasive species, and settlement encroachment (Berihun et al., 2019; Roy et al., 2022). Despite their high ecological and social value, small wetlands in these regions are often poorly understood and inadequately governed. In Kenya, ASALs comprise about 89% of the national territory and support millions of people whose livelihoods are closely tied to natural resource availability (Awandu, 2023). Many of the wetlands in these landscapes remain outside formal protection frameworks and lack integrated management strategies.

The Kiborgoch Wetland, located in Baringo County, Kenya, is a prime example of a wetland facing degradation due to multiple socio-ecological pressures. Over the past three decades, this wetland has experienced significant changes in land use, hydrological regimes, and vegetation cover, driven by factors such as population growth, changing land tenure systems, and the erosion of traditional environmental governance practices. These changes have had profound impacts on the wetland's capacity to provide ecosystem services and support local livelihoods. Despite its importance, there is limited empirical data on the socio-ecological dynamics influencing the degradation of the Kiborgoch Wetland. Most existing studies have focused on biophysical assessments, with little attention given to the social, institutional, and cultural dimensions that shape wetland use and management.

This study investigated the socio-ecological dynamics contributing to the degradation of the Kiborgoch Wetland over a 30-year period (1994 to 2024). The study focused on understanding the drivers of degradation, the role of land tenure and livelihood practices, and community perceptions of wetland changes and conservation strategies. Understanding these interactions is essential for informing inclusive wetland policy and adaptive conservation planning in similar dryland ecosystems. By combining household surveys with focus group discussions, the study identified community-led conservation strategies that could support ecosystem restoration in semi-arid landscapes.

LITERATURE REVIEW

Ecological and Socioeconomic Significance of Wetlands

Wetlands are globally recognised as some of the most productive ecosystems, providing critical ecological services such as hydrological regulation, sediment retention, nutrient cycling, and biodiversity conservation (Nayak & Bhushan, 2022; Sharma & Naik, 2024). Their importance extends to socioeconomic realms, especially in rural regions where wetlands supply water,

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pasture, food, medicinal plants, and cultural services essential to livelihoods (Kundu et al., 2024; Wood et al., 2013).

Despite covering only a small percentage of the Earth's surface, wetlands offer disproportionately high ecosystem service values (Chakraborty et al., 2023), including the provision of fish, timber, agricultural inputs (Altieri et al., 2022), carbon sequestration (Nag et al., 2023), and air and water quality regulation (Imdad et al., 2023). These ecosystems also contribute to flood control, climate stabilisation, shoreline protection, habitat preservation, and recreation (Zekarias & Gelaw, 2023).

However, wetlands globally are experiencing degradation due to pressures such as drainage, land conversion, industrial and agricultural pollution, invasive species, hydrological alterations, and unsustainable human activities (Brain & Prosser, 2022). The resulting loss of ecosystem functions diminishes biodiversity and reduces the resilience of livelihoods that depend on these services (Vinayachandran et al., 2022; Singha et al., 2023). These threats also affect migratory species, particularly birds that depend on wetland habitats during critical phases of their life cycle (He et al., 2023). Additionally, swamps, mangroves, peatlands, and marshes play integral roles in global carbon cycling, further emphasising their climate relevance (Bautista et al., 2023).

Wetland Degradation

Similar to global patterns, East Africa is undergoing extensive land use changes driven by demographic and economic pressures (Berihun et al., 2019; Marchant, 2021). Forest conversion into farmland, settlements, and grazing areas has intensified, resulting in a 1% annual decline in forest cover between 1990 and 2015, amid a 2% annual population growth rate (Brandt, 2020). These transformations underscore the shrinking land availability per household and increasing pressure on ecologically sensitive areas such as wetlands. In ASAL regions, wetlands serve as ecological and hydrological lifelines, particularly during dry seasons and periods of climatic stress (Kansiime & Maimbo, 2007). These landscapes are marked by fragile ecosystems and livelihood systems that are highly dependent on natural resource availability. Agricultural expansion and overgrazing have emerged as dominant drivers of wetland decline in dryland areas (Roy et al., 2022).

Land Use and Land Cover Change (LULCC) further exacerbates degradation in ASALs. Agro-pastoralism, settlement expansion, and irrigation agriculture have transformed land cover, leading to fragmentation and sedimentation in adjacent wetlands and rivers (Abdirahman, 2021). These shifts, such as converting woodlands to croplands and grasslands to paddies, disrupt hydrological flows, increase soil erosion, and degrade water quality (Mondal et al., 2024).

Land Tenure, Access, and Invasive Species

Land tenure systems play a crucial role in shaping wetland use and conservation outcomes. In many parts of sub-Saharan Africa, informal and customary land tenure arrangements dominate, often lacking regulatory oversight and leading to open-access exploitation of natural resources (Dixon & Wood, 2003; Mwangi, 2007). Inheritance-based systems, although culturally embedded, may lead to land fragmentation and unsustainable wetland use in the absence of institutional enforcement (Rajul, 2023; Ram et al., 1999). Competing claims over scarce land and water resources often fuel local conflicts (Achiba & Lengoiboni, 2020; Dechasa et al., 2019).

Another compounding factor in ASAL wetlands is the proliferation of invasive species such as *Prosopis juliflora*. Introduced to address desertification, *Prosopis juliflora*.has since outcompeted native flora, reduced biodiversity, degraded rangelands, and intensified community-livestock conflicts (Shiferaw et al., 2019; Gichua, 2014; Wabusya, 2013).

Indigenous Governance and Community-Based Conservation

The erosion of traditional ecological knowledge and community governance structures has significantly weakened wetland stewardship

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across many rural African contexts (Franco & Luiselli, 2014; Gebrehiwot, 2022). Modern conservation models often marginalise indigenous systems, favouring externally imposed strategies that fail to align with local realities (Reed, 2008; Dawson et al., 2021). This disconnect contributes to poor conservation outcomes and eroded trust between communities and authorities.

However, communities possess deep ecological knowledge and have the capacity to co-lead restoration efforts. Incorporating local perceptions into wetland management can enhance legitimacy, foster stewardship, and increase the effectiveness of interventions (Obradović et al., 2023). Community-driven approaches such as rotational grazing, water harvesting, and seasonal restrictions offer sustainable alternatives when supported by enabling institutions (Khan, 2024; Sapkota et al., 2018; Alikhani et al., 2021).

Knowledge Gaps and the Rationale for a Socio-Ecological Approach

Despite growing interest in wetland research in Kenya, existing studies disproportionately emphasise biophysical components such as hydrology and land cover change, with limited exploration of socio-economic, institutional, and cultural drivers (Joseph, 2014; Ongoro, 2017). This narrow focus leaves critical knowledge gaps, particularly for unprotected and community-dependent wetlands like Kiborgoch, where social dynamics are central to ecosystem health.

This study addresses these gaps by employing a socio-ecological systems framework to examine the degradation of the Kiborgoch Wetland. Using household surveys, focus group discussions, and key informant interviews, the study analyses the complex interactions between land tenure, livelihood strategies, institutional transitions, and local conservation knowledge. These insights inform inclusive, context-appropriate strategies for wetland restoration and sustainable management in ASAL regions.

MATERIALS AND METHODS

Study Area

This study was conducted in the Kiborgoch Wetland, located in Baringo County, Kenya (0°22'N, 36°03'E). The wetland spans approximately 1.5 km² and is situated at 1,411 meters above sea level along the floor of the Great Rift Valley. It is a freshwater system primarily fed by geothermal springs with temperatures around 35°C and a pH of 6.4–6.9.

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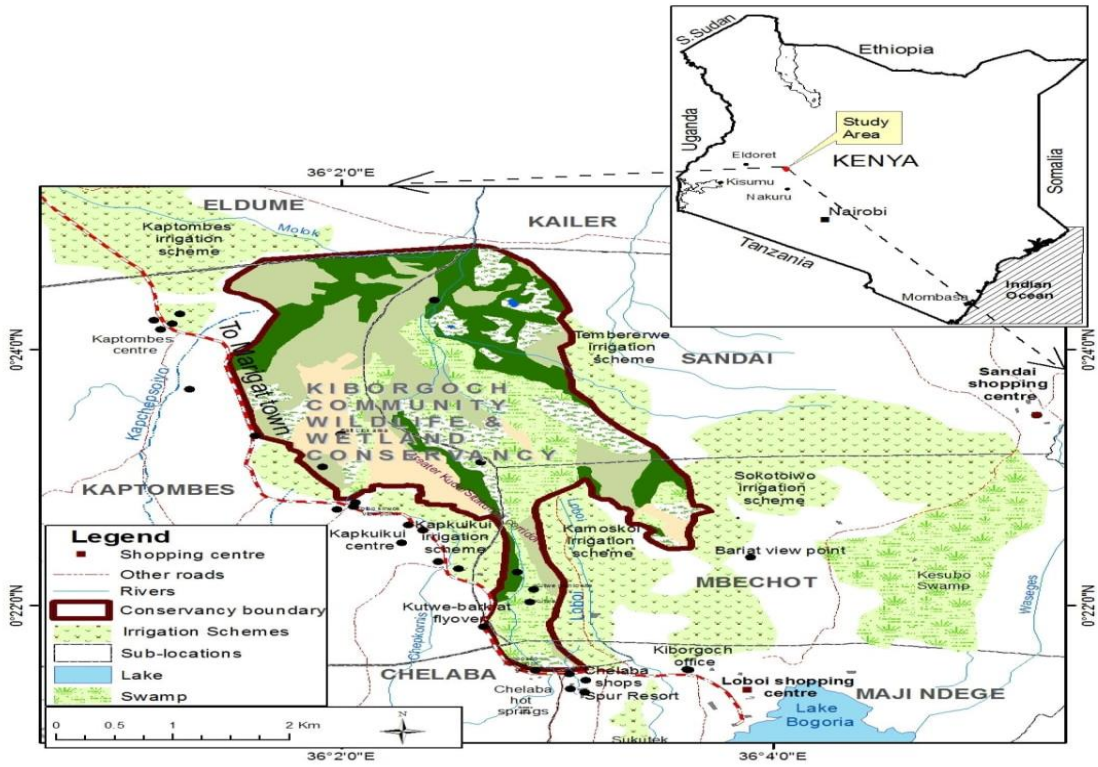
Figure 1: Geographic location of Kiborgoch Wetland in Marigat Sub-County, Baringo County, Kenya. The Wetland is Shown in Relation to Nearby Villages (Loboi, Sandai, Kapkuikui) and Hydrological Features.



Source: *Author, based on Kenya National Survey Maps (2024).*

Research Design

A mixed-methods approach was adopted to examine the socio-ecological drivers of wetland degradation. Quantitative data were gathered through household surveys, while qualitative insights were obtained from focus group discussions (FGDs) and key informant interviews.

Sampling Framework

The study focused on three locations near the wetland, Loboi, Sandai, and Kapkuikui, selected purposively due to their proximity and interaction with the wetland ecosystem. According to the 2019 Kenya National Bureau of Statistics, these areas had a combined population of 5,167 distributed across 849 households. The sample size was calculated using Yamane's (1967) formula with an 8% margin of error.

The Sample size was calculated using the formula adapted from Yamane (1967):

$n= N/ \{1+N(e)^2\}$

Where; n= Sample size, N=Population size, e= Desired fixed margin of error (8%)

$n=849/ \{1+849(0.08)^2\}$

$n=131.92$

n=132 households

A proportionate stratified sampling technique ensured representation across sub-locations. Households were selected systematically from the strata (Table 1).

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Table 1: Proportionate Sample Size per Location in Marigat Sub-County

Location	Sub location	Land (km^2)	Population (2019)	Number of households	Sample Size
Loboi	Maji/Ndege	14.6	989	161	25
	Chelaba	17.1	679	110	17
Sandai	Sandai	5.9	1217	204	32
	Mbechut	12.4	1048	170	26
Kapkuikui	Kapkuikui	40.7	739	119	19
	Kaptombes	5.5	495	85	13
Total			5,167	849	132

Source: *Modified from KNBS (2019)*

Focus Group Discussions and Key Informant Interview

Participant Selection

To complement the household survey data and deepen understanding of community perceptions, three Focus Group Discussions (FGDs) were conducted, each comprising 10–18 participants. Participants were purposively selected to ensure diversity across gender, age, and livelihood activities, allowing for a broad range of perspectives on wetland use and degradation.

Selection criteria for FGD participants included:

- Participants were required to have resided in the Kiborgoch area for at least 10 years, ensuring familiarity with long-term ecological and land use changes.
- Preference was given to individuals whose livelihoods depend directly on the wetland, such as smallholder farmers, pastoralists, water users, and basket weavers, to reflect everyday interactions with wetland resources.
- Key community representatives, including local elders, women's group members, and youth, were included to capture traditional ecological knowledge, generational perspectives, and diverse roles in wetland use and conservation.
- Three FGDs were conducted: one with women participants, another with youth representatives, and a third comprising mixed users, including elders and active wetland resource users. This structure allowed for a nuanced understanding of both historical knowledge and present-day resource use dynamics across demographic groups.

Although only three FGDs were conducted, the discussions reached thematic saturation, with participants consistently identifying common drivers of degradation and conservation challenges. The qualitative depth of the FGDs was further enriched by eight key informant interviews, which provided contextual insights into governance structures, ecological changes, and conservation practices. The key informants included**:** Two (2) local elders, Two (2) natural resource management experts, and Four (4) officials from Water Resource User Associations (WRUAs). All FGDs and key informant interviews were conducted in English, Kiswahili, and Tugen, based on participant preference. Responses given in Tugen were translated into English during transcription to ensure consistency in analysis. Trained facilitators led the discussions using a semi-structured interview protocol. The qualitative insights gathered, along with household survey data, provided a comprehensive understanding of the socio-ecological drivers of wetland degradation in the Kiborgoch Wetland**.**

Data Collection

Data were collected using semi-structured questionnaires and a guided FGD protocol. Survey questions covered land use practices, perceptions of environmental change, and resource use. FGDs focused on historical land tenure, local drivers of degradation, and community responses to ecosystem changes. Key insights from the focus group discussions were

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documented in detailed session minutes, which were later reviewed and analysed thematically.

Data Analysis

Data from the household surveys were coded and entered into Microsoft Excel, then exported to the Statistical Package for the Social Sciences for descriptive statistical analysis. Frequencies, percentages, and measures of central tendency were used to summarise respondent characteristics, land tenure patterns, and resource use. One-sample t-tests were conducted to assess the perceived importance of key wetland ecosystem services across different household livelihood categories.

Qualitative data from focus group discussions and key informant interviews were documented through detailed session minutes. These notes were manually reviewed and subjected to thematic analysis, where recurring patterns and narratives were grouped into core themes such as drivers of degradation, governance practices, and community-led conservation strategies. Triangulation between quantitative and qualitative findings helped validate emerging insights and enrich interpretation.

RESULTS

Land Tenure and Access

Inheritance is the dominant form of land acquisition among households in Kiborgoch, accounting for 78% of responses (Table 2). This form of tenure shapes land use decisions and affects resource conservation practices. Only 18.9% reported purchasing land, while lease and gifting were rare (Table 2)

Table 2: Methods of Land Acquisition Data

Method of land acquisition	Frequency	Percent	Cumulative Percent
Purchase	25	18.9	18.9
Inheritance	103	78.0	97.0
Gift	3	2.3	99.2
Lease	1	0.8	100.0
Total	132	100.0	

Source: *Author's Field data (2024)*

Livelihood Activities and Resource Dependence

Predominantly inhabited by the Tugen ethnic community, the area has shifted from traditional nomadic pastoralism to a more settled lifestyle based on livestock farming (cattle, goats, donkeys) and irrigated crop cultivation, as illustrated in Figure 2.

Livestock keeping and crop cultivation (83%) demonstrate that the majority of the community adopts a mixed livelihood strategy, integrating livestock rearing with crop farming. This reflects a strong dependence on both sectors for sustenance and economic stability. This region is well-suited for livestock keeping, as its climatic conditions support rangeland grazing, making it ideal for rearing animals (Kareri, 2018).

Subsistence crop cultivation (6%) accounts for a small portion of the population that relies solely on small-scale farming for household consumption. Additionally, 5% of respondents engage in cash crop farming, growing crops specifically for sale, thereby contributing to the local economy. Livestock keeping (4%) remains a less common standalone activity, as most people combine it with farming. Fishing (1%) is the least practised economic activity, likely due to limited water resources or alternative livelihood preferences. Lastly, 1% of the population participates in other unspecified economic activities, such as trade, small businesses, or wage employment.

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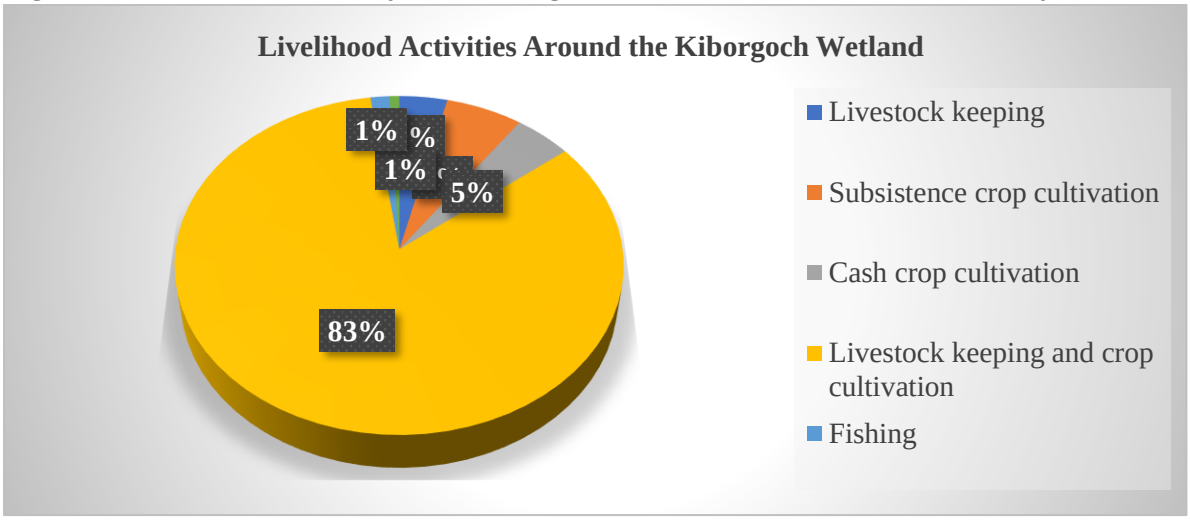
Figure 2: Socio-economic Analysis of Kiborgoch Wildlife and Wetland Conservancy

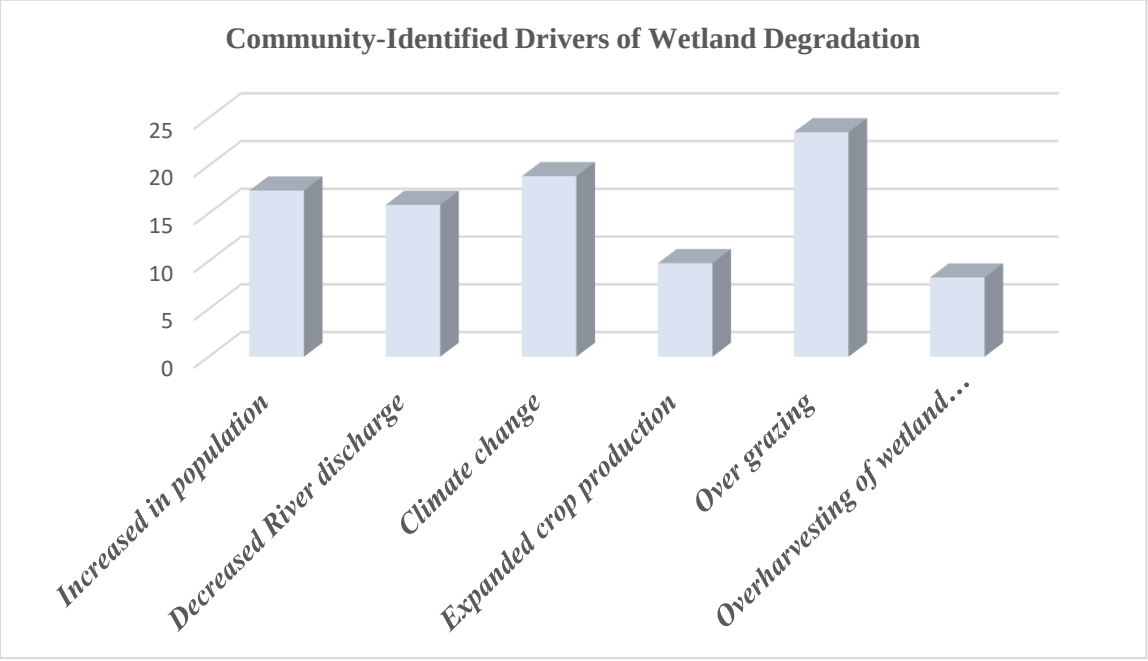


Source: *Source: Author's Field data (2024)*

Drivers of Kiborgoch Wetland Encroachment

Figure 3 provides insights into the key factors contributing to the degradation of the wetland. As part of the study's objective to analyse the drivers and extent of encroachment from 1994 to 2024, the figure highlights various influences on wetland encroachment. Overgrazing emerges as the most significant driver of wetland degradation, identified by 17.9% of respondents. This pressure leads to vegetation loss, soil compaction, and reduced water retention (Mihailou & Massaro, 2021; Skovlin, 2021). Other notable factors include agricultural expansion, population growth, climate change, and declining river discharge, which collectively contribute to wetland encroachment. Overharvesting of wetland vegetation, such as thatch grass, herbs, and building materials, was identified less frequently but still contributes to ecosystem stress, particularly through its impact on vegetation regeneration and resource availability.

Figure 3: Analysis of Main Drivers of Kiborgoch Wetland Encroachment



Source: *Author's Field data (2024)*

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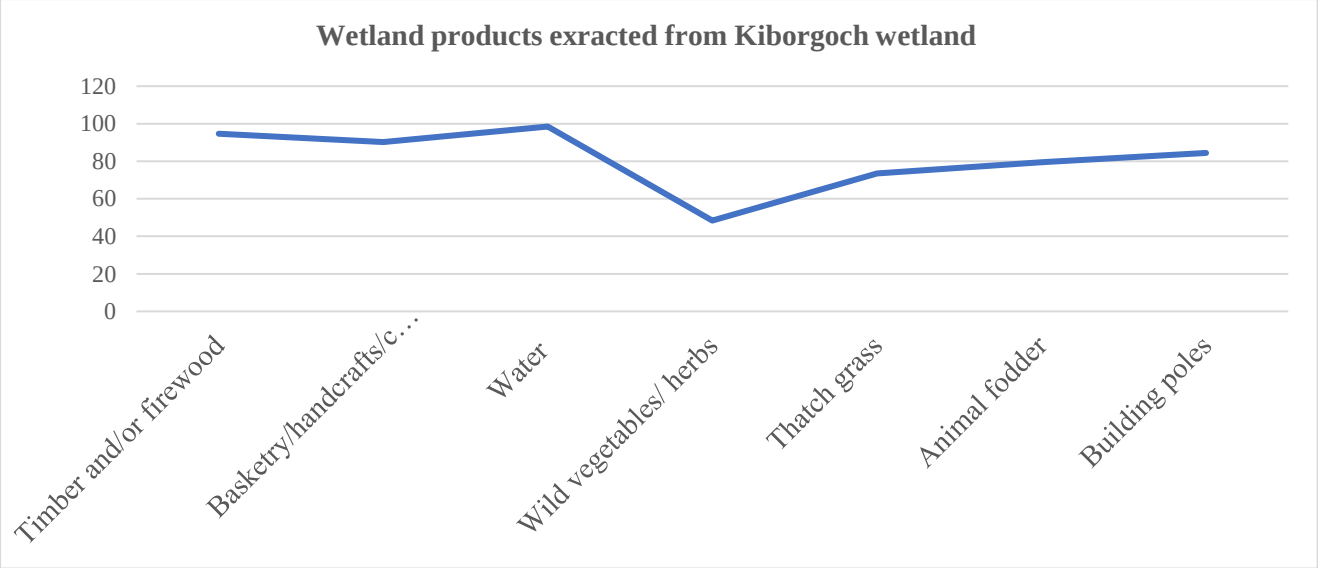
Although overharvesting of wetland plants was the least contributing factor to the degradation of Kiborgoch Wetland, it still plays a role in its decline. These wetland plants include timber and firewood, raw materials for cottage industries, basketry, and weaving, as well as wild vegetables, herbs, and thatch grass. Thatch grass, in particular, is harvested for both local use and commercial purposes by hotels and resorts. Additionally, wetland vegetation is used for animal fodder and building poles, further contributing to resource depletion.

Ecosystem Services and Livelihood Support

The wetland plays a central role in provisioning services, including water, pasture, raw materials for cottage industries, and medicinal plants (Figure 4). Statistical analysis showed high community dependence on the wetland across all categories (Table 3).

Figure 4: Percentage Distribution of Products That are Extracted from the Wetland



Source: *Author's Field data (2024)*

Importance of Wetland Ecosystem Services

To quantitatively assess the perceived significance of various wetland ecosystem services, a one-sample t-test was conducted. The results are presented in Table 3

Table 3: One-Sample t-Test Results for Perceived Importance of Wetland Ecosystem Services (n=132)

Ecosystem Service	t	df	One-Sided p	Two-Sided p	Mean Difference	95% CI Lower	95% CI Upper
Crop cultivation	23.255	131	< .001	< .001	1.5303	1.4001	1.6605
Grazing	46.531	131	< .001	< .001	1.07576	1.03	1.1215
Source of water	42.19	131	< .001	< .001	1.07576	1.0253	1.1262
Socio-cultural activities	32.063	131	< .001	< .001	1.72727	1.6207	1.8338
Cottage industry	29.521	131	< .001	< .001	1.73485	1.6186	1.8511

Note: CI = Confidence Interval

Source: *Author's Field data (2024)*

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Results from one-sample t-tests indicate that all assessed ecosystem services provided by the Kiborgoch Wetland were perceived as highly important by community members. The highest mean importance was reported for the wetland's contribution to the cottage industry (M = 1.73, SD ≈ 0.1), followed closely by socio-cultural activities (M = 1.73) and water provision (M = 1.08). Each service had a statistically significant mean value (all $p < .001$), suggesting strong community reliance and value attribution (Table 3). These findings underscore the wetland's multifaceted role in supporting livelihoods and cultural heritage within the region.

Provisioning Ecosystem Services of the Kiborgoch Wetland

The Kiborgoch Wetland provides a wide array of provisioning ecosystem services that are vital to the well-being and livelihoods of the surrounding community. These include access to water, wild foods, building materials, and natural products used in both household and economic activities.

Water Access and Use

Households in the region rely heavily on the wetland for water used in domestic chores, irrigation, and livestock rearing. As shown in Table 4, 63.6% of respondents reported using the wetland or the adjacent River Loboi for irrigation purposes, while the rest either did not engage in irrigation or had alternative sources. Water scarcity during dry periods has become more pronounced, with focus group participants linking reduced flow to upstream abstraction and land use changes.

Table 4: Household Use of Kiborgoch Wetland or River Loboi for Irrigation Farming

Frequency	Percent	Valid Percent	
Yes	84	63.6	63.6
No	14	10.6	10.6
Not applicable	34	25.8	25.8
Total	132	100.0	100.0

Source: *Author's Field data (2024)*

Wild Plants and Edible Products

About 48% of households reported harvesting wild vegetables, fruits, and medicinal herbs from the wetland (Figure 5). These natural foods play a supplementary role in household nutrition, particularly during periods of food insecurity. Traditional healers also depend on indigenous wetland plants for herbal remedies. However, participants noted that overharvesting, land clearance, and the spread of *Prosopis juliflora* have reduced the availability of these plant resources.

"We used to get herbs for stomach pains and fruits for children. Now, we find fewer every year." — FGD Participant, Kapkuikui.

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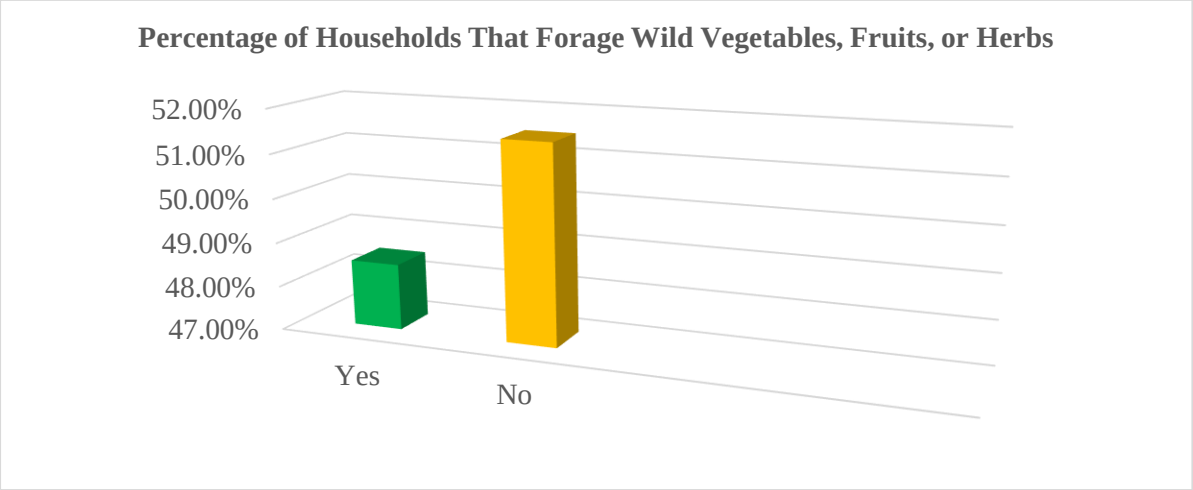
Figure 5: Consumers of Fruits, Vegetables or Herbs



Source: *Author's Field data (2024)*

Construction and Cottage Industry Materials

Wetland vegetation, especially thatch grass and reeds, serves as raw material for local construction and small-scale industries. These materials are used for roofing, fencing, and weaving baskets or mats, sustaining cottage industries led predominantly by women. As seen in Table 5, 87.1% of respondents categorised these products as either "important" or "very important" for household use or income generation. The collection of thatch grass is particularly notable, with participants reporting that nearby hotels and resorts also source it commercially from the area.

Table 5: Importance of the Wetland as a Source of Materials for Construction and Cottage Industry

		Frequency	Percent	Valid Percent	Cumulative Percent
	Very important	52	39.4	39.4	39.4
	Important	63	47.7	47.7	87.1
	Less important	17	12.9	12.9	100.0
	Total	132	100.0	100.0	

Source: *Author's Field data (2024)*

Impacts of Encroachment

Encroachment has led to biodiversity loss, with 56.8% of respondents observing declines in birds and wildlife. Habitat shifts and increased human-wildlife conflict were also noted (Figure 6).

"The frogs and birds are gone. Before, you would hear them every morning**."** *Elder participant, FGD 2.*

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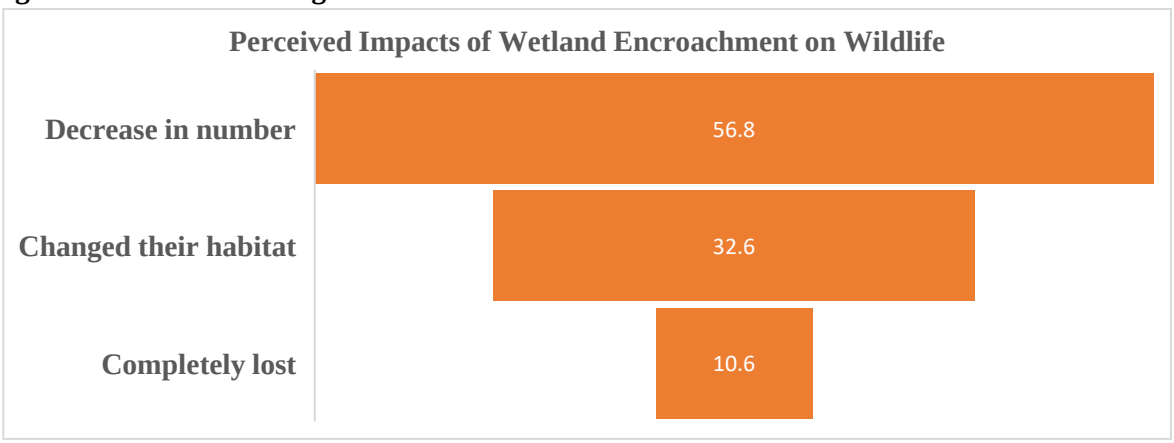
Figure 6: Effects of Kiborgoch Encroachment on Birds and Wildlife



Source: *Author's Field data (2024)*

Community Perceptions and Focus Group Insights

Target Group

The Focus Group Discussion (FGD) was conducted with the local community members of the Kiborgoch Community Wildlife and Wetland Conservancy, a group representing a broad spectrum of ages and genders. The participants were drawn from a heterogeneous group, with ages ranging from 18 to 76 years. This age diversity ensured that a wide range of perspectives, from youth to elders, were included in the discussion. The group consisted of between 10 to 18 participants, allowing for a rich, yet manageable, dialogue. The FGD lasted approximately 2.5 hours, providing enough time for participants to share their experiences, insights, and opinions regarding the conservation efforts and the condition of the wetland resources. The discussion was structured to encourage active participation from all members, ensuring a comprehensive understanding of the community's views and concerns.

Probing Question and Participants' Responses

FGD participants shared limited but valuable views, indicating moderate knowledge of wetland conservation and a need for greater community engagement (Table 6). Key themes included wetland history, land tenure, and drivers of degradation. Data were recorded in audio-visual formats and transcribed.

Table 6: FGD Matrix Design

Main topic		**FDG method**	**Indicator**
General	**Specific**		
History of land uses and tenure, drivers and negative effects of interference with the wetland	Main drivers of the wetland encroachment The main effects associated with encroachment	By discussing, brainstorming with the guidance of FGD questions	Problem solving priority; Potency and constraint; A model concept of implementation plan of appropriate technology for water and sanitation issues
Investigating local perceptions and obtaining recommendations to enhance the condition of the degraded wetland.	Vulnerable persons are mostly affected by the negative effects. Socio-economic/cultural opportunities that exist in the wetland		

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Main topic		FDG method	Indicator
General	**Specific**		
Clarify the current sanitation conditions based on the field survey that has been conducted.	History of the changes in the land tenure system		
	Problems facing the land users that may be contributing to the interference with the Kiborgoch wetland Recommendation for sustainable use		

Community Perceptions and Focus Group Insights

FGDs revealed detailed perceptions of ecosystem change, land tenure transitions, and conservation opportunities. Women and elders were identified as disproportionately affected by degradation due to water scarcity and pasture decline (Table 7)

Quote:

"Women suffer the most. We fetch water, and now the water is far and dirty." *Woman participant, FGD 1.*

"Our elders can't take animals far to graze anymore. They lose their animals due to poor feeding," *Youth participant, FGD 1.*

Table 7: Community and Environmental Vulnerabilities

Group Affected	Vulnerability Type	Cause
Women and children	Water access, safety	Wetland degradation, wildlife threat
Elderly livestock farmers	Loss of pasture	Invasive species, water shortage
Wildlife	Habitat loss, food scarcity	Human encroachment, human-wildlife competition

Source: *Author's Field data (2024)*

Community-Led Conservation Proposals

Participants proposed various solutions, including water harvesting, on-farm pasture development, and restoration of traditional grazing systems. Organic farming and Prosopis management were among key strategies (Table 8).

Verbatim Responses:

"We started collecting water from our rooftops. It helps during dry seasons." *Key informant, Kiborgoch Wetland Conservancy.*

"Let's plant fruit trees and keep the wetland for grazing only in dry seasons." *Key informant, Sotiche women's group women*

"If we make hay and store it, we won't need to bring cows into the wetland." *Youth FDG Kiborgoch.*

Table 8: Community-Recommended Strategies for Wetland Conservation

Strategy	Expected Outcome
Water harvesting (rooftop, pans)	Drought resilience
Organic farming	Reduced chemical pollution
Invasive species management	Restoration of native vegetation
On-farm pasture development	Reduced pressure on the wetland

Source: *Author's Field data (2024)*

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Historical Land Use and Governance Transitions

The historical governance of the Kiborgoch Wetland was deeply rooted in the customary practices of the Kalenjin community, particularly the Juma, Sawe, and Korongoi age-sets. These age-set groups played a pivotal role in demarcating ecological zones for livestock grazing, plant harvesting, and water extraction. Under this system, the wetland was protected through seasonal restrictions: during the wet season, livestock were grazed on surrounding hills while the wetland regenerated; plant harvesting was suspended and resumed only when ecological conditions permitted.

These practices were enforced by local elders who served as custodians of the landscape. Governance relied on oral traditions and collective memory, with violators facing social sanctions such as fines, exclusion from communal resources, or public reprimand. This communal ethic fostered long-term ecological stewardship and ensured that wetland use remained within sustainable limits.

By the 1970s, agricultural activities—primarily manual crop cultivation and forage harvesting—were introduced, still regulated by elder councils. However, between 1985 and 1990, the arrival of tractor-based cultivation marked the beginning of more intensive land use. Fertile soils and high-yield horticulture (e.g., melons, pawpaw, mangoes) attracted migrants and speculative land buyers, triggering the shift from communal tenure to individualised ownership. This transition weakened traditional institutions, fragmented collective decision-making, and enabled unregulated access to the wetland.

*"*In the past, we grazed here in turns. Elders made rules. Now, anyone can enter any time." Elder, *FGD Kapkuikui*

*"*Land buying started when irrigation farming became profitable. People came from other places." *Community member, FGD Sandai*

Between 1997 and 2000, the introduction and rapid spread of *Prosopis juliflora*—a drought-tolerant species introduced by the government to combat desertification—further disrupted the ecosystem. The plant aggressively outcompetes native vegetation, alters soil chemistry, and reduces the availability of quality forage, forming dense thickets that limit human and livestock movement. The redirection of the Loboi River's flow during this period also contributed to declining water levels and worsened ecological stress.

*"*We were not taught the old ways. Now everyone just farms or grazes where they can*." Young male farmer, FGD Loboi*

DISCUSSION

This study examined the socio-ecological drivers of degradation in the Kiborgoch Wetland over a 30-year period, revealing a complex interplay between land tenure, livelihood pressures, governance changes, and ecosystem service dependence. Findings from household surveys and focus group discussions indicate that degradation is largely anthropogenic, with overgrazing, agricultural expansion, and unregulated water abstraction identified as the most significant contributors. These drivers reflect broader patterns observed in arid and semi-arid landscapes (ASALs) across East Africa, where increasing population and resource competition continue to place stress on fragile ecosystems (Berihun et al., 2019; Grenfell et al., 2019). Despite its relatively small size, Kiborgoch Wetland provides critical ecological and socio-economic functions. Its degradation thus underscores the urgency of integrating localised conservation with national and global policy frameworks. The Ramsar Convention emphasises that all wetlands, regardless of legal protection or size, are vital to biodiversity and human well-being and must be managed wisely (Ramsar Convention on Wetlands, 2018).

A key structural driver of degradation is the region's land tenure system. Approximately 78% of households reported inheriting land through familial lineage, a practice that ensures continuity of access but also contributes to land fragmentation and weakened collective

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accountability. The absence of strong customary or formal enforcement mechanisms further exacerbates the challenge. These findings align with studies from other ASAL contexts, where informal land rights and shifting demographics complicate sustainable resource governance (Barbier et al., 2011; Abdirahman, 2021). In Kiborgoch, the breakdown of traditional Kalenjin age-set institutions, once responsible for regulating seasonal access to wetland resources, has diminished local stewardship. Factors such as population growth, land commodification, and generational shifts have contributed to the erosion of these systems, opening the wetland to unregulated exploitation. Water abstraction from geothermal springs, particularly Maji Moto and Kamoskoi, emerged as a significant concern. Community narratives and field observations confirmed declining water levels, attributed to unregulated extraction. This has disrupted natural flow regimes, reducing the wetland's capacity to support traditional uses like livestock watering and small-scale irrigation. These trends are consistent with findings from other small wetland systems, where even moderate hydrological stress can trigger rapid ecological decline (Davidson et al., 2019; Osland et al., 2022).

Livelihood dependence on wetland resources further intensifies pressure on the ecosystem. The community relies heavily on vegetation such as thatch grass, reeds, and herbs for cottage industries and household use. Women, in particular, depend on these materials for basket weaving and herbal medicine, yet overharvesting has pushed resource use beyond sustainable thresholds. This mirrors patterns in other dryland wetlands, where overexploitation leads to biodiversity loss and undermines the very resources critical to vulnerable groups (Kingsford et al., 2016). These dynamics align with broader sustainability concerns raised by global assessments, including the UNEP Emissions Gap Report, which highlights how ecological degradation in vulnerable regions deepens social inequalities and weakens climate resilience (UNEP, 2020). The spread of *Prosopis juliflora*, introduced in the late 1990s to combat desertification, has become a particularly harmful ecological stressor. Focus group participants and key informants described the invasive species' rapid expansion, its displacement of native vegetation, and its role in altering soil chemistry. The species has also restricted access and movement for both people and livestock, reducing forage availability and contributing to ecosystem instability. These effects illustrate the unintended consequences of poorly contextualised ecological interventions and point to the importance of community-informed invasive species management (Shiferaw et al., 2019; Gichua, 2014).

Quantitative findings from a one-sample t-test (Table 3) further confirmed the wetland's importance to the community. Ecosystem services, including water provision, grazing, raw materials, and cultural values, were all rated as highly significant, with p-values less than .001. This underlines the wetland's multifunctionality and its contributions to subsistence and local economies, especially among women (Lamsal et al., 2015). The recognition of these services supports calls to integrate ecosystem service valuation into conservation planning frameworks (Hambäck et al., 2023). The ecological consequences of ongoing degradation are already evident. Respondents reported reduced bird and amphibian populations, loss of wildlife, and increased human-wildlife conflict. These signs point to broader ecosystem destabilisation affecting biodiversity, public health, and livelihoods. Declining water quality and availability were linked to rising cases of waterborne diseases, while pasture loss has led to reduced livestock productivity. These cascading effects highlight the vulnerability of ASAL communities and the urgent need for integrated conservation strategies (Partridge & Finlayson, 2022; Kipkemboi, 2016).

Despite the challenges, community-driven solutions proposed during FGDs reflect local ecological knowledge and a readiness to engage in restoration. Suggested practices such as rotational grazing, organic farming, pasture regeneration, and water harvesting offer a strong

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foundation for sustainable wetland use. To operationalise these practices, institutional support is essential. Strengthening community conservancies, formalising wetland bylaws, and building capacity through Water Resource User Associations can reinforce governance and improve conservation outcomes.

This study is not without limitations. Language posed a constraint, as some FGDs and interviews were conducted in Tugen and later translated into English. While bilingual facilitators were engaged and translations cross-verified, some cultural nuances may have been lost. Additionally, reliance on qualitative data from community perceptions may not fully capture biophysical processes. However, field observations and secondary data (e.g., satellite imagery and land cover maps) were used to validate findings. Future research should incorporate more detailed biophysical assessments, including vegetation surveys, water quality analysis, and GIS-based land use mapping, to complement community insights and enhance understanding of wetland transformation.

CONCLUSION

This study examined the socio-ecological dynamics of wetland degradation in the Kiborgoch Wetland over a 30-year period, revealing how land tenure transitions, livelihood pressures, and the erosion of traditional governance have accelerated environmental decline. Community reliance on the wetland for water, grazing, wild plants, and income-generating activities highlights its central role in sustaining rural livelihoods, yet also underscores the vulnerability of the ecosystem to overexploitation.

Findings show that degradation is primarily driven by anthropogenic activities, especially overgrazing, agricultural expansion, and water abstraction, exacerbated by weak institutional enforcement and the spread of invasive species. Despite these challenges, the community demonstrates strong ecological knowledge and a willingness to engage in locally led conservation. Sustainable wetland management in dryland contexts like Kiborgoch wetland will require inclusive strategies that integrate traditional stewardship practices with science-informed interventions. Supporting community institutions, formalising local conservation bylaws, and investing in nature-based solutions can promote ecological restoration while safeguarding the livelihoods of wetland-dependent populations.

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