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Wetland Ecosystem Service Use and Household Welfare: Econometric Evidence from the River Nyando Basin, Kenya

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Abstract

Wetland ecosystems play a critical role in supporting rural livelihoods and maintaining environmental sustainability, yet they face increasing pressure from overutilization, weak institutional frameworks, and rapid land-use conversion. While general livelihood studies exist, there remains a critical empirical knowledge gap regarding the precise quantitative influence of specific wetland ecosystem services on household economic well-being, as monetary metrics that correlate household utility with vital regulating and cultural services are historically missing from national statistics. This study determined the influence of wetland ecosystem service utilization on household welfare and economic well-being within the River Nyando Wetland ecosystem in Kisumu County, Kenya. Grounded in Welfare Economics Theory and Common-Pool Resource (CPR) Theory, the study adopted an explanatory research design incorporating a cross-sectional descriptive survey. Primary data were collected from 377 randomly selected riparian household heads using structured questionnaires, key informant interview guides, and focus group discussion schedules. The study employed a multistage sampling strategy that combined purposive selection of sub-counties, stratified grouping of locations, and systematic random sampling of homesteads. A Binary Logistic Regression model regression model was used for data analysis to evaluate the socio-economic, spatial, and institutional determinants driving the continuous intensity of wetland resource utilization. The empirical results revealed that household income ($\beta = 0.318$, $p = 0.002$), land ownership status ($\beta = 0.263$, $p = 0.007$), and access to agricultural extension services ($\beta = 0.391$, $p = 0.002$) had statistically significant positive impacts on wetland utilization intensity, with a one-unit increase in income expanding the odds of household welfare improvement by 37%. Conversely, formal education level ($\beta = -0.287$, $p = 0.010$), physical distance to the wetland basin ($\beta = -0.451$, $p = 0.001$), and environmental policy awareness ($\beta = -0.277$, $p = 0.016$) exerted statistically significant negative effects on extraction intensity, with each additional kilometer of distance reducing the likelihood of wetland service use by 36%. The study concludes that while higher asset endowments and institutional resources enhance resource extraction efficiency to boost immediate well-being, a severe skills-resource mismatch prevents formal education from translating into sustainable welfare. Furthermore, current environmental policy awareness acts as a regulatory constraint that depresses immediate utility due to a lack of economic alternatives. The study recommends a three-pronged policy matrix: establishing specialized Technical and Vocational Education and Training (TVET) centers to equip educated residents with green- and blue-economy skills; designing a localized Payment for Ecosystem Services (PES) framework to financially reward conservation compliance; and decentralizing extension service delivery to deploy eco-friendly technology packages, such as solar irrigation pumps and non-destructive gear, along the wetland fringe.

Keywords: Binary Logistic Regression Model; Household Welfare; Knowledge Gap; River Nyando Wetland; Wetland Ecosystem Services.

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INTRODUCTION

Wetlands are among the world's most biologically productive and economically valuable ecosystems, providing essential services that sustain human life and environmental stability. Global natural wetlands are estimated to cover approximately 5–8% of the earth's land surface (Mitsch & Gosselink, 2000; Convention on Wetlands, 2018), functioning as critical natural capital that supplies provisioning services like food and raw materials, regulating services such as climate regulation and water purification, and diverse cultural benefits (Costanza et al., 1997; Leviston et al., 2018; Peng et al., 2019). Recognizing that global and regional climate changes threaten these vital resources on which human survival thrives, international frameworks such as the Ramsar Convention on Wetlands of 1971, the Rio de Janeiro Conference, the Kyoto Protocol of 1995, and the Copenhagen Climate Meeting of 2009 emerged to universalize wetland conservation and promote the "wise use" of over 1,800 internationally designated sites. However, in major economies like the USA, Bangladesh, China, India, Vietnam, and Russia, the growing demand for urbanization, accommodation, food commodities, fresh water, and fuel has driven human activities that swiftly and often irreversibly destroy these ecosystems, leading to a permanent loss of services (Peng et al., 2019). This global decline is driven by natural and anthropogenic stressors that invariably affect the physical, chemical, and biological characteristics critical to wetland health and functioning capacity (Miller, 2018). While the value of these services is gaining popularity in ecological economics, a degraded ecosystem triggers severe environmental contamination, biodiversity loss, land degradation, extreme climatic events, heightened urban heat effects, and increased public health risks, demonstrating that a spatial and environmental examination is critical for local, regional, and national planning (Miller, 2018).

In Sub-Saharan Africa, and specifically within Kenya, wetland ecosystems are vital pillars for rural development and national biodiversity conservation, yet they face severe environmental pressures. A critical example is the River Nyando Wetland, a deltaic ecosystem located on the eastern shores of Lake Victoria, Kenya, covering approximately 14,400 hectares, though its physical extent varies seasonally due to hydrological fluctuations (Oduor et al., 2016; Raburu, Okeyo-Owuor, et al., 2012). This lower basin ecosystem experiences a dynamic bimodal rainfall pattern that regulates seasonal flooding and water recession, creating highly fertile zones. Beyond its local geography, the Nyando wetland plays a crucial regional role by acting as a natural filter that traps sediments, retains nutrients, and purifies water before it drains into the Winam Gulf of Lake Victoria, thereby safeguarding the health of the entire shared water body (Oduor et al., 2016; Raburu, Okeyo-Owuor, et al., 2012). Despite these foundational benefits, studies in East African countries by Adunde et al. (2023), Barasa et al. (2021), and Muendoh & Sakwa (2024) link widespread wetland conversion to reduced flood regulation and severe water quality issues, causing adverse ripple effects on regional agriculture and public health.

For rural communities living along the fringes of the Nyando wetland, there is a well-documented, strong association between the ecosystem's services and community livelihoods (Baffoe et al., 2021). These households are intrinsically linked to the wetland's natural cycles, relying heavily on its provisioning services as vital safety nets that supply food, income, and other critical services during lean seasons or in the face of shocks (Baffoe et al., 2021b). Specifically, the lower Nyando basin supports intensive agricultural activities, livestock rearing, and artisanal fisheries (Maithya et al., 2022; Rongoei & Kariuki, 2019). Local families depend on these open-access resources for their daily subsistence and income generation, harvesting water, food, fodder, papyrus products, basketry materials, and

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construction materials (Maithya et al., 2022; Rongoei & Kariuki, 2019). By providing these essential goods and income streams for free, the wetland serves as a foundational economic driver that directly offsets household living costs and prevents acute destitution.

Despite the immense economic value generated by the Nyando wetland, the surrounding region is trapped in a cycle of deepening poverty and accelerating environmental degradation driven by rapid population growth, agricultural expansion, and frequent climate shocks such as flooding and drought. This survival-driven extraction has intensified threats such as land use and cover change, poorly managed drainage projects, increasing population pressure, intensification of agriculture, increased settlement density, infrastructural development, invasive species, pollution, and climate variability. These stressors have continued to alter hydrological regimes and reduce wetland extent and functionality without conservation being considered, yet the benefits of conserving these ecosystems are often far greater than the benefits associated with their alteration (Miller, 2018). Consequently, these compounding threats have resulted in the loss of direct livelihood goods, reduced water quantity and quality, increased exposure to hazards, a decline in community adaptive capacity, market and institutional impacts, and highly unequal gendered and intergenerational effects.

The River Nyando Basin in Kisumu County, Kenya, is an ecologically significant system that provides sustainable wetland ecosystem services (WES) to support riparian livelihoods. These vital services include water provisioning, food production, flood control, and natural water purification. Sustainable utilization of these resources, supported by robust and transparent governance structures, is essential to ensure that the ecosystem contributes effectively to regional poverty reduction and biodiversity conservation. Effective wetland management requires that conservation authorities implement integrated institutional arrangements that simultaneously improve local socio-economic conditions and protect core ecosystem attributes. Currently, the River Nyando wetland is trapped in a destructive "poverty-environment" cycle. High dependency, driven by a population where 42% of individuals are under the age of 15, and rising poverty levels, force local communities to exploit natural resources unsustainably. Approximately 80% to 85% of the local population derives its livelihood directly from the wetland, with 40% having no alternative means of economic support. This intensive extraction has caused catastrophic ecological degradation. For instance, wetland vegetation cover in critical zones like Nyangongo has plummeted from 73% to 18% due to rapid agricultural expansion, overfishing, and localized pollution. This ecological crisis is severely exacerbated by lax institutional practices in Kenya and "mandate overlaps" among conflicting government ministries, which lead to systemic confusion among stakeholders and an inability to avert ecosystem loss. A major driver of this ongoing degradation is that wetlands in the Lake Victoria basin have historically been undervalued, largely because the complex interplay between household socio-economic characteristics and wetland dependence is rarely captured in national economic statistics. While general livelihood studies exist, there remains a critical empirical knowledge gap regarding both the drivers of resource use and the precise quantitative influence of specific wetland ecosystem service utilization on household welfare in the River Nyando Wetland ecosystem. To address this gap, the primary objective of this study was twofold. Firstly, we modeled the determinants of ecosystem service utilization intensity among riparian households, which provided the findings for this paper. Secondly, we evaluated the subsequent effect of this utilization on household welfare by estimating the economic value of these services and the welfare losses associated with their potential degradation using a Compensating Variation (CV) approach. Specifically, this study applied a Binary Logistic regression model to evaluate how factors such as household income, size, education level, distance to the wetland,

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land ownership, access to extension services, primary occupation, and environmental policy awareness drive ecosystem service utilization. Generating this empirical evidence was essential to counter the historical mismanagement of the delta, justify community-led conservation, guide sustainable resource management, and inform evidence-based development planning in the Lake Victoria Basin."

Theoretical Framework

The theoretical foundation of this study was anchored in Welfare Economics Theory, which evaluates how changes in resource allocation, environmental quality, and institutional arrangements affect aggregate human well-being and economic efficiency. Within this paradigm, the River Nyando wetland was conceptualized as a critical natural capital asset that provides a continuous flow of ecosystem services directly affecting riparian households. When these ecological flows are altered by extraction, environmental degradation, or conservation policies, household well-being shifts. To operationalize these macroeconomic shifts at the household level, this study used the Indirect Utility Function model. This model relates household utility not only to standard market commodities but also explicitly to the extraction and consumption of specific Wetland Ecosystem Services (WES) under traditional budgetary constraints. Under this framework, any change in a household's intensity of wetland use or access moves the household to a different utility frontier. These welfare adjustments are measured empirically using the concept of Compensating Variation (CV), which quantifies the monetary trade-offs, expressed as Willingness to Pay (WTP) for ecosystem preservation or Willingness to Accept (WTA) compensation for resource restriction, required to keep household utility constant.

Because household decisions about ecosystem service use and participation in conservation involve discrete choices, the study used the Random Utility Model (RUM) to bridge microeconomic theory and econometric estimation. The RUM posits that an individual household's true utility is latent and consists of two components: a deterministic element, which can be predicted from observable socioeconomic characteristics (such as income, education, and proximity), and a stochastic error term representing unobservable idiosyncratic preferences. To classify and measure these service flows within the utility function, the Total Economic Value (TEV) framework is used as an analytical taxonomy. The TEV framework systematically disaggregates the wetland's contributions into direct use values (provisioning services like fisheries and papyrus harvesting), indirect use values (regulating services like flood mitigation and natural water purification), and non-use values (cultural and existence values). This allows the study to trace how the use of specific ecosystem service categories interacts with household choices to alter overall economic well-being. Finally, this microeconomic valuation framework is contextualized by Common-Pool Resource (CPR) Theory and Property Rights Theory, which explain the institutional and behavioral drivers governing resource extraction intensity and its impact on welfare. The River Nyando wetland exhibits classic CPR characteristics: high subtractability of use combined with difficulty of exclusion. Property Rights Theory explains how weak enforcement, overlapping institutional mandates, and poorly defined tenure systems transform parts of the wetland into an open-access regime. This institutional vacuum distorts economic incentives, forcing capital-constrained households to prioritize short-term provisioning extraction over long-term conservation. Consequently, communities become trapped in a destructive poverty-environment cycle where rising poverty accelerates resource depletion, which in turn degrades the non-market regulating services that stabilize household welfare. By combining these institutional theories with welfare economics, the study establishes a holistic framework capable of evaluating how the specific use of wetland services directly influences household economic welfare.

Conceptual Framework

The conceptual framework maps out the structural pathways through which wetland ecosystem service use and household socio-economic characteristics interact to determine overall household economic welfare. At the core of this framework was the direct link between the independent variables, comprising household socio-economic welfare indicators, environmental, and institutional factors, and the dependent variable, which was household welfare. The socio-economic factors (household income, size, education level, distance to the wetland, and primary occupation) and institutional factors (land ownership, access to agricultural extension services, and environmental policy awareness) directly dictate a household's capacity, dependency, and intensity of wetland resource use. This resource utilization is categorized via the TEV framework into provisioning services (such as papyrus harvesting, fisheries, and agricultural cultivation) and regulating services (such as flood mitigation and water purification). Concurrently, the framework recognizes institutional governance and conflicting ministerial mandates as key intervening variables that can either mitigate or accelerate wetland degradation. Ultimately, the interaction between resource extraction intensity and socio-economic drivers determines the outcome variable: household economic well-being. This well-being is empirically captured through changes in household utility, income generation, and measured welfare shifts within the Compensating Variation framework.

METHODOLOGY

Research Design

This study adopted an explanatory mixed-methods research design, integrating a quantitative cross-sectional household survey with qualitative contextual inquiry to comprehensively analyze wetland ecosystem service utilization. Specifically, the quantitative component utilized a cross-sectional descriptive survey to investigate the structural relationships between wetland resource use and household well-being, applying econometric estimations and demand-side valuation models to measure how the utilization of specific wetland ecosystem services impacts key household welfare outcomes, such as total income, family food security, and health status (Babbie, 2020). Conversely, the qualitative component leveraged key informant interviews (KIIs) and focus group discussions (FGDs) to capture narrative data on household motivations and institutional factors.

The adoption of this explanatory mixed-methods design is justified because it successfully combined quantitative data collection with qualitative insights to generate both robust statistical findings and deep contextual explanations (Creswell & Creswell, 2018). While the econometric models provided the necessary analytical rigor to quantify the determinants and welfare impacts of resource utilization, they often mask the underlying socio-cultural dynamics and institutional behaviors driving these patterns. Engaging in qualitative inquiry directly addresses this limitation by uncovering the hidden dynamics behind the statistical trends, enabling empirical triangulation via community narratives to minimize measurement error and enhance overall data reliability. Ultimately, integrating quantitative economic valuations with qualitative institutional context produces a more comprehensive, policy-relevant analysis necessary for guiding sustainable resource management in the River Nyando wetland ecosystem.

The Study Area

Geographical and Administrative Location

The study was conducted within the River Nyando wetland ecosystem, which is a deltaic complex situated across the Nyando and Nyakach sub-counties within Kisumu County, Kenya (Government of Kenya (GoK), 2010). Geographically, this wetland lies between latitudes 0°11' S and 0°19' S, and longitudes 34°47' E and 34°57' E. The ecosystem forms a substantial floodplain that encompasses the expansive Nyakach and Kano swamps, maintaining an average elevation of 1,134 meters above sea level (Raburu et al., 2012). It stands as one of the most prominent wetland networks within the Lake Victoria basin, and it is officially recognized as the second-largest wetland in Kenya after the Tana River Delta (Njuguna & Howard, 1992; Okotto-Okotto et al., 2016).

Administratively, the overarching Nyando River basin spans 3,517 square kilometers, the Nyando sub-county encompasses 1,168 square kilometers, and the specific focus area of the Lower River Nyando Basin covers approximately 500 square kilometers (Bloemertz, 2014). The spatial scope of this research covers six specific locations and their corresponding sub-locations, which include the sub-locations of Border II, Ayucha, Border I, and Wang'aya within the Awasi location. It also includes the sub-locations of Kakola/Ombaka, Kakola Ahero, and Tura within the Kakola location, alongside Magina, Ayweyo, and Nyakongo sub-locations within the Wawidhi location. The remaining study areas consist of West Kabodho sub-location within the Kabodho West location, North Kabodho sub-location within the Central Nyakach location, and both Jimo East and Awach/Achego sub-locations within the North East Nyakach location (County Government of Kisumu, 2018; KNBS, 2015). Topographically, these study sites represent two distinct bands where five of the locations lie entirely within the low-lying, flood-prone plains of the Lower Nyando Basin, while the Nyakach/Jimo East zone is situated on a higher terrain that is hydrologically shielded from seasonal flooding regimes (Bloemertz, 2014; County Government of Kisumu, 2018).

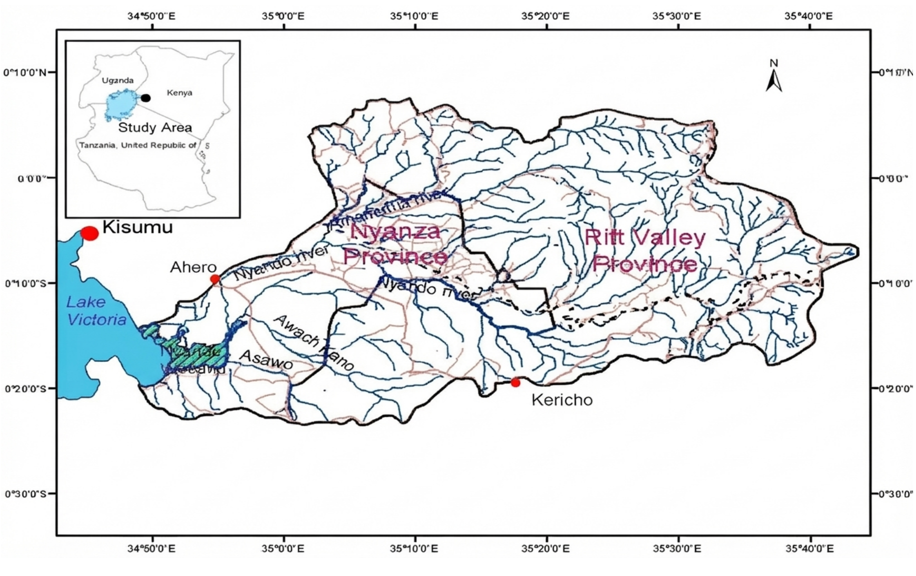

Figure 1: Location Map of Nyando River Basin
Source: Adapted from *Community-Based Approach to the Management of Nyando Wetland,*

Lake Victoria Basin, Kenya (Raburu et al., 2012).

Catchment Hydrology and Ecological Significance

The primary hydrological driver of this wetland is the River Nyando, which originates from the Mau Escarpment (Opere & Okello, 2011). The river has an expansive catchment area of 3,600 square kilometers and discharges into the Winam Gulf of Lake Victoria at an average rate of 15 cubic meters per second, functioning as the leading contributor of sediment loads and phosphorus influxes into the lake (Opere & Okello, 2011). The wetland landscape transitions smoothly from upland agriculture and riverine forests into lowland plains, permanent marshes, papyrus swamps, and seasonally inundated grasslands (Bloemertz, 2014; Raburu et al., 2012). These eco-zones are governed by bimodal rainfall patterns, upstream land-use pressures, and catchment-level hydrology (Raburu et al., 2012). Crucial ecological services include regulating microclimates and filtering pollution, while the habitat sustains high native biodiversity, including the endangered Sitatunga antelope (*Tragelaphus spekii*), the African civet (*Civettictis civetta*), and foundational flora such as the papyrus reed (*Cyperus papyrus*) (Gichuki, 2001; Obiero et al., 2021). However, historical fluctuations in Lake Victoria's water levels, combined with anthropogenic climate shocks, have severely disrupted local water availability, depressed net fish catches, exacerbated water-borne diseases, and sparked intense resource-access conflicts (UNEP, 2006).

Socio-Economic Profile and Livelihood Strategies

The riparian communities around the Nyando wetland employ diversified livelihood strategies that integrate small-scale subsistence agriculture, pastoralism, artisanal fishing, and open-access resource harvesting (Oduor et al., 2016). Recessional crop farming utilizes fertile alluvial soils left during dry-season water recessions to grow staple food commodities. Livestock keeping is dominated by indigenous Zebu cattle, goats, and sheep, which rely on the wetland for dry-season grazing and water (Ministry of Planning, 2005). Artisanal fishing serves as a critical seasonal economic buffer, with 33% to 65% of households engaging in the sector during heavy rain cycles to stabilize food and income lines (Ministry of Planning, 2005; Raburu et al., 2012). Furthermore, direct extraction of non-timber forest products includes harvesting papyrus and reeds for commercial mat-making and basketry, alongside commercial sand harvesting and brick-making from wetland clays (Oduor et al., 2016).

Despite the diversity of these natural safety nets, local livelihood sectors suffer from low structural productivity and poor veterinary disease control (Ministry of Planning, 2005). The intersection of these economic constraints and environmental hazards manifests as an acute poverty incidence, averaging 61% across the rural divisions (Kenya National Bureau of Statistics (KNBS), 2003). Paradoxically, poverty rates are even higher in urban perimeters at 72% compared to rural areas, with the highest concentrations of vulnerable populations localized within Nyando, Upper Nyakach, and Miwani (KNBS, 2003). This systemic vulnerability is driven by a lack of secure land title deeds, inadequate sanitation infrastructure, an overall unemployment rate of 11%, and historical health shocks such as HIV/AIDS, which maintains an infection rate of 29.4% in the area (KNBS, 2003).

Target Population

The target population for this inquiry comprised all riparian households residing within the immediate and contiguous zones of the Nyando and Lower Nyakach wetlands. These households are defined as units whose micro-economies are directly or indirectly reliant on

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the provisioning, regulating, and cultural services of the ecosystem. Key livelihood actions, such as small-scale irrigation, artisanal fishing, papyrus or reed processing, and domestic energy collection, are structurally organized at the household level (KNBS, 2019). Consequently, the primary unit of inquiry and statistical analysis was the household head. The accessible sample framework spanned eight locations, including North Kabotho, West Kabotho, Nyakach/Jimo East, Awach/Achego, Kakola-Ombaka, Wawidhi, and Awasi, comprising a total accessible population of 80,540 individuals distributed across 19,386 distinct households (KNBS, 2002).

Sample Size Determination

To ensure statistical representation and adequate power for subsequent econometric modeling, the optimal household sample size was mathematically derived from the total accessible household population of 19,386 households using the formula proposed by Krejcie and Morgan (1970). The estimation assumed a 95% confidence level, a margin of error of 0.05, and a population proportion set at 0.5 to maximize the required sample variance. The model is specified as:

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

Within this mathematical specification, n represents the required sample size for the study, and X^2 represents the chi-square table value for one degree of freedom at the 95% confidence level, which is equivalent to 3.841. The parameter N represents the total target household population of 19,386 households, while P is the estimated population proportion assumed to possess the characteristic under study, which is set at 0.5. Finally, the parameter d represents the acceptable margin of error or degree of precision expressed as a decimal value of 0.05.

To find the sample size, the variable values are then fitted into Equation 1 as shown below.

$$n = \frac{3.841x\ 19{,}386\ \ x\ 0.5\ (1-0.5)}{0.05^2(19{,}386\ -1)+3.841\ x\ 0.5(1-0.5)} = \frac{18{,}615.4065}{49.42275} = \mathbf{377}$$

The final sample size of 377 respondents provides an exceptionally robust foundation for the binary logistic regression model analysis. With eight independent variables specified in the econometric model, this sample yields an observations-to-variable ratio of approximately 47:1. This comfortably exceeds the standard econometric recommendations of 10:1 to 20:1 required to achieve high statistical power, ensure stable parameter estimation, and prevent model overfitting in multivariate categorical analysis (Green, 1991; Hair et al., 2018). This high observations-to-variable ratio is methodologically essential for several reasons within a logistic framework. Because binary logistic models rely on maximum likelihood estimation (MLE) rather than ordinary least squares, a large sample size is critical to guarantee that the mathematical optimization algorithms converge reliably without encountering the problem of complete or quasi-complete separation, a statistical anomaly where a small sample causes an independent variable to perfectly predict the binary outcome, leading to infinite standard errors. Furthermore, according to Peduzzi et al. (1996), logistic regression models require a sufficient number of "events per variable" (EPV) to avoid biased coefficients. With a 47:1 ratio, the dataset provided a substantial data buffer that guaranteed the calculated log-odds, Wald statistics, and exponentiated odds ratios (Exp(β)) were statistically reliable, asymptotically efficient, and valid for policy generalizations within the River Nyando basin.

Sampling Procedures and Techniques

The study employed a multistage sampling technique to systematically select representative riparian households and qualitative informants within the River Nyando Wetland Ecosystem. This approach was executed in three sequential stages to ensure geographic and statistical representation. In the initial stage, purposive sampling was used to select Nyando and Nyakach sub-counties, specifically focusing on the Nyando and Lower Nyakach divisions. These administrative areas were targeted due to their ecological proximity to the watershed and the high levels of community livelihood dependence on the wetland ecosystem.

In the second stage, a stratified sampling technique was employed to categorize the study area into seven distinct locations and fifteen sub-locations surrounding the wetland ecosystem. This stratification ensured that diverse micro-ecological and socio-economic zones were represented. The first stratum comprised the Awasi location, encompassing the sub-locations of Border II, Ayucha, Border I, and Wang'aya. The subsequent strata included Kakola location (encompassing Kakola/Ombaka, Kakola Ahero, and Tura sub-locations), Wawidhi location (encompassing Magina, Ayweyo, and Nyakongo sub-locations), and Ahero location (encompassing Ahero sub-location). The remaining strata consisted of the Kabodho West location (encompassing West Kabodho sub-location), Central Nyakach location (encompassing North Kabodho sub-location), and North East Nyakach location (encompassing Jimo East and Awach/Achego sub-locations).

In the final stage, a systematic random sampling approach was used to identify specific riparian households for the survey. To ensure an unbiased selection process, every fifth homestead was sampled from comprehensive, serially numbered registry lists provided by local area chiefs who maintain the most current administrative records. These lists were randomized to give every eligible household head an equal probability of inclusion. This rigorous process was designed to yield a representative sample size.

To complement the household survey, purposive sampling was applied to select key informants for semi-structured interviews and participants for focus group discussions. This non-probability targeted approach intentionally selects individuals who possess specialized institutional memory, regulatory oversight, or direct experiential knowledge regarding the local watershed landscape (Creswell, J. W., & Creswell, J. D, 2018; Patton, 2015). This method is highly effective when researchers must target individuals based on their professional "typicality" or specialized expertise (Oso & Onen, 2009). For this study, key informants were defined as actors possessing deep, reliable knowledge relevant to wetland governance and economic use. This cohort included local community elders, administrative officers such as chiefs and assistant chiefs, and institutional heads of various non-governmental organizations and government departments operating at both the county and national levels.

Data Collection and Survey Instrument

To ensure the empirical rigor and dependability of the field data, the primary data collection instruments underwent a comprehensive validation, pre-testing, and ethical clearance process before full deployment. The content and face validity of the research instrument were established through an expert review process to guarantee direct alignment with the study's objectives and theoretical constructs, during which two senior faculty experts from the University of Eldoret evaluated the questionnaire structure, relevance, and clarity. Following this expert review, a pilot test was conducted to evaluate the field practicality of the

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questionnaire using a sample of 38 respondents, representing exactly 10% of the target sample size, drawn from the Kadibo location in the neighboring Nyando division due to its identical socio-ecological and demographic characteristics. Data collected during this pilot phase were analyzed using Cronbach's alpha coefficient (Cronbach, 1951) to mathematically verify internal consistency, with all key construct scales achieving acceptable academic thresholds. Furthermore, the field survey was executed in strict adherence to international research ethics standards, which involved obtaining official institutional ethical clearance from the National Commission for Science, Technology and Innovation (NACOSTI), a Kenyan permit, and local administrative permits before field entry. Explicit written or verbal informed consent was also secured from the riparian household heads after full disclosure of the study's academic purpose, ensuring voluntary participation, strict anonymity, and the unconditional right to withdraw at any stage.

Primary data for this study were collected directly from household heads and key informants using a structured and semi-structured questionnaire, key informant interview guides, and focus group discussion schedules. The primary household survey instrument explicitly captured the utilization patterns of diverse ecosystem services representing the environmental parameters being valued, including provisioning services (such as fish abundance, clean water supply, and harvesting levels of papyrus reeds, sand, clay, and grass for crafts or construction), regulating services (comprising flood control, water purification, and biodiversity habitat maintenance), as well as supporting and cultural services. This questionnaire was administered face-to-face to 377 sampled household heads across the study area by the primary researcher and two trained research assistants who were well-versed in instrument administration, behavioral protocols, and data recording techniques. The field survey was executed over eight weeks, conducted entirely in the local language to maximize internal reliability, and subsequently translated into English for data entry and econometric analysis.

To complement the household datasets with institutional and expert insights, qualitative field tracking was carried out through Key Informant Interviews (KIIs) with 22 purposively selected local leaders, including wetland managers, environmental officers, and administrative authorities. These informants were chosen based on their institutional oversight, daily interactions with wetland usage, and direct exposure to the regional socioeconomic shocks of environmental degradation and ecosystem loss. The interviews targeted cross-cutting policy frameworks, landscape changes, and regulatory management dynamics using a semi-structured interview schedule.

Concurrently, Focus Group Discussions (FGDs) were organized to capture community-level qualitative consensus regarding resource use conflicts and ecological challenges. Focus groups provide one of the most effective methods for obtaining a comprehensive overview of the social and technical complexities inherent in resource planning and joint fact-finding initiatives (Hesselink, 2008). These focus groups ranged in size from 8 to 20 participants and were moderated by the primary researcher alongside a team of enumerators. To anchor the qualitative narratives in actual production dynamics, each group was systematically structured to include at least one active member of a local cooperative directly involved in the commercial extraction of River Nyando wetland resources.

Data Processing, Analysis, and Econometric Model Specification

Upon collection of the field instruments, raw primary and secondary data underwent an intensive preliminary screening process. The completed questionnaires, key informant

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interview guides, and focus group schedules were systematically sorted, coded, classified, tabulated, and cleaned to transform the qualitative and quantitative field responses into a machine-readable data file (Kothari, 2004). During this processing phase, incomplete data sources or compromised questionnaires were discarded to protect data integrity. The cleaned and coded dataset was subsequently keyed into statistical packages for computing. Data analysis was executed using both descriptive statistics (frequencies, percentages, means, and standard deviations) and inferential econometric statistics, utilizing Stata Version 16 (alongside preliminary sorting in SPSS and Microsoft Excel)..

To evaluate the determinants of localized household economic welfare and wetland ecosystem service use, this study employed a Binary Logistic Regression model (Gujarati & Porter, 2009; Wooldridge, 2010). The logistic framework is the mathematically appropriate econometric tool because the dependent variable measuring household welfare outcomes is naturally binary or dichotomous (1 representing a household achieving a higher welfare threshold or utilizing services, and 0 otherwise). Applying Ordinary Least Squares (OLS) regression through a Linear Probability Model (LPM) to such binary outcomes yields severe structural limitations, including non-normal error terms, heteroscedasticity, and nonsensical predicted probabilities that fall outside the logical [0, 1] interval (Greene, 2018). The binary logistic model circumvents these restrictions by using a cumulative logistic distribution function to estimate the maximum-likelihood probability of an event occurring. The mathematical specification of the econometric model is defined as specified in Equation 2:

$$P_i = E(Y_i = 1|X_i) = \frac{1}{1 + e^{-(\beta_0 + \sum_{j=1}^{k} \beta_j X_{ji}}} = \frac{e^{(\beta_0 + \sum_{j=1}^{k} \beta_j X_{ji}}}{1 + e^{-(\beta_0 + \sum_{j=1}^{k} \beta_j X_{ji}}{}_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

To linearize the parameters for estimation via maximum likelihood, Equation 2 is transformed into a log-odds logit framework by taking the natural logarithm of the odds ratio $(\frac{P_i}{1-P_i})$, expressed as follows in Equation 3:

$$L_i = 1n(\frac{P_i}{1 - P_i}) = \beta_0 + \sum_{j=1}^{k} \beta_j X_{ji} + \varepsilon_i$$

Where:

L_i represents the logit (the log-odds of a household experiencing higher welfare or resource utilization).

P_i is the estimated probability that household i achieves a higher welfare state $Y_i = 1$.

$1 - P_i$ is the probability that the household remains in a lower welfare state $Y_i = 0$.

β_0 represents the constant intercept parameter.

β_j represents the vector of logit coefficients to be estimated, determining the direction and significance of each explanatory variable.

ε_i is the stochastic error term.

The explicit operationalization of the independent vector X_{ji} comprises eight distinct socioeconomic welfare indicators, spatial metrics, and institutional variables:

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X_1 = Household Income (measured as a continuous monetary scale in Kenyan Shillings [KES]).

X_2 = Household Size (the total count of family members living under one roof).

X_3 = Education Level (the total years of formal schooling completed by the household head).

X_4 = Distance to the Wetland (the spatial proximity measured continuously in kilometres).

X_5 = Land Ownership (a categorical dummy variable capturing property rights status; 1 = Owner, 0 = Otherwise).

X_6 = Primary Occupation (a categorical variable capturing the main livelihood or agricultural activity).

X_7 = Extension Access (a binary dummy variable capturing household access to agricultural or environmental extension support; 1 = Access, 0 = No Access).

X_8 = Policy Awareness (an index score representing household knowledge of local environmental regulations and wetland policy frameworks).

ε_i = Stochastic error term.

RESULTS AND DISCUSSIONS

Results for Household Socioeconomic Characteristics (Categorical Variables)

The descriptive results summarize riparian households' demographic and socioeconomic characteristics that may influence their willingness to pay (WTP) and willingness to accept (WTA) for wetland ecosystem services. A summary statistic result on the categorical socio-economic characteristics of the riparian household heads in the River Nyando Wetland ecosystem is shown in Table 1.

Table 1: Summary Statistics Results for Categorical Variables

Variable	Category	Frequency (N)	Percentage (%)
Gender of Household Head	Male	238	63.8
	Female	135	36.2
Age of Household Head (Years)	18–29	64	17.2
	30–44	148	39.7
	45–59	111	29.8
	60 Above	50	13.3
Marital Status	Single	21	5.6
	Married	280	75.1
	Divorced/Separated	10	2.7
	Widow/Widower	50	13.4
	Others (Specify).....	12	3.2
Household Head	Father	301	80.7
	Mother	48	12.9

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	Child	24	6.4
Education Level	No formal education	39	10.5
	Primary	214	57.4
	Secondary	99	26.5
	Tertiary	60	16.1
Household Occupation	Main Occupation (Farming)	284	71.0
	Main Occupation (Fishing)	72	18.0
	Main Occupation (Small Business)	44	11.0

Source: Author's Computation from Survey Data (2019)

The descriptive statistics results in Table 1 show that male-headed households were 238 (63.8%) and female-headed households were 135 (36.2%). The results show that the riparian households in the River Nyando Wetland ecosystem were male-dominated. This result reflects the typical rural household structures in the study area, which implies that gender may influence household decision-making on wetland resource use. The role of gender can also influence other socioeconomic activity practices, including land use changes and value added, given that female households must also perform other duties apart from farming. These duties may include, but are not limited to, making mart (*goyo*/*twang'o par*), looking for firewood, fetching water, pot moulding (*chweyo agulu*), cooking, and general hygiene maintenance of the home.

Age of household head in years was categorized into 18-29, 30-44, 45-59, and 60 and above as shown in Table 4.1 of the results. Results reveal that 39.7% of the riparian household heads were in the age group of 30-44, followed by 29.8% being in the age group of 45-59. This was followed by 17.2% for ages between 18-29, and lastly 13.3% for respondents above 60 years of age. Statistical results on marital status indicate that 75.1%, 13.4%, 5.6%, and 3.2% were married, widow/widower, single, and others (not yet attained marriage age), and 2.7% were divorced/separated, respectively. Descriptive statistics regarding household heads reveal that a large majority of the respondents, 301 individuals (80.7%), reported that the household head was male (the father). This was followed by 48 households (12.9%) headed by mothers, while the remaining 24 respondents (6.4%) indicated that a child was the head of the household. The result on the level of education of the respondents (Table 4.1 of results) showed that 57.4% attained primary education, 26.5% secondary, 16.1% tertiary, and 10.5% had no formal education. The results here indicate that the majority of the population had primary education, an indication that the majority of the residents here dropped out of school to pursue other socioeconomic activities.

The finding on household occupation reveals that 71% of households rely on farming, followed by fishing (18%) and small business (11%), which strongly converges with existing literature identifying the Lake Victoria Basin (LVB) as a region dominated by subsistence agriculture and primary production. This heavy reliance on land-based livelihoods aligns with findings that rural Kenyan populations remain largely agricultural, with many households in the Nyando Basin operating on less than one hectare of land.

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Results for Household Socioeconomic Characteristics (Continuous Variables)

Table 2 shows the summary statistics results for continuous socioeconomic characteristics variables, which include household size (members), monthly income (KES), farm size (acres), wetland demand intensity, distance to wetland (km), and years of residence. The results reveal that the average household size consists of approximately five members. This moderately large household size implies a high degree of dependency, which may increase reliance on wetland resources for local livelihoods. The minimum household size of 1 and the maximum of 12 reflect significant heterogeneity in household composition. This variation suggests differences in household labour availability, which is an important factor in riparian households where household members often provide essential labour for local household livelihoods.

Table 2: Summary Statistics Results for Continuous Socioeconomic Characteristics

Variable	Mean	Std. Deviation	Min.	Max.
Household Size (Members)	5.47	2.12	1	12
Monthly Income (KES)	18,460.75	7,962.40	4,500	35,000
Farm Size (Acres)	1.84	1.27	0.25	6.50
Wetland Demand Intensity (Scale 1–3)	2.89	0.65	1	3
Distance to Wetland (km)	1.32	0.74	0.1	4.0
Years of Residence	18.75	9.31	2	40

Source: Author's computation from Survey Data (2019)

The findings in Table 2 indicate that the average monthly household income across the study area was KES 18,460. This constrained financial baseline signals severe cash scarcity, which structurally intensifies household dependency on wetland provisioning services as a primary survival mechanism. Because alternative livelihood options are limited, the wetland functions as an essential, non-market capital asset that buffers households against extreme economic shocks. The results reveal that the average farm size is approximately 1.8 acres with a standard deviation of 1.27 acres.

Results presented in Table 2 further reveal that the average wetland demand intensity stands at 2.89, with a standard deviation of 0.65. Further, results revealed that the average distance to the wetland was 1.32 kilometres with a standard deviation of 0.74 kilometres, indicating moderate variation in wetland accessibility among households. The minimum distance of 0.1 kilometre and maximum of 4 kilometres reflect differences in geographic location and access to the wetland. The descriptive results also show that the average duration of village residency is 18 years, with a standard deviation of 9.31 years. The minimum number of years of residency is 2 years, while the maximum of 40 years provides critical socio-ecological insights. They explain how the community interacts with, relies on, and impacts the surrounding wetland.

Results On Wetland Ecosystem Service Utilization Patterns (2010–2020)

This study further analysed the household socio-economic variables and wetland ecosystem service utilization between 2010 and 2020, and the results are shown in Table 3. The results indicate a shift in household expenditure patterns between 2010/11 and 2019/20, characterized by a decrease in cereal consumption (0.459 to 0.401) and an increase in dietary

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diversification, such as higher expenditure on vegetables and beverages. Demographic shifts show potential trends toward smaller household sizes or younger heads, while institutional support, such as credit access, increased alongside a significant rise in reliance on ecosystem services.

Table 3: Summary Statistics for Socio-Economic Variables and Wetland Ecosystem Service Utilization

Variable	2010/11		2019/20	
	Mean	**S.D**	**Mean**	**S.D**
Household Expenditure Pattern				
Cereals	0.459	0.296	0.401	0.215
Grains	0.373	0.133	0.384	0.112
Bread and Cereal Products	0.152	0.098	0.174	0.089
Pulses	0.336	0.069	0.329	0.076
Meat	0.296	0.213	0.299	0.203
Fish and Seafood	0.333	0.058	0.327	0.073
Milk and Milk Products	0.251	0.203	0.247	0.232
Oil and Fats	0.253	0.413	0.275	0.461
Fruits	0.182	0.037	0.125	0.596
Vegetables	0.221	0.105	0.284	0.141
Roots and Tubers	0.094	0.762	0.115	0.748
Sugar	0.217	0.458	0.211	0.710
Honey	0.192	0.481	0.145	0.607
Chocolate and Other Confectionery	0.135	0.423	0.174	0.123
Non-Alcoholic Beverages	0.083	0.165	0.114	0.016
Spices and Condiments	0.056	0.131	0.123	0.021
Households' Socioeconomic Characteristics				
Household Age?	46.49	2.834	14.34	0.089
Household Gender	3.896	2.259	1.258	0.067
Household Income	1.254	0.566	0.432	0.436
Household Education	1.642	0.885	2.282	0.796
Household Size	2.430	1.436	2.531	0.099
Household Land Size Ownership	1.041	0.261	1.821	0.052
Household Market Access	2.533	2.099	2.936	0.581
Household off Farm Income	1.820	0.523	3.721	0.532
Household Asset Owned	2.851	0.753	2.038	0.947
Household Distance to Wetland	5.478	0.834	3.001	0.521
Institutional Factors				
Institutional Credit Access	0.223	0.214	0.274	0.064

Institutional Support Structure	0.713	0.434	0.794	0.434
Institutional Social Protection	4.863	1.494	4.937	0.148
Institutional Trust	4.167	0.839	4.967	0.231
Institutional Access to Extension Service	2.496	0.214	2.629	0.214
Institutional Access to Social Networks	2.353	0.894	2.298	0.244
Environmental				
Reliability of Regional Water Use	2.353	0.894	2.298	0.244
Perceived impact of climate change	3.603	1.989	1.043	0.261
Awareness of the value of wetland ecosystem	2.284	0.796	2.853	0.075
Public involvement in H_2O resource management	3.869	0.259	2.692	0.429
Physical proxy to local wetlands	2.574	0.324	2.719	0.419
Ecosystem Service Use				
General Irrigation Use	0.054	0.113	0.079	0.156
Domestic Water Dependency	0.043	0.081	4.945	2.839
Livestock Pasture Extraction	0.135	0.213	2.614	2.204

Source: Author's computation from Survey Data (2019)

From the results, cereals are the most significant component of household food expenditure in the River Nyando Basin, though their share declined from 45.9% in 2010/11 to 40.1% in 2019/20. This contraction likely reflects the "income effect" and "substitution effect" driven by agricultural production declines and macroeconomic shocks, including global oil price volatility, currency fluctuations affecting food imports, and the disruptive impacts of the Russia-Ukraine conflict on supply chains. Such shifts in expenditure toward staples, yet with declining volume, heighten the vulnerability of households to food and nutrition insecurity.

Grains, pulses, and seafood emerged as the second most vital expenditure category. While grains saw a marginal increase from a mean of 0.373 to 0.384, pulses experienced a slight mean decline from 0.336 to 0.329, and fish and seafood dropped marginally from a mean of 0.333 to 0.327. This relative stability in expenditure shares, despite rising prices, suggests these are "inelastic" necessities for local households. However, the high reliance on market purchases, aligning with the Kenya Comprehensive Household Survey report (2020) that rural households often purchase over 80% of their food, exposes residents to extreme price shocks. The data results show a notable increase in the expenditure share for vegetables, which rose from a mean of 0.221 to 0.284, and non-alcoholic beverages, which climbed from a mean of 0.083 to 0.114. This trend suggests a change in consumption patterns, possibly driven by the diminishing availability of "own-produced" food due to wetland degradation. This dietary shift toward market-acquired processing is also supported by bread and cereal products, which increased from a mean of 0.152 to 0.174, and spices and condiments, which rose sharply from a mean of 0.056 to 0.123. As highlighted by (Wong et al., 2015) and (Barbera, 2010), when agricultural productivity fails due to ecological loss, households often transition from producers to net consumers, forcing a reallocation of limited budgets to satisfy basic caloric needs. In contrast to rising vegetable costs, households experienced a decline in other nutritionally diverse categories, such as fruits, where the mean fell from 0.182 to 0.125. Similarly, honey expenditures dropped from a mean of 0.192 to 0.145, and milk and milk products saw a minor contraction from a mean of 0.251 down to 0.247. When agricultural productivity fails due to ecological loss, households often transition from independent producers to net consumers, forcing a strict reallocation of limited budgets to satisfy basic caloric needs rather than nutritional variety. The findings underscore a paradox: despite being a region of crop and livestock farmers, Kisumu County maintains a food poverty headcount of 34.9%, slightly exceeding the national average of 34.4% (KCHS, 2020). This persistent poverty is closely tied to the diminishing returns from the River Nyando Basin's ecosystem services. The decline in household welfare is a direct driver of "diversified dependence," where households compensate for agricultural failure by intensifying the extraction of wetland resources.

The remaining expenditure items show minor budgetary adjustments or coping mechanisms under economic pressure. Meat expenditures remained statistically flat, moving from a mean of 0.296 to 0.299, while oils and fats rose slightly from a mean of 0.253 to 0.275. Sugar consumption experienced a minimal drop from a mean of 0.217 to 0.211, whereas chocolate and confectionery products saw an increase from a mean of 0.135 to 0.174. These subtle fluctuations reflect how low-income households reorganize their remaining disposable funds across minor luxury and essential commodities as broader environmental degradation reduces overall agricultural returns.

Results on the socioeconomic-demographic profile of the households experienced massive changes over the decade, signaling shifts in household vulnerability, lifecycle stages, and economic capacity. Household age and size dropped sharply from a mature mean of 46.49 to a youth-dominated mean of 14.34. The data became highly concentrated around this younger cohort (S.D fell from 2.834 to 0.089). Meanwhile, average household size grew marginally from 2.43 to 2.53 members. Results further show that the average educational attainment levels rose from 1.642 to 2.282, showing institutional improvements in local literacy. Conversely, the income proxy metric collapsed from 1.254 to 0.432, showing a severe contraction in wealth. While assets and land size ownership climbed from 1.041 to 1.821, off-farm income potential also surged from 1.820 to 3.721. The staggering decline in mean household age alongside rising family sizes indicates a demographic explosion of young dependents. When paired with a steep drop in household income, these families face heightened economic vulnerability. While increased land ownership and education offer pathways out of poverty, the reduction in income likely forced households to rely more heavily on immediate, low-cost natural resources for survival.

Further, Table 3 presents the results on institutional factors. Institutional factors track the access households have to credit, agricultural extension programs, secure land tenure, and local support structures. Results reveal that access to credit improved slightly from a mean of 0.223 to 0.274. Access to agricultural extension services also experienced a steady increase from 2.496 to 2.629, while secure land tenure rose from 0.713 to 0.794. Social protection programs and institutional trust both trended upward over the decade, with institutional trust seeing a notable jump from 4.167 to 4.967. Institutional social networks experienced a marginal decrease from 2.353 to 2.298. The uniform upward trajectory across almost all institutional metrics indicates a concerted effort by external organizations or local governments to formalize safety nets between 2010 and 2020. Higher tenure security and better access to extension services generally empower communities to manage assets

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sustainably. Furthermore, the sharp increase in institutional trust, combined with tight standard deviations in 2019/20, suggests that communities became highly aligned and reliant on formal regional support frameworks.

Table 3 further presents results on Environmental factors. Environmental factors measured the changing availability of natural resources, community awareness of conservation, and physical proximity to local wetlands in the study area. The mean result on awareness of the value of wetland ecosystem services grew from 2.284 to 2.853, and proximity to wetland areas rose from a mean of 2.574 to 2.719. The mean perceived impacts of climate change plunged from 3.603 to 1.043, while the reliability of regional water use stayed completely static, moving from 2.353 to 2.298, which mirrors the behavior of institutional social networks. However, public involvement in water resource management dropped notably from 3.869 to 2.692. The mean results data reveal a geographic consolidation, as households lived closer to the wetlands by 2020 and reported a higher awareness of ecosystem benefits. Interestingly, active participation in water management frameworks collapsed. This implies that while the community became more knowledgeable about environmental value, actual hands-on governance devolved or became centralized, distancing households from local conservation enforcement.

Further, results on Ecosystem Service Use. Ecosystem Service Use dictates how intensely households extract provisional wetland resources like irrigation water, domestic water, and livestock forage. Results on general irrigation use stayed extremely low but grew slightly from 0.054 to 0.079. Domestic water dependency exploded from a negligible 0.043 mean to a massive 4.945 mean. Livestock forage/pasture extraction followed a matching trajectory, rising from 0.135 to 2.614. The Standard deviations for both domestic water (2.839) and pasture extraction (2.204) ballooned in 2019/20, showing highly polarized behavior among community members. These results on Ecosystem Service Use expose a critical ecological transition. The exponential growth in domestic water reliance and livestock foraging proves that the local population drastically accelerated their direct extraction of provisional wetland goods. The widening standard deviations suggest a split economy: while some households became completely dependent on the wetland for daily domestic water and livestock survival, others remained insulated from it. When these results on Ecosystem Service Use are cross-referenced with results under households' socioeconomic-demographic characteristics, this extraction boom aligns perfectly with the drop in household income, indicating that families weaponized the wetland as an economic safety net to offset losses in traditional income.

Estimates of Wetland Ecosystem Service Use on Household Welfare

To address the primary objective of this study, a binary logistic regression model was estimated to analyze the quantitative influence of socioeconomic, institutional, and spatial parameters on household welfare and economic well-being within the River Nyando wetland ecosystem. The logistic framework was selected because the dependent variable measuring household economic welfare is binary in nature (representing distinct welfare thresholds), making ordinary least squares parameter estimates inappropriate and highly biased. The empirical results of this maximum-likelihood estimation, detailing the vital underlying drivers of welfare states in resource-dependent communities, are presented in Table 4. To verify the mathematical validity and overall performance of the econometric specification, standard goodness-of-fit diagnostic measures were evaluated. The logistic regression model demonstrated a robust fit to the field data, yielding a -2 Log Likelihood statistic of 412.6. The computed Nagelkerke R^2 value of 0.41 indicates that approximately 41.0% of the variance in the log-odds of household economic welfare is explicitly explained by the vector of independent welfare indicators and socioeconomic variables included in the model. Furthermore, the model exhibits strong predictive accuracy, correctly classifying 76.8% of the observed household welfare states. Taken together, these diagnostic indicators confirm that the specified econometric framework possesses strong explanatory power and is highly appropriate for isolating the structural determinants of household well-being in the basin.

The empirical outputs detailed in Table 4 reveal that household income (β = 0.318, p = 0.0022), household size (β = 0.214, p = 0.0162), secure land ownership (β = 0.263, p = 0.0073), and access to agricultural extension services (β = 0.391, p = 0.0024) are statistically significant positive drivers of household welfare. This indicates that an increase in these household assets and institutional resources expands the likelihood of households transitioning into higher economic welfare brackets. Conversely, the estimated coefficients for formal education level (β = -0.287, p = 0.0104), physical distance to the wetland (β = -0.451, p = 0.0009), and environmental policy awareness (β = -0.277, p = 0.0432) are negative and statistically significant. This implies that higher formal educational attainment, greater geographical distance from the delta, and robust regulatory literacy act as structural constraints that decrease the probability of households achieving higher welfare states under the current resource regime. Finally, the primary occupation of the household head (β = 0.236, p = 0.2746) was found to be statistically insignificant, indicating that specific livelihood types do not independently dictate welfare variations when controlling for broader cross-cutting asset endowments and shared ecological vulnerabilities.

Table 4: Logistic Regression Estimates on Wetland Ecosystem Service Use on Household Welfare

Variable	Coefficient (β)	Std. Error	*z*-test (*z=β/Std. Error)*	Wald (z^2)	Sig. (*p*)	Odds Ratio (*Exp(β)*
Household income	0.318	0.104	3.058	9.349	0.0022*	1.374
Household size	0.214	0.089	2.404	5.782	0.0162**	1.239
Education level	-0.287	0.112	-2.562	6.566	0.0104**	0.751
Distance to the wetland	-0.451	0.136	-3.316	10.997	0.0009*	0.637
Land ownership	0.263	0.098	2.684	7.202	0.0073*	1.301
Extension access	0.391	0.129	3.031	9.187	0.0024*	1.478
Occupation	0.236	0.216	1.093	1.194	0.2746	1.266
Policy Aware	-0.277	0.137	-2.022	4.088	0.0432**	0.758
Constant	-1.872	0.512	-3.656	13.368	0.0003*	0.154

Legend

Model fit:

- −2 Log Likelihood = 412.6
- Nagelkerke R^2 = 0.41
- Correct prediction = 76.8%

**p < 0.001, **p < 0.05, ***p < 0.10*

Source: Author's Computation from Survey Data (2019)

From Table 4 of the results, household income has a positive and statistically significant effect on household welfare (β = 0.318, p = 0.0022). The positive coefficient confirms that as

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household income increases, household welfare also improves. The positive coefficient indicates that higher household income is associated with an increased probability of experiencing higher welfare levels. This relationship is highly significant at the 1% level ($p < 0.01$), rejecting the null hypothesis of no effect. The odds ratio ($Exp(\beta) = 1.374$) means that for every one shilling increase in household income, the likelihood (odds) of the household attaining higher economic welfare increases by 37%, holding all other variables constant. This implies that every additional unit of household income (Ksh) will increase the odds of using household welfare by 37.0%. This result suggests that higher-income households have more "financial cushioning," which may allow them to use wetland resources more efficiently or sustainably compared to poorer households, who remain constrained by subsistence extraction. This finding implies that total household income, which likely includes off-farm sources, is a vital driver of economic well-being. As noted by Mwakubo & Obare (2009), households with higher diverse income streams are better positioned to invest in better fishing gear or agricultural inputs. This capacity allows them to extract greater valuefrom the ecosystem services sustainably without falling into the "poverty trap." Ultimately, the 37.4% increase in the odds of welfare improvement highlights that income growth serves as a powerful lever for enhancing the quality of life in the Nyando basin.

Household size has a positive and statistically significant relationship with household welfare ($\beta = 0.3214$, $p = 0.0162$). The positive coefficient indicates that larger households are associated with an increased probability of experiencing higher welfare levels. This relationship is statistically significant at the 5% level ($p < 0.05$), rejecting the null hypothesis of no effect. The odds ratio ($Exp(\beta) = 1.239$) indicates that for every additional member added to the household, the odds of that household attaining higher economic welfare increase by 23.9%, holding all other variables constant. In rural wetland contexts like the Nyando basin, this finding strongly suggests that household size acts primarily as a proxy for available family labor rather than an economic dependency burden. Larger families possess a greater labor endowment, enabling them to simultaneously diversify into multiple wetland-based livelihoods, such as crop cultivation, fishing, and papyrus harvesting, without facing severe labor constraints. This finding aligns with labor-surplus economic theories in smallholder agriculture. As noted by Turyahabwe et al. (2013) in similar East African wetland ecosystems, abundant family labor lowers transaction costs and allows households to maximize the extraction and processing of open-access ecosystem services, directly translating into improved food security and welfare. Furthermore, Kakuru et al. (2013) observe that wetland resource utilization is highly labor-intensive; therefore, households with greater human capital capacity can efficiently balance subsistence extraction with commercial processing (e.g., weaving mats or burning charcoal). While large household sizes can sometimes strain resources in purely urban contexts, in resource-dependent rural economies, they provide the essential manpower needed to escape the poverty trap by leveraging diverse ecosystem pathways (Mwakubo & Obare, 2009). Consequently, the 23.9% increase in the odds of welfare improvement underlines the critical role that rural family labor allocation plays in maximizing wetland ecosystem benefits.The results in Table 4 indicate that the education level of the household head has a negative and statistically significant effect on household welfare ($\beta = -0.287$, $p = 0.0104$). This inverse relationship is statistically robust at the 5% significance level ($p < 0.05$), implying that implying that higher formal educational attainment by the household head is associated with a lower probability of the household achieving higher economic welfare within this specific ecosystem context.. The Odds Ratio ($Exp(\beta) = 0.751$) indicates that for each additional level or year of formal education completed by the household head, the odds of the household attaining higher economic welfare decrease by 24.9% (1 – 0.751), holding all other variables constant. While this

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finding appears provocative as it diverges from classical Human Capital Theory, which posits that formal education linearly enhances productivity and economic prosperity, it exposes critical structural realities within rural, resource-dependent communities.. In the context of the River Nyando riparian zones, this inverse dynamic can be explained bya severe skills-resource mismatch and the scarcity of formal, off-farm employment in rural Kenya. As observed byMwakubo & Obare (2009), rural economies heavily reliant on primary ecosystem extraction (such as artisanal fishing, sand harvesting, and subsistence wetland farming) reward tacit local knowledge and hands-on ecological experience rather than formal academic credentials. Highly educated individuals often lack the specialized, generationally transmitted skills required to optimize returns from intense manual wetland extraction, yet they reside in an environment where white-collar corporate or public-sector positions are virtually non-existent. Furthermore, as noted by Oduor et al. (2015) in Western Kenya baseline surveys, the opportunity cost of investing years in formal school cycles often strains rural household capital without yielding proportional financial returns in localized labor markets, effectively acting as a short-term economic drain. This implies that the conventional formal education curriculum is structurally misaligned with the blue economy and agricultural realities of the Nyando Basin. Rather than validating formal schooling as an automatic driver of prosperity, these results highlight a pressing need to reorient local education toward Technical and Vocational Education and Training (TVET) frameworks. Such programs should explicitly equip educated youth with modern, sustainable techniques for commercial agribusiness, value-added papyrus processing, and eco-tourism, thereby bridging the gap between formal academic achievement and practical economic well-being.

From Table 4, the physical distance between the household and the wetland basin exhibits a negative and highly statistically significant relationship with household welfare ($\beta = -0.451$, $p = 0.0009$). This inverse relationship is statistically robust at the 1% significance level ($p < 0.001$), demonstrating that as the distance from a household to the River Nyando riparian zone increases, the probability of the household achieving higher economic welfare significantly decreases. The odds ratio ($\mathrm{Exp}(\beta) = 0.637$) provides a precise measure of this spatial impact, indicating that for every one-kilometre increase in distance away from the wetland basin, the odds of a household attaining higher economic welfare decrease by 36.3% (1 - 0.637), holding all other variables constant. This finding strongly underscores a distinct geographical advantage held by households living in immediate proximity to the basin, who leverage seamless access to localized ecosystem services to sustain their livelihoods. This spatial dynamic closely converges with findings by Mwakubo & Obare (2009), who argued that in rural Kenya, proximity to natural resources serves as a critical determinant of income by directly minimizing the transaction and transportation costs associated with resource extraction. For households situated along the immediate periphery of the Nyando area, proximity translates to more frequent, low-cost access to crucial provisioning services, such as domestic water, active fishing grounds, and fertile, naturally irrigated soils for wetland farming. Conversely, households located further inland suffer from a "distance decay" effect regarding their economic well-being. The compounding time, physical labor, and transport costs required to haul domestic water or harvest raw papyrus function as an implicit tax on their constrained assets, ultimately depressing their overall economic productivity and net welfare returns. The structural implications of this distance-dependency are profound for regional planning and targeted poverty alleviation in the basin. It reveals that while the River Nyando wetland serves as a localized ecological safety net, its protective economic capacity is strictly bounded by geographical reach. For more distant households, the lack of proximity to these "free" ecosystem provisions creates a structural welfare gap. This gap can only be realistically bridged through alternative rural infrastructure, such as piped water systems, rural electrification, and improved road networks connecting them to broader markets. Without these interventions, inland households will continue to experience lower economic well-being, while peripheral households face the opposite hazard: an escalating over-dependence that risks driving the ecological degradation of the wetland as they aggressively exploit their proximity-based advantage.

From Table 4, awareness of wetland policies by the household head exhibits a negative and statistically significant relationship with household welfare ($\beta = -0.277$, $p = 0.0432$). This inverse relationship is statistically robust at the 5% significance level ($p < 0.05$), indicating that higher policy awareness is associated with a lower probability of the household achieving higher economic welfare within the River Nyando ecosystem. The odds ratio ($\mathrm{Exp}(\beta) = 0.758$) provides a precise measure of this impact, implying that for every one-unit increase in policy awareness, the odds of a household attaining higher economic welfare decrease by 24.2% (1 - 0.758), holding all other variables constant. This counterintuitive finding strongly suggests that knowledge of wetland regulations acts as an economic constraint rather than a catalyst for livelihood improvement, as informed households find themselves legally restricted by conservation laws that limit their traditional extractive activities. This apparent compliance burden typically manifests when regulatory frameworks prioritize strict environmental protection over local livelihood support. As argued by Anyango (2021), households in the Nyando wetland are frequently caught in a structural conflict between daily survival and state-mandated conservation; those who are acutely aware of the legal repercussions of riparian encroachment, sand harvesting, or over-fishing voluntarily limit their extraction levels to avoid institutional sanctions. In the short term, this legal compliance leads to a direct contraction of household income streams. This dynamic closely aligns with findings by Oduor et al. (2015), who observed that the implementation of environmental policies across the broader Lake Victoria Basin routinely fails to provide viable alternative livelihoods, effectively "penalizing" the specific sub-population that understands and attempts to adhere to the rules. In the absence of structured Payment for Ecosystem Services (PES) frameworks or alternative income-generating activities, policy awareness serves only to internalize the structural limitations placed on a household's economic freedom—a systemic vulnerability echoed by Obwoyere et al. (2018) regarding the declining welfare of compliant riparian communities in Western Kenya. Consequently, this result underscores the urgent necessity of moving beyond conventional "command-and-control" policy dissemination. The significant negative impact on welfare demonstrates that for the River Nyando community, awareness of the law is currently synonymous with an awareness of economic restrictions. These findings provide strong empirical weight to the arguments of Krhoda (2021), who asserts that for environmental policies to be successful in Kenya, they must be fundamentally "pro-poor." Households that are cognizant of conservation needs must be actively incentivized through green subsidies, eco-tourism partnerships, or sustainable agribusiness inputs, rather than being left to bear the disproportionate economic costs of environmental compliance alone.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study examined the influence of wetland ecosystem service (WES) utilization on household economic welfare within the River Nyando Wetland ecosystem using a probabilistic logistic regression framework. The diagnostic performance indicators (-2 Log

Likelihood = 412.6, Nagelkerke R^2 = 0.41) confirm that socio-economic, spatial, and institutional parameters explain a substantial proportion (41.0%) of the variance in localized household economic well-being, with the model correctly predicting 76.8% of the observed cases. The empirical findings underscore a complex relationship between resource extraction patterns, spatial configurations, regulatory frameworks, and rural welfare. The study concludes that household resource endowments and institutional support structures function as primary positive drivers of economic well-being. Increased household income (β = 0.318, p = 0.0022), secure land ownership (β = 0.263, p = 0.0073), and access to agricultural extension services (β = 0.391, p = 0.0024) significantly expand the odds of households achieving superior welfare outcomes. Rather than acting as purely destructive forces, higher financial capital and extension-led technical capacity provide a vital cushioning mechanism. This endowment allows asset-rich households to invest in efficient extraction inputs, bypass subsistence traps, and secure commercial margins from provisioning services like fisheries and crop production. Furthermore, larger household sizes (β = 0.214, p = 0.0162) expand welfare odds by 23.9% per additional member, indicating that abundant family labor is a crucial asset needed to meet the high labor demands of raw manual extraction in this resource-dependent economy. Conversely, spatial proximity, formal education, and environmental governance indicators act as negative structural constraints within the basin. Physical distance from the wetland (β = -0.451, p = 0.0009) reduces the odds of higher household welfare outcomes by 36.3% for each unit moved away from the wetland. This confirms that the River Nyando ecosystem serves as an indispensable geographical safety net; as families live further away, the cumulative transaction and transportation costs of resource exploitation become prohibitively high, suppressing household utility. Importantly, the negative impacts of formal education (β = -0.287, p = 0.0104) and policy awareness (β = -0.277, p = 0.0432) expose a structural mismatch in the basin. The traditional human capital system fails to translate into economic prosperity due to a lack of formal white-collar jobs, leaving educated individuals ill-equipped with the tacit, local extraction skills needed to thrive in a primary-product blue economy, decreasing welfare odds by 24.9%. Similarly, current environmental policies act as regulatory compliance burdens that restrict access to basic livelihood resources without offering viable income alternatives, depressing the immediate economic well-being of policy-literate households by 24.2%. Finally, the statistical insignificance of primary occupation (β = 0.236, p = 0.2746) reveals that specific livelihood labels (e.g., fishing vs. papyrus harvesting) do not dictate welfare; rather, uniform exposure to perennial climate shocks and systemic resource degradation equally flattens the economic returns of all primary extraction roles along the riverbanks.

Policy Recommendations

Based on the empirical findings, this study proposes a targeted, multi-sectoral policy framework that integrates human capital, governance, and infrastructural interventions to balance biodiversity conservation with household economic well-being in the River Nyando basin. First, to deconstruct the skills-resource mismatch (β = -0.287), the Kisumu County Government, in collaboration with the Ministry of Education, should overhaul the local curriculum by establishing specialized Technical and Vocational Education and Training (TVET) centers within the Nyando and Nyakach sub-counties. Rather than relying on generic academic schooling, these institutions must focus heavily on green- and blue-economy vocational skills, explicitly targeting modern aquaculture, sustainable agribusiness value-addition, eco-tourism management, and commercial-grade papyrus handicraft design. Second, to alleviate the 24.2% compliance burden associated with environmental policy awareness (β = -0.277), NEMA and the Water Resources Authority (WRA) must transition from conventional "command-and-control" enforcement to incentive-based mechanisms by designing a localized Payment for Ecosystem Services (PES) framework that directly compensates riparian land-owning households (β = 0.263) for maintaining papyrus buffers and natural flood-regulation zones. Third, because access to agricultural extension services (β = 0.391) emerges as a powerful institutional lever that expands household welfare odds by 47.8% (Exp(β) = 1.478), the Ministry of Agriculture, Livestock, Fisheries and Co-operatives should deploy decentralized extension networks directly to the sub-locations closest to the wetland fringe (β = -0.451), bundling eco-friendly technologies like low-emission solar-powered irrigation pumps and fuel-efficient fish-smoking kilns to optimize extraction values while mitigating severe habitat loss in critical zones like Nyangongo. Finally, to bridge the spatial welfare gap caused by the 36.3% "distance decay" effect affecting inland communities, regional planners must invest in alternative public infrastructure, such as piped water networks and all-weather market-feeder roads, while the National Drought Management Authority (NDMA) deploys cross-cutting climate-resilience structures like index-based crop insurance and flood-diversion channels to lift the community out of the baseline poverty trap that currently flattens the economic returns of all primary occupations (β = 0.236, p = 0.2746) along the riverbanks.

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