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Linking Mangrove Restoration and Household Food Security: A Study of Ecosystem-Based Resilience in Mida Creek, Kilifi County in Kenya

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Abstract

Coastal communities in Kenya face persistent food insecurity driven by environmental degradation and declining marine resources. Mida Creek in Kilifi County has experienced significant mangrove loss, threatening livelihoods and food systems that depend on healthy coastal ecosystems. This study examined the impact of mangrove restoration on household food security in Mida Creek, applying an ecosystem-based adaptation approach grounded in the Ecosystem Services Framework, Sustainable Livelihoods Framework, and Community-Based Natural Resource Management principles. A mixed-methods design was adopted. Using Yamane's formula, 296 households were sampled from a population of 1,146. A total of 306 households participated, representing a 103% response rate. Ten key informant interviews supplemented the household data. Mangrove restoration significantly improved food availability, access, and utilization among participating households. Specific gains included increased fish catch, greater seafood availability, and improved dietary diversity. Community engagement and livelihood initiatives emerged as critical drivers of restoration success. Effective stakeholder coordination among government agencies, non-governmental organizations, and local communities further strengthened outcomes. Mangrove restoration programmes should be integrated with sustainable livelihood initiatives to maximise household food security outcomes. Community-led management structures should be supported through targeted training and capacity-building programmes. Stakeholders across government, civil society, and local communities should establish coordinated governance frameworks for long-term mangrove management. Mangrove restoration offers a viable

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ecosystem-based strategy for enhancing food security and resilience in coastal communities. Sustained community participation and multi-stakeholder collaboration are essential for durable impact.

Keywords: *Mangrove restoration; ecosystem services; food security; community-based management; sustainable livelihoods*

1.0 Introduction

Over 2.4 billion people, approximately 40% of the global population live within 100 kilometers of the coastline (UNEP, 2021). Nearly one in three people depend directly on coastal ecosystems for food security, storm protection, livelihoods, and carbon sequestration. Coastal ecosystems such as mangroves, sea grasses, coral reefs, and sand dunes provide essential ecological and socioeconomic services, including fisheries production, tourism, aquaculture, and shoreline stabilization. Mangrove forests, in particular, enhance coastal resilience, support livelihoods, and buffer communities from climate-related hazards while also supplying timber, fodder, and medicinal resources. Coasts are key areas for global biodiversity; hence degraded coastal ecosystems directly threaten human well-being.

Despite their global importance, coastal ecosystems are increasingly degraded by human activities and climate change. Mangroves are being destroyed at an alarming rate; approximately one quarter of the world's mangrove cover has already been destroyed (Spalding et al. 2010) and the current rate of mangrove loss remains high estimated to be around two to five times greater than the average rate of loss for all forests globally (FAO 2007). Anthropogenic drivers including unsustainable fishing, coastal vegetation clearance, tourism expansion, overexploitation of timber resources and pollution are the primary drivers of mangrove degradation (UNEP-WCMC 2014). Mangroves are frequently cut down for fuel wood used in cooking and heating and their timber is harvested for construction materials. In addition, large areas are also being cleared to create agricultural land further accelerating their loss. These pressures are compounded by climate-related stressors such as sea-level rise, ocean warming, and intensified storm surges, with impacts extending across both terrestrial and marine environments.

As of 2013, only 16% of the world's coastal regions remained ecologically intact, while nearly 48% were heavily impacted by human activity, and 84% of countries had lost more than half of their coastal ecosystems (UNEP, *Measuring Progress: Water-related Ecosystems and the SDGs*, Chapter 7). Given that nearly half of global coastal zones are severely degraded, large-scale restoration is critical to halt biodiversity loss and safeguard essential ecosystem services.

In Kenya, more than 4 million people depend directly on the coastal and marine environment including mangroves for their livelihoods. The Kenya coastal zone extends over 600 km along the western Indian Ocean and is rich in biodiversity including mangroves, seagrass beds, and coral reefs. Mangrove forests are widely distributed across creeks, protected bays, lagoons, and river deltas along the coast. *According to the National Mangrove Ecosystems Management Plan 2017-2027* (NMEMP), Kenya's mangrove cover is estimated at 61,271 hectares, representing about 3.0% of the countries natural forest area and less than 1% of its total land area (GoK, 2017). Nature Kenya reports that, approximately 61% (37,350 ha) of this cover occurs in Lamu County while Kilifi County hosts about 14% (8,536 ha). These ecosystems provide critical services such as fisheries production, tourism, coastal protection, and carbon sequestration.

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Mida Creek**,** a tidal inlet in Arabuko-Sokoke Forest and forms part of Watamu Marine National Reserve (3°20'S, 40°00'E) illustrates these dynamics at a local scale. Established in 1968, the reserve is located approximately 100 kilometers north of Mombasa in Kilifi County, Kenya. It contains diverse coastal habitats including mangroves, coral reefs, and mud flats and is a sanctuary for shorebird populations. The mangroves of Mida Creek which lie within the Watamu Marine Protected Area (WMPA) cover an estimated 1,746 ha representing about 20% of the Kilifi County's total mangroves area (8536ha) and equivalent to roughly 14% of Kenya's mangrove cover (GOK, 2017). Management of these forests is a collaborative effort between the Kenya Forest Service (KFS) Community Forest Associations (CFAs), and various conservation partners.

Despite ongoing conservation efforts, the Mida mangrove ecosystem face significant threats due to overexploitation for wood products and encroachment by developers, uncontrolled bait harvesting particularly of *Avicennia marina*, sedimentation and insect pest infestation. Occasional damage also results from boat anchoring, pollution from boatyards, oil spills and social pressures. Limited livelihood options, high poverty rates and the perception that mangroves are inexhaustible resources further drive overexploitation. (MIDA Creek Mangrove Forest Ecosystem Restoration Plan 2024-2029). Food insecurity in adjacent communities drives illegal logging; intensified bait harvesting and overfishing creating a feedback loop that threaten both human and ecosystem well-being (Mida Creek Restoration Plan 2024-2029).

Mangrove restoration offers an opportunity to recover essential ecosystem services such as fisheries, shoreline stabilization, and carbon sequestration. By enhancing these services, mangrove restoration can enhance local livelihoods and contribute to long-term food security. In addition, integrating mangrove restoration initiatives with livelihood initiatives is critical for enhancing community engagement and ensuring long-term success of restoration efforts.

Current livelihood based interventions in Kilifi, Lamu, Mombasa and Kwale Counties including beekeeping, aquaculture (fish farming and crab fattening), mangrove eco-tourism, carbon financing, and adoption of energy-efficient stoves aim to reduce pressure on mangroves, promote conservation-based community development while enhancing food security. By providing alternative income sources and reducing dependence on mangrove resources such approaches reduce anthropogenic pressure on these mangroves ecosystems (GOK, National Mangrove Ecosystem Restoration Guidelines, Kenya, 2025).

In Mida Creek, where overexploitation, bait harvesting, and food insecurity exert significant pressure on mangrove forests, the study examined how linking mangrove restoration to community-based livelihoods including aquaculture, ecotourism, and energy-efficient technologies simultaneously safeguards ecosystem integrity and improve local food security and resilience.

1.1 Statement of the Problem

Kenya lacks a comprehensive, empirical framework that connects restoration outcomes with socioeconomic indicators at scale. Mangrove restoration initiatives largely emphasize the ecological outcomes such as forest cover, seedlings planted and survival rates or carbon sequestration while the social and economic and economic aspects of restoration have not been explored. For instance, projects like the Mikoko Pamoja Initiative in Kwale County have demonstrated success in linking mangrove restoration with carbon markets and delivering positive environmental outcomes. Nonetheless, these efforts are often evaluated in isolation.

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Kenya's mangrove ecosystems are vital for the sustainable development of coastal communities. Despite their ecological and socioeconomic importance, Kenya's coastal ecosystems are experiencing severe degradation. According to United Nations Environment Programme (UNEP) and WIOMSA (2021), the decline of seagrass meadows, coral reefs, and mangroves is accelerating across the western Indian Ocean region, including Kenya. It is estimated that Kenya has lost approximately 50% of its mangrove cover over the past 50 years. This degradation has intensified coastal erosion and flooding while exacerbating poverty and food insecurity (Fatima et al., 2023).

Currently, only 43% of Kenya's mangroves are under formal protection while about 40% of existing mangrove forests are considered degraded, resulting in reduced ecosystem functionality. Although available data on mangrove degradation vary due to methodological differences, multiple studies indicate a consistent decline in mangrove cover (FAO 2007; Kirui et al., 2013; Eftermeijer et al., 2022). The main drivers of mangrove loss in Kenya include overfishing and destructive fishing practices, unregulated tourism, over-exploitation of wood resources, conversion of mangrove areas to other land uses, pollution, and impacts of climate change such as sea-level rise and coral bleaching. This degradation not only reduces biodiversity and disrupts essential ecological processes but also weakens the capacity of mangroves to provide critical ecosystem services such as fisheries production, shoreline protection, and carbon sequestration.

Furthermore, coastal communities in Kenya face persistent socioeconomic challenges including limited access to nutritious food, which is partly due to declining fisheries, agricultural productivity and over dependence on natural resources. These communities are particularly vulnerable, as they rely heavily on mangrove forests for fishing, fuel wood, agriculture and small-scale tourism. The situation is compounded by poverty, lack of infrastructure, and increasing population pressure, poverty, inequality, limited financial resources, economic pressures and weak governance which collectively heighten food insecurity and reduce livelihood resilience.

Additionally, a critical research gap remains in quantifying and understanding the socioeconomic benefits of mangrove restoration, particularly in terms of: 1) improved livelihoods for local populations (e.g., fishing, tourism, sustainable harvesting); 2) economic gains, such as increased fishery yields, income diversification, and carbon financing; 3) enhanced food security, and 4) the overall contribution of restored ecosystems to resilient, inclusive development. Understanding this relationship is critical for designing ecosystem-based adaptation interventions that are both ecologically sustainable and socially beneficial. Therefore, this research addressed this gap by evaluating the ecological recovery and socioeconomic co-benefits of mangrove ecosystem restoration in Mida Creek, Kilifi County, Kenya, with a focus on livelihoods, economic empowerment, and food security.

1.2 Research Questions

The study addressed the following research questions: 1) How has restored mangrove ecosystems contributed to household food sources such as fish, crabs and forest products 2) How has mangrove restoration impacted household income and food access in communities around Mida Creek, and finally 3) What are the primary challenges and enabling factors within communities and existing projects that influence the successful integration of ecosystem restoration with food security initiatives in Mida Creek?

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1.3 Research Objectives

The research investigated the role of mangrove restoration in enhancing household food security through ecosystem-based adaptation in Mida Creek. Kilifi County, Kenya. More specifically, the research was guided by the following specific research objectives: 1) To assess the contribution of restored mangrove ecosystem to household food sources, particularly fisheries and forest products. 2) To evaluate the impact of mangrove restoration on household income and access to food, and 3) To analyze the primary challenges and key enabling factors that influences the successful integration of ecosystem restoration efforts with food security outcomes.

2.0 Literature Review

2.1 Conceptual Framework

The conceptual framework provided the foundation of the study which showed the importance of restoring mangroves to enhance/improve ecosystem services and their impact on household food security. The framework is made of the following four components:

i. ***Mangrove Restoration*:** Includes the efforts done to rehabilitate degraded mangrove ecosystems through plating and protecting mangroves in Mida Creek. Activities include establishment of mangrove nursery, planting of mangrove seedling and monitoring and protecting of mangrove rehabilitated areas. These are mainly initiatives led and managed by communities with support and oversight from government agencies and local conservation organizations. They are regulated by the Kenya Forest Services.

ii. ***Improved Mangrove Ecosystem Services**:* Ecosystem services include the tangible and intangible benefits/services that communities get from restored mangroves. When the degraded mangrove areas are restored they provide ecosystem services to the surrounding communities ranging from provisioning, regulating, supporting and cultural services. 1) provisioning services; these are the tangible services communities get from mangrove ecosystems including fish, crabs, fuel wood, honey and building materials used by communities as food sources of sources of income 2) Regulating services; mangrove ecosystems regulate environmental conditions including coastal protection from storms and erosion and carbon sequestration 3) Supporting services; mangrove ecosystems serve as habitat for fish breeding and biodiversity conservation and 4) Cultural services; mangrove sites support ecotourism and recreation activities.

iii. ***Enhanced Livelihood:*** When ecosystem services are improved they contribute to enhanced livelihood opportunities such as fishing, beekeeping and ecotourism activities.

iv. ***Household Food Security*:** The linkage between mangrove restoration and food security include **e**nhanced fisheries and livelihoods, increased income from sustainable forest products, support for coastal agriculture and improved resilience to climate change. The framework focuses on the four dimensions of food security including food availability, accessibility, utilization and stabilization that may be influenced by restored mangroves. 1) Availability; restored mangroves contribute to increased food sources such as fish, honey and protection of farmlands which increase food availability. 2) Food access; Restored mangroves enhance livelihoods, activities like fishing, beekeeping and ecotourism are as source income enabling households to access food. 3) Utilization, marine life is a source of nutritious foods to communities 4) Stability; Restored mangroves

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mitigate climate change and provide protection from climate related shock thereby ensuring food security.

2.2 Theoretical Perspectives

The study is grounded on Ecosystem Services Framework, Sustainable Livelihoods Framework and, Community-Based Natural Resource Management.

The Ecosystem Services (ES) framework (Villamagna et al., 2013) recognizes the importance of ecosystems in providing essential services that support human well-being. According to the ES framework highlighted the need to conserve and manage ecosystems sustainably to maintain ecosystem services and ensure human well-being. The ES framework provided a holistic understanding of how restoring mangroves supports sustainable food systems, integrates ecological and socioeconomic benefits and strengthens community resilience to climate change and environmental degradation.

Mangrove ecosystems in particular provides diverse range of ecosystem services that are essential for both environmental sustainability and the livelihoods of adjacent communities. Primarily restored mangroves enhance coastal resilience by buffering against storm surges, thereby protecting shorelines from erosion and flooding. These ecosystems also are significant carbon sinks sequestering atmospheric carbon dioxide and contributing to climate change mitigation and long-term ecological stability. Importantly, mangrove habitats act as breeding environments for fish, crabs and other aquatic species, thereby increasing local fishery yields for household consumption and for sale. These ecosystem services also provide key provisioning services, including fuelwood, honey and medicinal plants that are important for both subsistence use and income generation. In addition to these ecological and provisioning benefits, mangroves offer cultural ecosystem services; ecotourism associated with these environments contributed to local livelihoods and economic development. Collectively, these services highlight the multifaceted value of mangrove conservation and restoration as integrated strategies for enhancing biodiversity, strengthening community resilience and promoting socio-economic development.

Complementing the ecosystem services approach, the Sustainable Livelihoods (SL) framework provides a holistic lens to understanding how mangrove restoration contributes to multiple dimensions of community well-being. SL framework (Chambers & Conway, 1992) focused on understanding the complex relationships between people, their livelihoods, and the environment. Restored mangroves contributed to increased access to fish stocks and enhanced biodiversity both of which are critical for local food systems. Additionally, they also provided essential resources such as fuel wood and edible plants. Consequently, restored mangroves contributed to more secure, diverse and resilient food systems, particularly for communities in Mida Creek generating long-term, sustainable impacts on both ecosystems and food security.

The Community-Based Natural Resource Management (CBNRM) framework reinforces the importance of participatory approaches by placing local communities at the center of natural resource conservation. The CBNRM (Western et al., 1994; Berkes, 2004; Snorek & Bolger, 2022) framework emphasized the importance of involving local communities in the management and conservation of natural resources. The framework aimed to promote sustainable natural resource use, improve livelihoods, and enhance community well-being. As applied to mangrove restoration, in Mida Creek mangrove ecosystem, the study observed that CBNRM significantly enhanced food security by restoring ecosystem services that support fisheries, and provide coastal protection. Furthermore, capacity building within local communities fostered ecological knowledge and

stewardship reducing overexploitation and encouraged sustainable management of mangrove resources. As a result, communities benefited directly from increased fish harvests and additional livelihood options strengthening both economic resilience and food security.

By using these conceptual frameworks, the study contributes to a deeper understanding of the linkages between mangrove restoration and food security, the study will inform programs that support sustainable coastal management and improve the well-being of vulnerable coastal populations. By applying these frameworks, practitioners can develop more effective strategies for promoting sustainable development, improving livelihoods, and conserving natural resources.

2.3 Empirical Literature Review

Empirical evidence demonstrates that mangrove conservation and restoration as part of ecosystem-based adaptation (EbA) strategies not only conserves biodiversity but also have tangible benefits for sustainable livelihoods and food security. Evidence from *UNEP Briefing Note 9: Coastal Ecosystems-Based Adaptation- How Nature Protects Our Shores* shows that restoration and protection of mangroves provide communities with mangrove services and enhanced livelihoods opportunities. Additionally, mangroves have wider ecological benefits, they help to reduce vulnerability to climate related coastal hazards, prevent coastal erosion, and act as a barrier against typhoons, cyclones, hurricanes, and tsunamis, helping to minimize damage done to property and life. Mangroves may keep pace with sea level rise. Mangroves may also provide a refuge from ocean acidification; they may also provide a refuge for coral reef species from climate change. The briefing note presents two case studies: one from Tanzania and the other from Madagascar. In Tanzania, mangrove restoration initiatives safeguarded the coastline and also enhanced local fish populations, resulting in increased incomes and improved food security for the community. Similarly, Madagascar integrated coral conservation within coastal management; the initiative facilitated better access to marine resources and strengthened resilience against storms, ultimately enhancing food security (UNEP, 2022). These two examples show how restoring mangroves can stabilize shorelines, improve local livelihoods and promote long-term food security.

Empirical evidence from the Commonwealth's case study on the Mikoko Pamoja in Gazi Bay, Kenya conducted in 2020 demonstrates how mangrove restoration can sustain livelihoods and improve household food security. The study conducted in Gazi Bay, Kenya, found that community-led mangrove restoration and conservation efforts not only protected the ecosystem but also improved livelihoods and food security of local communities.

Initiated in 2010 after losing about 20 per cent of their mangrove forests to timber harvesting, residents of Gazi Bay, Kenya partnered with the UK charity Plan Vivo and the Scotland-based Association for Coastal Ecosystem Services (ACES) and launched a mangrove conservation and restoration project, which involved both the prevention of further mangrove deforestation and new reforestation efforts. The community led initiative protected 117 hectares of mangroves in Gazi Bay from illegal deforestation. The initiative involved nearly 500 members of the community who participated in the regular planting of new mangroves. From 2014 to 2018, the project generated 9,880 credits through a Payment for Ecosystem Services (PES) agreement between Plan Vivo and the community, representing 9,880 tons of CO2 avoided yielding $58,591. Funds were utilized to finance local development in the community including clean water projects, education support and hiring of staff to prevent illegal logging (Commonwealth n.d.). The project demonstrates how mangroves restoration can mitigate climate change and at the same time enhance livelihoods and food security.

In 2014, the United Nations Environmental Programme World Conservation Monitoring Centre (UNEP-WCMC) published an important report titled: *The importance of Mangroves to People: A Call to Action.* The report highlighted the critical role of mangrove ecosystems in providing essential products and services such as coastal protection, carbon sequestration and support for biodiversity. According to (UNEP-WCMC), mangroves supply a range of products that support livelihoods. Wood is a particularly important mangrove product, with many coastal and indigenous communities relying on mangroves for timber and construction material, as well as for fuel. In addition, non-timber mangrove forest products provide significant revenue through the provisioning of, for example, honey, dye, fodder, herbal remedies and fruits. These services are vital for the livelihoods of coastal communities, particularly in Kenya where mangroves contribute significantly to food security, income, and employment opportunities.

Donato et al., 2011 seminal study provides important evidence on the role of mangroves in carbon storage, it highlighted the need for their conservation and restoration. It stated that conservation and restoration of mangroves can contribute significantly to climate change mitigation. Their ability to trap organic sediment and thus store carbon is why mangroves, among other systems, are referred to as 'blue carbon' sinks. On average, the carbon stock of one hectare of mangroves, including soil carbon, is approximately 937 tons of carbon per hectare, more than twice the carbon storage of upland forests and five times that of savannah (Donato et al. 2012), meaning that mangroves are among the most carbon-rich forests in the tropics.

Although mangroves cover less than 1% of the world's tropical forests, this research revealed a critical issue: destroying them releases a significant amount of carbon, far more than other forest types. This is because mangroves store a lot of carbon, and when they're destroyed, that carbon goes into the atmosphere. In fact, some estimates suggest that mangroves account for up to 10% of all carbon emissions from deforestation worldwide (Donato et al. 2011). This underscores how crucial mangroves are in fighting climate change. This research has promoted the inclusion of mangrove conservation in carbon offset programs such as REDD+ and Blue Carbon Offset. These programs aim to conserve mangrove ecosystems to enhance carbon storage and reduce greenhouse emissions. In Kenya, the Gazi Bay Mikoko Pamoja project applied the principles from the study to demonstrate how mangrove restoration can generate carbon credits providing income to local communities while contributing to global carbon sequestration. Such initiatives demonstrate how mangrove conservation can mitigate climate change, but also support mangrove conservation and improve the livelihoods of communities.

3.0 Research Methodology

The research applied combined qualitative and quantitative methods to gather data on mangrove restoration, household food security, and ecosystem-based resilience.

The mixed-method approach provided a rich and detailed understanding of the linkages between mangrove restoration and household food security for communities adjacent to the Mida Creek mangrove ecosystem in Kilifi County, Kenya. Qualitative method provided in-depth perspectives with community members and experts on mangrove restoration activities and food security situation. While quantitative data collected using questionnaires measured the impact of mangrove restoration activities on household food security. Questionnaires were used for collecting data using closed-ended questions and qualitative questions that allowed respondents to provide detailed, qualitative responses.

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The study applied the Yamane's formula (Yamane, 1967) to determine the sample size which is widely used for calculating an appropriate sample size for a given population while maintaining a specific margin of error. The formula used is as follows:

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

Where:

n = Sample size

N = Total population (1,146 households)

e = Desired margin of error (commonly set at 5%, or 0.05)

Using this formula with a 5% margin of error, the sample size was calculated as follows:

$n=1,146/ (1+1,146(0.05^2) = 1,146/ (1+2.865) =1146/3.8655 =296$

The sample size for the study was approximately 296 households, considered sufficient to provide reliable and generalizable results for the entire population living around the Mida Creek mangrove ecosystem allowing for in-depth analysis of the food security situation of communities living around the Mida Creek mangrove ecosystem. A sample of this size was large enough to capture the variability within the population while ensuring cost effectiveness in data collection (Kothari, 2019). The sample was proportionally distributed across the villages adjacent to the Mida Creek mangrove ecosystem to ensure that each mangrove restoration site is adequately represented. The population was first divided into strata based on administrative location and further into mangrove restoration sites and groups. Stratified random sampling was employed to ensure that households from different mangrove sites and livelihood backgrounds are fairly included, thus providing a holistic view of the food security situation within the households. Stratified sampling was effective for reducing sampling bias and improving the precision of estimates (Saunders, Lewis, & Thornhill, 2019).

The study employed a stratified random sampling technique to ensure a more representative distribution of the target population. The sampling frame was divided into distinct strata comprising of the villages adjacent to mangrove restoration sites in Mida Creek. From each village, households were selected randomly to ensure that each subgroup is proportionally represented in the final sample. Purposive Sampling was also being used to collect data from key stakeholders such as community leaders, mangrove restoration sites leaders, community based organizations representatives, forestry officers and experts in mangrove restoration and food security. A total sample size of 296 households was determined using Yamane's sample size calculation formulas to ensure statistical reliability. In the proposal stage, time and budget constraints were anticipated as potential limitations that would have affected the full implementation of the intended sample size and scope. However, the study was completed within the planned schedule, budget and the sample size was accomplished reaching 306 respondents including 10 key informant interviews due to effective planning and respondents' willingness to participate. The research gathered primary data directly from households and individuals living around the mangrove restoration sites in Mida Creek in Kilifi County, through surveys and interviews. Secondary data used existing data from government reports, research studies, and databases to gather information on mangrove cover, deforestation rates, and food security. The research study used the online platform Kobo Toolbox to collect data in the field.

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Data analysis involved both quantitative and qualitative approaches to ensure a comprehensive understanding of the impact of mangrove ecosystem restoration on the food security situation among communities living in villages adjacent to Mida Creek.

Quantitative data obtained from structured questionnaires was analyzed using SPSS (Version 22) and Microsoft Excel (2016). Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize household socio-demographic characteristics and overall response patterns. Cross-tabulations and Chi-square (χ^2) tests were applied to examine relationships between demographic variables and key outcome categories. Composite indices were computed to quantify multiple dimensions, including *Income Improvement*, *Perception of Mangrove Contribution to Household Food Sources*, *Perceptions on Enabling Factors and Challenges Influencing Mangrove Restoration*, and *Food Availability*.

Multiple linear regression analyses were then conducted to identify the demographic and participation-related predictors influencing each composite index. All analyses were performed at a 95% confidence level ($p < 0.05$). Specifically, data collected using the Household Food Insecurity Access Scale (HFIAS) was analyzed to assess the extent, severity, and nature of food insecurity among the surveyed households. The analysis focused on four key components: household food insecurity access-related conditions, access-related domains, the household food insecurity access score (HFIAS score) and household food insecurity access prevalence to help understand the characteristics of and changes in household food insecurity (access) of communities living in villages adjacent to the mangrove restoration sites in Mida Creek as follows:

i. *Household Food Insecurity Access-related Conditions:* These are the various circumstances or experiences that indicate a household's limited or uncertain ability to access adequate food. These conditions served as key indicators providing disaggregated information about the behaviors and perceptions of the surveyed households. For example, they showed the proportion of households that experienced food insecurity access related-conditions at any time during the past 30 days preceding the survey. These indicators were used to determine the severity of food insecurity as it relates to the access dimension of food security and typically reflected the access dimensions of food security.

ii. *Household Food Insecurity Access-related Domains:* Data was analyzed using Household Food Insecurity Access-related domains defined by the HFIAS framework: -1) anxiety and uncertainty about food, 2) insufficient quality of food, and 3) insufficient food intake and its physical consequences. Households reporting one or more experiences within each domain during the recall period were identified to determine the prevalence of each domain. The domain level analysis gave a clear understanding of the specific types of food access constraints affecting the communities. It gave insights into whether households are primarily affected by psychological stress, compromised diet quality or actual food deprivation. Association between domain prevalence and household characteristics was explored using chi-square tests. This domain-based analysis helped distinguish between households that are psychologically food insecure (e.g., worry and anxiety), those with compromised diet quality, and those facing actual food deprivation.

iii. *Household Food Insecurity Access Scale Score:* The study utilized the HFIAS to reflect the degree of food insecurity (access) experienced by a household in the past four weeks (30

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days) prior to the survey. Each household was assigned a total HFIAS score ranging from 0 to 27, based on the frequency of food insecurity access-related conditions such as anxiety over food, reduced diet quality and decreased food intake experienced in the past 30 days. These scores 1) assessed the severity of food insecurity on a continuous scale. 2) Compared average scores across different household characteristics. A lower score indicated less food insecurity while higher scores indicated more severe condition

iv. *Household Food Insecurity Access Prevalence:* The study employed the Household Food Insecurity Access Prevalence (HFIAP) to assess the extent of food insecurity among households. Based on the standard HFIAS classification criteria, households were classified as food secure or experiencing mild, moderate or severe food insecurity. This indicator was essential for quantifying the overall burden of food insecurity in Mida Creek.

Qualitative data collected from key informant interviews was analyzed using thematic analysis, a method that involved identifying and interpreting patterns within the data. This approach allowed the categorization of responses based on key themes related to the mangrove ecosystem based adaptation and food security. The thematic analysis process included coding the data, generating themes, and interpreting the findings to provide richer context to the quantitative results. This mixed-methods approach ensured that the study captured both the statistical significance of mangrove ecosystems and the food security situations of individuals and households impacted by the mangrove restoration initiatives.

4.0 Findings, Discussions, Conclusions and Recommendations

4.1 Key Findings

The study findings indicate a significant positive impact of mangrove restoration on household food security and income. Quantitative analysis reveals that 71% of respondents reported improved fish catch, and 73% reported increased seafood availability, contributing to enhanced food security. The mean score for food availability and access was 4.11, indicating a positive perception of mangrove restoration impact on household food security. 85% of respondents agreed that mangrove restoration enhanced marine productivity and food security. The FAAI showed that 70% of households were either food secure or moderately food insecure.

Similarly, the qualitative findings revealed that there is greater variety of marine life, such as increased fish stocks and crabs around the restored mangrove areas due to the regeneration of mangroves that provided favorable environments for breeding and reproduction of fish and crabs. The findings also showed that mangroves are important for supporting local food sources, increasing food availability while restored mangroves contributed to more stable income to buy food. The community involvement in ecotourism, sale of honey from beekeeping activities and mangrove restoration activities such as sale of seedlings are a source of income to the households. This income in turn is used to purchase food for household consumption. This finding is consistent with *UNEP (2022)* that documented that restoration and protection of mangroves provided communities with mangrove services and enhanced livelihoods opportunities using two case studies from Tanzania and Madagascar. Overall this study reinforces the importance of restored mangroves in improving food security among coastal communities.

The Income Improvement Index (III) analysis reveals that 57.8% of respondents experienced significant income improvement attributed to mangrove-related activities.54.7% of male respondents and 58.9% of female respondents reported high income improvement. The Chi- square test showed no statistically significant gender difference in income improvement levels

($\chi^2 = 0.759$, $p > 0.05$). The regression analysis highlights the importance of community involvement in mangrove restoration. Community involvement is the strongest predictor of perceived restoration success ($B = 0.414$, $\beta = 0.809$, $t = 23.76$, $p < 0.001$). The model explains 67% of the variance in perceived restoration success ($R^2 = 0.67$).

Furthermore, quantitative analysis confirms that mangrove restoration has a positive impact on household food security and income. Community involvement and participation are crucial factors in determining the success of mangrove restoration efforts.

The demographic profile of the respondents reveals a predominantly female, mature, and moderately educated population with strong engagement in traditional agricultural and fishing livelihoods. The household size and gender dynamics influence livelihood strategies, with medium-sized households leveraging their labor most effectively across diverse livelihoods. The study also shows that longer residency is associated with engagement in traditional land and livelihood-based activities, whereas newer and mid-term residents diversify more into non-farm income sources.

The findings indicate that restored mangrove ecosystems significantly contribute to household food sources and food security. Over 85% of respondents agreed or strongly agreed that restoration activities have enhanced marine productivity and food security. The study also shows that mangrove restoration has increased fish catch and seafood availability, contributing to improved food security.

The regression analysis reveals that gender has a small but significant effect on perceptions of mangrove contribution to household food sources, with females slightly more (90.5%) likely than males (78.7%) to perceive greater benefits. This finding on gendered benefits highlights how a range of mangrove ecosystem services are viewed by both males and females. Additionally, women rely on a broad range of mangrove ecosystem services such as fish, crabs, honey, medicinal plants and fuel wood that are used for household consumption, household income and food security; this contributes to the higher perception levels.

The findings align with Fortman et al., (2019), which revealed that women and men often have differential access to and derive different benefits from ecosystem services; therefore, their perception and knowledge of ecosystem services also differ. Women perceived higher ecosystem service flows from mangroves attributed to women's greater interaction with mangrove areas because they are usually closer to villages/homes and more accessible to women while men dominated activities like deep sea fishing.

In addition, the FAAI showed that 70% of households were either food secure or moderately food insecure whereas the HFIAS findings indicated that households remain food insecure where nearly 50% (152 out of the 306) of the households faced some level of food insecurity or food-related stress during this period. The findings further highlight notable gender differences in both the prevalence and frequency of these experiences, with women consistently reporting higher levels of food stress across most indicators.

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The difference in the findings is attributed to the different methods of data collection used to measure food security. The HFIAS measured the food security situation at the household level using a standard validated metrics whereas the other survey was more descriptive and based on perception of the respondents. The finding suggests that as much as mangroves are important in providing ecosystem services not all the services directly contribute to food and nutrition. Only the provisioning services directly contribute to food security, these may also be affected by the scale, seasonality and dietary behavior of households. While other services such as the regulatory, cultural and supporting services may support livelihoods directly and may not directly impact the household food security situation. This showed that communities may benefit ecologically and economically but the benefits may not have an impact on the food security situation at the household level. This information will assist organizations and policy makers to design restoration programs that will ensure food security of households and sustainable livelihoods.

4.2 Discussion

The study demonstrates that mangrove restoration has positively impacted household income, with over 90% of respondents reporting improved access to mangrove resources and increased economic activities. The Income Improvement Index (III) shows that a majority of both male and female respondents experienced significant income improvement attributed to mangrove-related activities. The regression analysis identifies community involvement in restoration as a strong predictor of improved income outcomes.

The findings show that mangrove restoration had a positive impact on household income and access to food. Additionally, respondents in the study expressed strong positive perceptions of the socio-economic benefits of mangrove restoration. The study aligns with the GOK, National Mangrove Ecosystem Restoration Guidelines, Kenya, 2025 which noted that current livelihood based interventions in Kilifi, Lamu, Mombasa and Kwale Counties including beekeeping, aquaculture (fish farming and crab fattening), mangrove eco-tourism, carbon financing, and adoption of energy-efficient stoves aim to reduce pressure on mangroves, promote conservation-based community development while enhancing food security.

However, lower agreement levels were observed on income reliability (60%), ability to meet basic needs (57%), and improved savings (72%), indicating persistent livelihood challenges despite overall improvement. The study observed that income from mangrove restoration particularly for women was mainly from sale of seedlings and planting which is normally short-term and irregular; when the income is unpredictable it becomes difficult to allocate money for basic needs or savings. In addition, other conservation sites have been supported to establish ecofriendly restaurants. It also shows that the income generated might be too small to cover basic needs and savings or it may not be realized at the individual level. For instance, the funds from the Mikoko Pamoja carbon credit revenue is largely pooled into a community development fund, so the direct benefits to individuals at the household level may not be realized. It is important for projects and government agencies to provide alternative income sources to communities involved in conservation to reduce dependence on mangrove resources and anthropogenic pressure on the mangrove ecosystems.

4.3 Conclusions

The study highlights that broad-based participation, strengthened social cohesion, and reduced environmental stressors are key enablers driving the success of mangrove restoration and its contribution to food security outcomes. The findings also reveal that community members are

actively involved in mangrove restoration efforts, and restoration initiatives have positively influenced community cohesion. The regression analysis shows that community involvement in restoration is the strongest predictor of perceived restoration success.

The study findings underscore the importance of mangrove restoration in enhancing household food security and income in coastal communities. The results highlight the need for community engagement, livelihood initiatives, and coordination among stakeholders to ensure the success of mangrove restoration efforts. The study also demonstrates that mangrove restoration can be an effective strategy for promoting sustainable livelihoods and improving food security in coastal communities.

4.4 Recommendations

The study recommends the following:

i. To enhance community engagement and ensure long-term success, mangrove restoration efforts should be integrated with livelihood initiatives that provide sustainable income opportunities for local communities.
ii. Support community-led initiatives through training, capacity-building programs, and access to resources to ensure the sustainability of mangrove restoration efforts.
iii. Collaboration among stakeholders, including government agencies, NGOs, and local communities, is essential for effective mangrove restoration and management.
iv. Encourage active participation and inclusion in restoration activities to enhance community ownership and sustainability.
v. Integrate mangrove restoration with livelihood initiatives that provide sustainable income opportunities for local communities.
vi. Regularly monitor and evaluate the impact of mangrove restoration efforts to identify areas for improvement and ensure long-term sustainability.

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