ECONOMIC VALUATION OF THE ENVIRONMENTAL MANAGEMENT OF *Prosopis juliflora* (*MATHENGE*) IN BARINGO SOUTH SUB-COUNTY, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Master of Science Degree in Agricultural and Applied Economics of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented in this university or any other for the award of a degree.

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Recommendation

This thesis has been submitted with our approval as university supervisors.

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DEDICATION

I dedicate this thesis to my dear family, your unwavering love, prayers, and support have been my foundation. Thank you for believing in me and walking with me every step of the way.

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ABSTRACT

Prosopis juliflora is an invasive tree species that has caused significant impacts across arid and semi-arid regions across Kenya, including Baringo South Sub-County. Initially introduced as a measure to combat desertification, the tree has spread profoundly, contributing to biodiversity loss and undermining agro-pastoral livelihoods. As a result, utilization-based management interventions have emerged as a means to mitigate its adverse effects while simultaneously offering income-generating opportunities to the affected communities. This study sought to assess the economic value of its management in Baringo South Sub-County. Specifically, it aimed to characterize management interventions, identify socio-economic and institutional factors influencing adoption intensity, and assess their net economic benefits. A cross-sectional research design was used, combining data from 270 randomly selected households, 10 key informants, and 2 focus group discussions. Quantitative data was analysed using descriptive statistics, a generalized Poisson regression model, and probabilistic cost-benefit analysis through Monte Carlo simulations with 10,000 iterations. Qualitative data underwent thematic analysis. From the results, charcoal (84.85%) and firewood (47.73%) production were the most widely implemented strategies of managing *Prosopis juliflora*. Adoption intensity was significantly associated with factors such as landholding size and proximity to markets (both positively correlated at $p < 0.01$). All interventions demonstrated a benefit-cost ratio (BCR) greater than 1, indicating profitability under uncertainty. Livestock feed processing (BCR = 7.49), charcoal production (BCR = 4.97), land reclamation (BCR = 4.55), and biochar production (BCR = 3.37) emerged as the most economically viable options. In conclusion, utilization-based management of *Prosopis juliflora* enhances rural livelihoods while contributing to ecological restoration. These findings offer policy-relevant insights for developing integrated strategies that balance economic use with sustainable environmental management of *Prosopis juliflora* in Kenya's dryland regions. They also align with the Baringo County Integrated Development Plan (2023–2027), Kenya's Vision 2030, and the Sustainable Development Goals.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIC	Akaike Information Criterion
ASALs	Arid and Semi-Arid Lands
BCR	Benefit-Cost Ratio
BIC	Bayesian Information Criterion
BORESHA	Building Opportunities for Resilience in the Horn of Africa
CBA	Cost-Benefit Analysis
CMP	Conway-Maxwell-Poisson
DFID	Department for International Development
FFS	Farmer Field Schools
FGD	Focus Group Discussions
GPRM	Generalised Poisson Regression Model
HH	Household
IAPS	Invasive Alien Plant Species
IAS	Invasive Alien Species
IID	Independently and Identically Distributed
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IRR	Incidence Rate Ratios
JOD	Jordanian Dinar
KEFRI	Kenya Forest Research Institute
KES	Kenyan Shilling
KFS	Kenya Forest Service
KII	Key Informant Interviews
KNBS	Kenya National Bureau of Statistics
NACOSTI	National Commission for Science, Technology and Innovation
NGO	Non-Governmental Organization
NPV	Net Present Value
ODK	Open Data Kit
PERT	Program Evaluation and Review Technique
PMF	Probability Mass Function
PRM	Poisson Regression Model
SDG	Sustainable Development Goals
SLF	Sustainable Livelihood Framework

SLM Sustainable Land Management

USD United States Dollar

VIF Variance Inflation Factor

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Invasive Alien Plant Species (IAPS) pose significant threat to ecosystems worldwide, disrupting native habitats, ecological balances, and economic activities. Defined as plants unintentionally or intentionally introduced into non-native ecosystems and causing substantial harm (Shuvar *et al.*, 2021), these species impact biodiversity, agriculture, human health, and livelihoods. In the year 2023, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, 2023) reported that 1,061 alien plants (6% of all established alien plants) are invasive globally.

In East Africa, *Prosopis juliflora*, a hardy and fast-growing tree native to parts of Central and South America and the Caribbean, has become one of the most problematic invasive species. It wasn't always seen this way. In the 1970s and 1980s, the tree was introduced to Kenya by the Ministry of Agriculture with good intentions, i.e., to combat desertification, deforestation, address fuelwood shortages, and restore degraded landscapes (BORESHA, 2020; Eckert *et al.*, 2024). But, despite fulfilling the initial intentions of its introduction, the species spread aggressively across arid regions, often outcompeting native vegetation and disrupting both ecological balance and rural livelihoods (Shiferaw *et al.*, 2019). All this was made possible by its resilience, especially the deep taproots and tolerance for poor soils.

Locally known as *Mathenge*, *Prosopis juliflora* has quite literally become established in Kenya's Arid and Semi-Arid Lands (ASALs), which make up roughly 80% of the country's land area (Mwalewa *et al.*, 2022). Estimates suggest that it has invaded between 700,000 and 1.2 million hectares of the ASALs (Eckert *et al.*, 2024), forming dense thickets that are nearly impossible to walk through, l*et al*one farm or graze (Kamiri *et al.*, 2024).

Turkana, Baringo, Isiolo, and Tana River counties host high densities of *Prosopis juliflora*. In these areas, the tree has displaced the native vegetation and taken over grazing lands. This has resulted in noticeable declines in livestock productivity (Choge *et al.*, 2022; Eckert *et al.*, 2024; Koech *et al.*, 2020). Within Baringo County, the area covered by *Prosopis juliflora* expanded from below 900 hectares to almost 19,000, a growth rate of about 4% annually between 1988 and 2016 (Mbaabu *et al.*, 2019). Around Lake Baringo, the spread was even more pronounced, with the tree's coverage increasing more than 200-times during the same period (Mbaabu *et al.*, 2021).

Various efforts have been taken to eradicate this invasive tree, including; mechanical methods, chemical approaches, and biological control (Arocha, 2020). However, none of these approaches has proven to be fully effective. Quite often, they tend to be expensive, labour-intensive, or difficult to sustain over time (Chandrasekaran & Swamy, 2016; Okumu, 2019). This has shifted the attention towards utilization-based management which involves finding ways to turn the tree into a resource rather than a nuisance.

The Kenyan government, through Kenya Forestry Research Institute (KEFRI) and Kenya Forest Service (KFS), and various Non-Governmental Organizations (NGOs), have researched and approved the utilization-based approach in areas like Baringo South Sub-County. In these communities, people have been given a greenlight to use *Prosopis juliflora* for charcoal, firewood, timber, poles, and even pod-based livestock feed, among others. Besides, the National Strategy and Action Plan for the Management and Control of *Prosopis juliflora* tree species (2023-2032) advocates for the deliberate removal of *Prosopis juliflora*, to be replaced by perennial grass species (e.g., *Cenchrus ciliaris*) and other crops (Adoyo *et al.*, 2022; Eshetu, 2024; Kamiri *et al.*, 2024; Tabe-Ojong, 2023).

Managing *Prosopis juliflora* through utilization holds promise for the affected communities. This approach can help restore degraded ecosystems while offering new income streams for households that have been negatively impacted by its invasion. However, the economic value of these utilization strategies has not been fully quantified. While the adoption rates vary widely, an understanding of what drives or hinders their implementation could shape more effective policies. This study sought to estimate the net economic benefits of *Prosopis juliflora* management interventions in Baringo South Sub-County and identified factors influencing the intensity of implementation.

1.2 Statement of the Problem

Prosopis juliflora continues to pose a serious threat in the ASALs of Kenya, including Baringo South Sub-County. Communities have tried converting the tree into something useful, but it has continued to spread aggressively. While its management sounds promising on paper, the actual impact of the strategies used to control it have been, at best, uneven. One reason for this may be the lack of clarity around their economic viability as households and policymakers alike are often left guessing. Furthermore, considerable attention is being paid to the ecological damage that it causes and to its potential uses, but much less to the economic trade-offs involved in managing it. What’s missing is a grounded understanding of whether the management strategies pay off since without this evidence, it is hard to know what is working.

This uncertainty makes it difficult to build sustainable strategies. It further risks wasting resources in strategies that may not be scalable or effective in the long run. What is needed, then, is a closer look at the economics of *Prosopis juliflora* management, something that can help guide decisions not just about what to do, but how to do it in ways that genuinely support both livelihoods and environmental recovery.

1.3 Objectives of the Study

1.3.1 General Objective

To evaluate the economic benefits and determinants of adoption intensity of *Prosopis juliflora* management interventions in Baringo South Sub-County, thereby contributing to improved livelihoods and sustainable environmental management.

1.3.2 Specific Objectives

i. To characterize *Prosopis juliflora* management interventions being implemented by households in Baringo South Sub-County.
ii. To determine the factors shaping the adoption intensity of *Prosopis juliflora* management interventions among households in Baringo South Sub-County.
iii. To evaluate the net economic benefits of *Prosopis juliflora* management in Baringo South Sub-County.

1.4 Research Questions

i. What are the *Prosopis juliflora* management interventions being implemented by households in Baringo South Sub-County?
ii. Which factors shape the adoption intensity of *Prosopis juliflora* management interventions among households in Baringo South Sub-County?
iii. What are the net economic benefits of managing *Prosopis juliflora* in Baringo South Sub-County?

1.5 Justification

Having identified which utilization strategies bring both ecological and financial benefits, the study provides practical lenses through which national and county-level stakeholders can better allocate resources. Households and communities in Baringo South Sub-County can integrate these findings into their development plans to enhance sustainable land management and livelihood diversification, thus aligning with the goals of economic growth and environmental sustainability of the Kenya Vision 2030.

The study also highlights how adoption intensity may influence such outcomes as land restoration, grazing recovery, and the return of native biodiversity. These gains align with global efforts like the UN Sustainable Development Goals, specifically SDG 13 on Climate Action and SDG 15(Life of Land). These goals call for more integrated approaches to managing invasive species and restoring degraded ecosystems (Kamiri *et al.*, 2024).

From an academic point of view, this work contributes to the increasing debate about invasive species management.

1.6 Scope and Limitations of the Study

The study focused on Baringo South Sub-County where *Prosopis juliflora* is predominantly found, particularly in the lowland areas along riparian zones of lakes and rivers like Lake Baringo, Lake Bogoria, River Molo, and River Perkerra. The reason for targeting households from this sub-county was because the tree species is extremely widespread there, whereas its distribution is not uniform in Baringo County. The study targeted households that were implementing *Prosopis juliflora* management interventions, including specialized groups formed for its extraction and utilization (Tuwei *et al.*, 2019).

A possible limitation on the study findings was the reliance on self-reported data. Several steps were taken to mitigate its potential impact and improve the reliability of the findings including; a pilot study which helped to refine the data collection tools, adequate enumerator training, and the collection of both quantitative and qualitative methods to allow for data triangulation. Furthermore, regular consistency checks were carried out to catch discrepancies early.

1.7 Operational Definition of Terms

Adoption intensity: This refers to the degree or extent to which households implement *Prosopis juliflora* management interventions. In this study it was measured by the number of interventions adopted by a household.

Alien plant: A plant that has been introduced, often by humans, into an environment where it didn't naturally occur. Even plants that are introduced without direct human help, as long as they come from places where they're already considered exotic, fall under this category (Witt *et al.*, 2024).

Benefits: Tangible gains, like increased crop yields or extra income, that result from managing *Prosopis juliflora*.

Costs: Expenses, both financial and labour-related, that households incur when they try to manage *Prosopis juliflora*.

Economic value: The costs and benefits associated with the implementation of *Prosopis juliflora* management interventions.

Invasive alien plant species: A plant species that is harmful to its growing habitat and foreign, as previously mentioned (Witt *et al.*, 2024).

Sustainable environmental management: Responsible implementation of *Prosopis juliflora* control practices that mitigate the negative impacts of the invasive species to meet current needs without compromising the ability of future generations to meet their own, thereby balancing ecological, economic, and social goals.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

This chapter explored the global spread and management of Invasive Alien Plant Species, focusing on *Prosopis juliflora*. It examined the factors influencing the adoption intensity of *Prosopis juliflora* management interventions, their economic implications, and critiqued existing literature to identify research gaps. The chapter also explained the Utility Maximization Theory and the Sustainable Livelihoods Framework (SLF) in so doing providing a theoretical foundation for analysing household-level decision-making and environmental sustainability in Baringo South Sub-County. A conceptual framework further illustrated the interplay between socio-economic and institutional factors in shaping management outcomes.

2.1 Global Perspective on Invasive Alien Plant Species

Invasive alien species (IAS) are a global concern, and according to a 2023 assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), there are more than 37,000 alien species in the world, and 200 new species are discovered every year. Over 3,500 species are invasive, including 141 microorganisms (11%), 1,852 invertebrates (22%), 461 vertebrates (14%), and 1,061 plants (6% of alien plants). 37% of alien species were discovered after the year 1970, and their numbers are expected to increase by 36% by 2050 from the year 2005 (IPBES, 2023).

Annually, the economic toll of biological invasions exceeds $423 billion, and by the year 2019, 92% of these invasions were associated with ecosystem damage and losses in human well-being, with indigenous lands hosting over 2,300 IAS. From the 1970s, the financial burden of these invasions has quadrupled decennially, disproportionately impacting Africa (7%), Asia-Pacific (25%), Europe and Central Asia (31%), and the Americas (34%) (Bacher *et al.*, 2024).

Worldwide, Invasive Alien Plant Species account for over 1,061 invasive species (IPBES, 2023). They are very disruptive, with the most common ones being the *Lantana camara* (lantana) and *Pontederia crassipes* (water hyacinth). These plant species do not just compete with native species, they often win. And when they do, ecosystems lose their balance, biodiversity shrinks, and soil health deteriorates. Some IAPS, however, provide ecosystem and human benefits, for example, Zengeya *et al.* (2017) found that *Ammophila arenaria* (Marram grass) aids erosion control and dune stabilization, moreover, IAPS contributions to income, food, and medication were documented by Baral *et al.* (2017) and Srithi *et al.* (2017).

Across much of Africa, the challenge of managing invasive alien plant species is becoming increasingly complex. Some countries, South Africa, Ethiopia, Kenya, Tanzania, Zambia, and Uganda, seem to be struggling with it more intensely than others. In East Africa alone, Witt and Luke (2017) documented 51 alien plant species, with 21 considered invasive, where key threats include *Prosopis juliflora* (mesquite), *Opuntia stricta, Lantana camara, Chromolaena odorata, Tithonia diversifolia* (Mexican sunflower), and *Parthenium hysterophorus* (parthenium weed). In Kenya, invasive plants include, but not limited to, water hyacinth (*Pontederia crassipes*), *Prosopis* species, Kariba weed (*Salvinia molesta*), and Stinking roger (*Tagetes minuta*).

Efforts to reduce the impacts of IAPS have increased globally. For instance, Boadie-Ampong and Nishi (2024) identified 25 management practices which they classified into strategic, collaborative, and hybrid approaches. Strategic management includes pathway controls (e.g., early detection, biosecurity), species-based interventions (mechanical, chemical, biological controls), and ecosystem restoration; whereas collaborative management engages stakeholders, while hybrid approaches integrate scientific and traditional knowledge.

2.2 *Prosopis juliflora* Spread and Management

Prosopis juliflora (Figure 2.1) has spread extensively across arid and semi-arid regions all over the world, leading to both beneficial and detrimental impacts (Obonyo *et al.*, 2017). Its spread is mainly facilitated by waterborne seed dispersal through runoff and river flow during rainy seasons, as well as the actions of livestock and humans that ease seed distribution across different locations (Auala *et al.*, 2014).

In Africa, its introduction took place at varying timelines, suggesting different motivations and contexts. For instance, it was introduced in Senegal as early as 1822, and later on in Egypt around the 1900s. In Eritrea, it was introduced in the early 1980s from Sudan, and Ethiopia began planting it in the 1970s, while South Africa had already introduced it by 1880 (Shiferaw *et al.*, 2018). Between the early 1970s and the 1980s, *Prosopis juliflora* was actively planted in some parts of Kenya as a response to desertification and chronic fuelwood shortages, especially in the arid and semi-arid regions (Masakha & Wegulo, 2015). Its large-scale cultivation was actively promoted by government agencies and NGOs due to its adaptability to harsh environments. However, by 2008, the Kenyan Minister of Agriculture officially declared the plant noxious due to its invasive nature (Arocha, 2020).

Figure 2.1: (a) A mature *Prosopis juliflora* tree, (b) *Prosopis juliflora* thorn, (c) Dense stand of *Prosopis juliflora* trees growing along the banks of River Loboi, (d) *Prosopis juliflora* encroaching on the roadside vegetation along the route to Lake Bogoria National Reserve.

Eradicating *Prosopis juliflora* is both difficult and costly once it invades an ecosystem as its invasiveness is driven by multiple factors (Patnaik *et al.*, 2017). Globally, various methods of managing the its invasiveness, including mechanical, chemical, and biological, have been tried (Abdulahi *et al*., 2017; Akwee & Nambafu, 2023; Arocha, 2020; Gebrehiwot & Steger, 2024). Each has its merits, but none has managed to fully eliminate the tree species (Shiferaw & Demissew, 2022). As a result, a mixed management approach that integrates utilization and land restoration has been proposed as a more sustainable solution.

Scholars have since started emphasizing the importance of participatory, and locally tailored strategies, particularly in low-income countries where costly control measures are impractical. Al-Assaf *et al*. (2020), for instance, suggested that selective clearing should be combined with pasture development, as well as technical and financial support, and government-community collaboration. Eschen *et al*. (2021), Kamiri *et al*. (2024), and Tebboth *et al*. (2020) also promote location-specific approaches that range from containment and eradication to commercial and community-based use.

This is considered essential to the success of management efforts, given that such an approach would be consistent with the peculiar ecological, economic, and social conditions in areas of infestation. Guided by these insights, this study approached the management of *Prosopis juliflora* from a local perspective in Baringo South Sub-County.

2.3 Factors Influencing the Adoption Intensity of Management Interventions

Technology adoption in agriculture is typically a gradual process: people pass through stages of hearing about the innovation, developing opinions about it, adopting or rejecting it, and adopting the new idea (Dalango & Tadesse, 2019; Feder *et al*., 1985). Nkonya *et al*. (1997) also explained the scope of technology adoption as an indicator of the extent to which a particular technological package is accepted by its users.

These levels are affected by different demographic, institutional, and socio-economic determinants that differ from place to place (Dalango & Tadesse, 2019). For instance, Gebre *et al*. (2019) applied a double-hurdle model to analyse gender differences in Ethiopia where, female-headed households had lower likelihood of adopting improved maize varieties than male-headed households; likewise, Sodjinou *et al*. (2015) showed that labour availability has a strong impact on adoption decisions. They found that farmers who had relatively larger families without labour constraints were more likely to adopt family labour-intensive practices.

While studying wheat farmers in Northern Ethiopia, Leake and Bekele (2015) found that farmers with many years of formal schooling have a tendency of allocating more land to improved varieties as compared to those without formal schooling. This implies that education also matters in influencing adoption decisions. In another study, Awotide *et al*. (2016) studied rice farmers in Nigeria and found that adoption intensity was influenced by a whole mix of factors including membership in farmer groups, income from rice, seed cost, distance to seed sources, yield, and extension training.

Using Count Data models, Mensah-Bonsu *et al*. (2017) established that access to credit, extension services, and previous experience with food shocks were the most significant drivers in the adoption of land and water management practices. Beshir (2014) also made similar findings: farm size, labour, and land tenure all are important determinants for forage adoption.

A related study by Okumu (2019) analysed the drivers of *Prosopis juliflora* management adoption among households in Marigat Sub-County. She noted that land size, income from *Prosopis juliflora* products, age, and household size significantly influenced the level of adoption of the management interventions.

While the wider literature provides the framework on adoption intensity, local dynamics can also help to provide a clear understanding of the factors that influence how intensively households in Baringo South Sub-County implement *Prosopis juliflora* management interventions.

2.4 Economic Benefits of *Prosopis juliflora* Management Interventions

Prosopis juliflora has proved to be economically beneficial in many parts of the world. In India, for example, Tewari *et al*. (2022) assessed the use of *Prosopis juliflora* pods by farmers as feed for their livestock. This reduced the cost of feed from approximately USD 9.09 – 9.84 per 50 kg bag to about USD 6.82 – 7.58. Consequently, incomes at household level increased up to USD 36 per month, with a total enterprise value of USD 338,000, demonstrating some economic benefits that could be achieved through proper utilization of *Prosopis juliflora* resources.

Another strong example is that of Kenya. Mwalewa *et al*. (2022) reported that the incomes from *Prosopis juliflora* charcoal ranged between KES 3 million and KES 16 million annually, with a much bigger range, KES 60 million and KES 200 million, in Garissa and Tana River counties, respectively. This value demonstrates a great market potential for *Prosopis juliflora* charcoal within the highly infested areas of the tree species. Similar results were documented by CARE International (2022) in Mandera County, with the charcoal briquettes and livestock feed being some of the value-added products developed by the communities. These management approaches create employment opportunities, improve incomes, and provide new market channels for areas with often limited economic opportunities.

Argaw (2015) and Wakie *et al*. (2016) reported that in commercial contexts, *Prosopis juliflora* contributed up to 96% of the environmental income of household in Ethiopia.

However, it adversely affected subsistence households, who reported losses as high as up to 240%. But, the profitability of different management strategies greatly differed, with irrigated farming providing a net present value (NPV) of as high as USD 5,234 per hectare over a ten-year period, while flour production resulted in a negative NPV of USD -17,905, emphasizing context-specific management approaches.

Tuwei *et al*. (2019) reported that the *Prosopis juliflora* charcoal production in Baringo County generated KES 93.7 million, with a further KES 12.2 million from other *Prosopis juliflora*-based products in the year 2016. In another study, Al-Assaf *et al.* (2020) documented annual net earnings of JOD 754.5 per household from *Prosopis juliflora* management activities in Jordan.

Even though various studies have demonstrated the economic benefits of *Prosopis juliflora* utilization, an understanding of the net economic impacts due to these utilization-based interventions in Baringo South Sub-County is required.

2.5 Gaps in the Literature

There is a marked trend towards market-oriented discourse within the literatures reviewed on *Prosopis juliflora* use. Works by Argaw (2015), CARE (2022), Tuwei *et al.* (2019), and Wakie *et al.* (2016) have investigated the tree for its economic value, especially its profitability and its use for generating income. However, the majority of this research focuses on profitability and excludes an entire aspect of value.

Furthermore, Okumu (2019) did a critical work on the socioeconomic and demographic factors that shape households' decisions to adopt *Prosopis juliflora* management techniques. But all the same, her focus stopped at the decision point, with the intensity being less explored.

Although literature provides useful insights, there is still a lack of empirical evidence on the net economic benefits and the determinants of adoption intensity of *Prosopis juliflora* management interventions at household level. Therefore, this study, aimed to fill this knowledge gap by providing insights that are both grounded and locally relevant, which can be used to inform more sustainable management strategies and help shape policies that reflect reality on the ground.

2.6 Theoretical Framework

2.6.1 Utility Maximization Theory

This theory assumes a kind of rationality that individuals weigh their preferences against their constraints and choose the path that offers the most satisfaction or welfare. In the context of this study, the assumption is that households in Baringo South Sub-County are essentially risk-neutral. This means that a rational household evaluates available alternatives and opts for the choice that yields the highest expected utility, for instance, it adopts the management interventions that it anticipates will be beneficial or profitable to it (Ouya *et al.*, 2020).

While the utility isn't directly observable, it can often be inferred from the choices and actions of households. Suppose that U_a and U_b denote a household's utility for two different choices, represented by Y_a and Y_b, respectively. Building on prior research by Lubinga *et al.* (2024) and Yirga *et al.* (2015), the linear random utility function can be expressed as:

$$U_a = \beta_a x_i + \varepsilon_a \text{ and } U_b = \beta_b x_i + \varepsilon_b \quad (1)$$

In this context, U_a and U_b represent the perceived utilities for the choices of adopting one or more *Prosopis juliflora* management interventions and not adopting any, represented by a and b, respectively. x_i is the vector of explanatory variables affecting the perceived appeal of each choice. β_a and β_b are utility shifters, while ε_a and ε_b are error terms assumed to be independently and identically distributed (iid).

If a household opts for choice a, it indicates that the perceived utility or benefit from choice a exceeds that from choice b, as illustrated by:

$$U_{ia}(\beta_a x_i + \varepsilon_a) > (U_{ib}(\beta_b x_i + \varepsilon_b),\ b \neq a\ \ \forall\, i \quad (2)$$

The probability that a household will opt to adopt one or more *Prosopis juliflora* management interventions by selecting a over b can be expressed as:

$$P(Y = 1|x) = P(U_{ia} > U_{ib}) \quad (3)$$

$$P(\beta_a' x_i + \varepsilon_a - \beta_b' x_i - \varepsilon_b > 0|x)$$

$$P(\beta_a' x_i - \beta_b' x_i + \varepsilon_a - \varepsilon_b > 0|x)$$

$$P(x^* x_i + \varepsilon^* > 0|x = F(\beta^* x_i)$$

Where P is a probability function, U_{ia}, U_{ib} and x_i are as defined earlier. The term $\varepsilon^* = \varepsilon_a - \varepsilon_b$ and represents a random disturbance, while β' is a vector of unknown parameters that reflect the net influence of independent variables on adoption. $F(\beta^* x_i)$ is the cumulative distribution function of the error term ε^*, evaluated at $\beta^* x_i$. The form and behaviour of this function depends entirely on how the error term behaves.

Households in Baringo South Sub-County do not merely decide whether to manage *Prosopis juliflora* or not. They face a complex system of competing needs (Fishburn, 1968).

Their decisions represent an effort towards enhancing the general welfare amidst negative impacts due to *Prosopis juliflora* invasion. The theory is thus useful for the perspective it provides on patterns of adoption behaviour in offering the reasons why some households adopt multiple strategies while others are fixed to one or none (Ouya *et al.*, 2020).

2.6.2 Sustainable Livelihoods Framework (SLF)

The SLF is one of the tools that describes how individuals navigate the everyday realities of survival, adaptation, and long-term well-being. Its original thinking came from Robert Chambers and Gordon Conway (Chambers & Conway, 1992). The British Department for International Development (DFID, 1999) later on took the idea and gave it more structure, turning it into a framework that can be used in development planning and research. The framework is about understanding livelihoods not just as jobs or income, but a mix of skills, resources, and activities that people rely on to make a living.

Chambers and Conway (1992) argued that a livelihood is sustainable if it can handle shocks without falling apart. They further added that it should also be able to maintain or improve its resource base over time, and ideally, support future generations without degrading the natural systems it depends on (Chambers & Conway, 1992). Figure 2.2 presents the SLF:

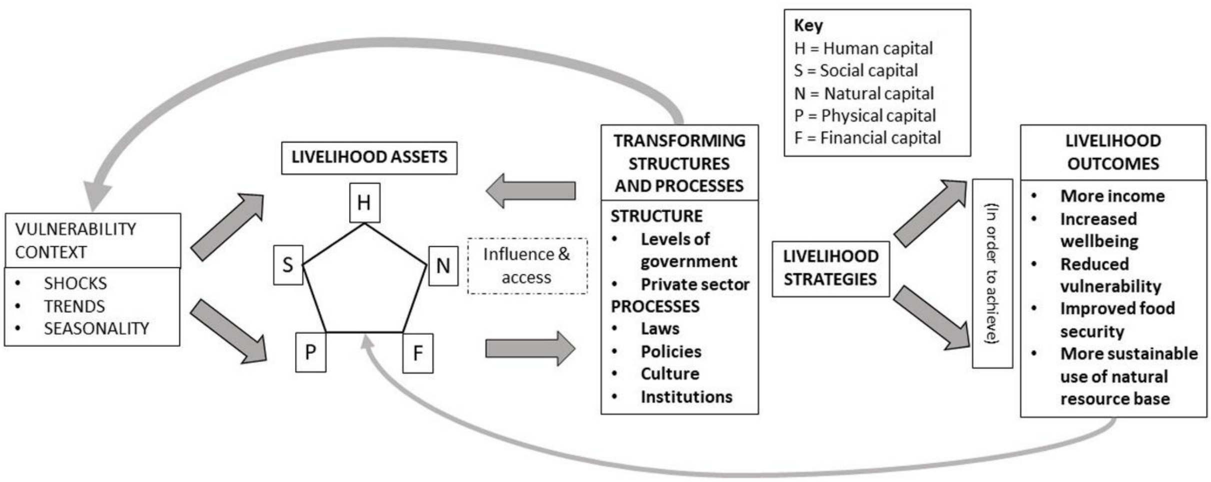

Figure 2.2: Sustainable livelihood framework

Source: Adapted from DFID (1999)

The framework was found relevant for this study because of its ability to link environmental management with livelihood outcomes. Households in Baringo South Sub-County manage *Prosopis juliflora* by making decisions that affect their income, land, and long-term resilience. It also fits well with the broader goals of sustainability as it treats ecological resilience and economic well-being as intertwined. In contexts where environmental degradation and poverty reinforce each other, solutions need to be both ecologically sound and socially grounded (Dogma *et al.*, 2018; Mashaba *et al.*, 2014; Persson *et al.*, 2016; Quintas-Soriano *et al.*, 2018).

2.7 Conceptual Framework

Error! Reference source not found. illustrates how households decide which *Prosopis juliflora* management interventions to adopt, and how many. It's shaped by a mix of socio-economic characteristics and institutional factors. Environmental conditions also play a role, though more indirectly.

The framework captures the way households draw on a bundle of assets, in order to navigate their livelihood strategies. And it is through the interaction of these elements with broader socio-economic and institutional factors that households decide not just whether to engage in *Prosopis juliflora* management, but how to deeply commit.

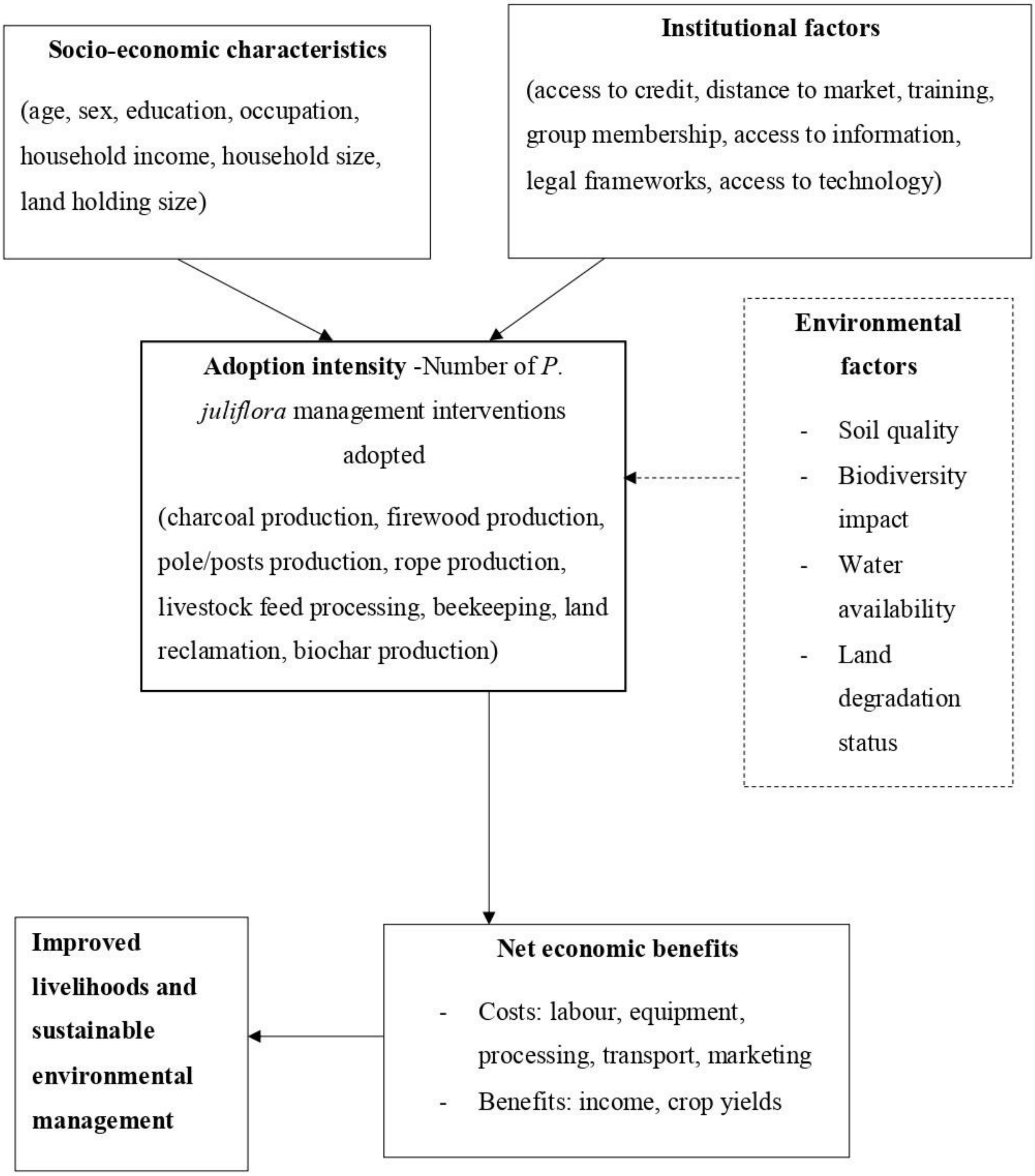

Figure 2.3. Conceptual framework

Source: Author's conceptualization

CHAPTER THREE
METHODOLOGY

3.0 Introduction

This chapter gives a brief description of the study area, research design and methods of data collection. The last section provides models that were used to analyse the data that was collected.

3.1 Study Area

Baringo South Sub-County, situated in Baringo County, Kenya, spans between longitudes 35˚50’E and 36˚30’E and latitudes 0˚10’N and 0˚40’N (Figure 3.1). Covering approximately 1,985 km^2, it includes about 139.5 km^2 of surface water from Lake Bogoria and Lake Baringo (BCIDP, 2023). The sub-county lies within the Eastern Rift Valley, with elevations ranging from 870 meters in the lowlands to 2,499 meters in the Tugen Hills (Petek, 2015).

The sub-county’s semi-arid climate is characterized by agroclimatic zones IV and V, with high temperatures and low, erratic rainfall. Annual precipitation ranges from 300-700 mm in the lowlands to 1,000-1,500 mm in the highlands, and rainfall peaks occur between April-May and October-November, with average temperatures ranging from 22°C to 24°C, and reaching highs of 30°C during hotter months (Nyambari *et al.*, 2024).

In the region’s lowlands, the invasive *Prosopis juliflora* has taken over, crowding out other plants. There are also patches of grass, *Eragrostis superba* and *Themeda triandra*, and scattered herbs like *Ocimum gratissimum*, which add some seasonal colour and utility (Petek, 2015). Land use is mostly agro-pastoral, with households combining livestock rearing with small-scale farming, often growing drought-tolerant crops like pigeon peas and millet. Beekeeping is also practiced, though usually on a modest scale (Ogendi *et al.*, 2020).

The local communities which comprise of Pokot, Tugen, Ilchamus, and Endorois ethnic groups rely heavily on subsistence farming and livestock rearing for their day-to-day survival. There are other sources of income, but they tend to be supplementary rather than central, for example, charcoal production, beekeeping, and tourism linked to Lake Baringo and Lake Bogoria’s biodiversity, hot springs, and geysers (Ochuka *et al.*, 2019).

As a result of being one of the areas in Kenya which has been most visibly impacted by *Prosopis juliflora* invasion, and also a focal point for both government and community-led efforts to manage the tree species, Baringo South Sub-County was found to be a compelling place to examine both the economic valuation and adoption intensity of *Prosopis juliflora* management interventions (Tuwei *et al*., 2019).

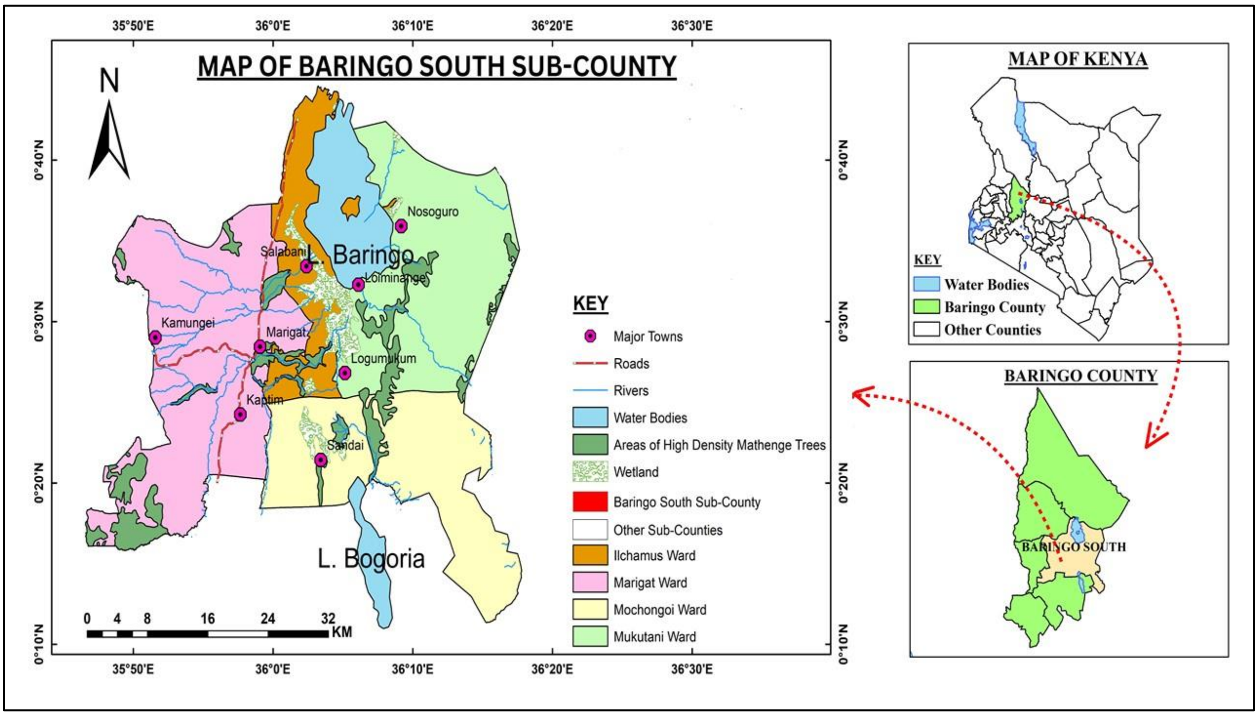

Figure 3.1: Map of study area

Source: Egerton University, Department of Geography (2025)

3.2 Research Design

A cross-sectional research design was used so as to enable the collection of both quantitative and qualitative data at a single point in time (Creswell & Hirose, 2019). Data was collected using a social-ecological household survey, Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs).

3.3 Population of the Study and Respondents

Households implementing *Prosopis juliflora* management interventions formed the study population. In addition, FGDs included men and women from community structures like the Charcoal Producers Association, civil society organizations, and local leadership, while KIIs targeted stakeholders from government offices, KEFRI, and KFS.

3.4 Sampling Procedure and Sample Size

A multi-stage sampling procedure was used to select the sample. In the first stage, Baringo South Sub-County was purposively chosen since it’s the Sub-County where *Prosopis* *juliflora* was introduced in the early 1980s in Baringo County, thus having the highest density of *Prosopis juliflora* cover in the county. Furthermore, it's one of the priority areas where most of the *Prosopis juliflora* management interventions are taking place in Kenya.

To allow for variation, in the second stage, four administrative wards of *Ilchamus, Mukutani, Marigat* and *Mochongoi* were selected, and in the final stage, simple random sampling was used to select the sub-samples of households that have adopted *Prosopis juliflora* management interventions and those that have not. During data collection, households were screened and classified as adopters or non-adopters of *Prosopis juliflora* management interventions based on their self-reported participation. If a selected household was unavailable or declined to participate, it was replaced by another randomly selected household. Furthermore, purposive sampling was used to select participants for the FGDs and the KIIs.

Since the population size for all the four wards was known, the formula by Yamane (1967) was used to determine the sample size for the study:

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

Where n is the desired sample size, N is the population size, and e is the desired level of precision (acceptable error). The percentage at which the sample's behaviour differs from that of the entire population is shown by the level of precision, the more representative the sample is of the population at a certain confidence interval, the narrower the level of precision (Taboka, 2016). The study assumed that the estimated sample size would be within plus or minus 6% of the population value, and an acceptable error of 0.06 was chosen, meaning that the study was willing to tolerate an error of 6% in the sample estimation. Therefore, the overall sample size for the study was:

$$n = \frac{9546}{1+9546(0.06)^2} = 270 \quad (2)$$

The number of respondents per administrative ward was determined using proportionate sampling, as each of the four wards had varying number of households. The number of households in each ward was multiplied by the overall sample size, and the result was divided by the total number of households in all the four wards to get the sample size distribution (Timu *et al.*, 2014).

$$n(per\ administrative\ ward) = \frac{No.of\ households\ per\ ward\ x\ 270}{total\ number\ of\ households} \quad (3)$$

Table 3.1: Distribution of sample size across the wards

Administrative Ward	Number of Households	Sampled Households
Ilchamus	1080	30
Marigat	5580	158
Mochongoi	2599	74
Mukutani	287	8
Total	9546	270

Source: Kenya Population and Housing Census (2019)

3.5 Data Collection Instruments and Analysis

Trained *Tugen*, *Endorois* and *Ilchamus* speaking enumerators collected data for the study using questionnaires administered face to face to randomly selected households, and the data was recorded using ODK collect v2023.1 software which enabled the researcher to monitor the submission of the enumerators daily for quality control. Before the main data collection exercise, enumerators were recruited and trained to ensure data quality and consistency. The training lasted three days and covered the objectives of the study, the structure and content of the questionnaire, ethical considerations, and techniques for conducting interviews with household respondents. Practical sessions and role-plays were included to familiarize enumerators with field conditions and to standardize the interpretation of questions, and the training was supervised by the researcher and an experienced field coordinator.

At each household, the head was interviewed, and in their absence, another person from the household above the age of 18 was interviewed. A semi-structured questionnaire (below) was used to collect relevant information on the various themes of the research, consistent with the specific objectives and the data was managed using STATA 17 and Microsoft Excel. Additionally, qualitative questionnaires were developed and used to collect data from 2 focus groups (below) and 10 key informants (below), and the data was analysed through manual thematic analysis (below).

3.5.1 Validity Test

A pilot study was conducted in Salabani location, Ilchamus ward, to assess the validity of the survey instrument before full-scale data collection. For context, this refers to how accurately a tool assesses what it is intended or designed to measure (Dunn, 1989), and for this study, both face and content validity were considered. The test for face validity was done by evaluating the clarity, layout, and relevance of the questionnaire items from the perspective of the respondents. This ensured that the instrument was appropriate and understandable (Johnson, 2021). On the other hand, content validity was ensured by thoroughly reviewing all questionnaire items to confirm that they adequately captured the variables under study (Heale & Twycross, 2015). Furthermore, the data collection instruments were reviewed by research supervisors and field experts to eliminate irrelevant items and refine its structure, and also, feedback from the pilot sample (n=30) ensured that the tool was appropriate for the target population, minimizing measurement errors in the final study.

3.5.2 Ethical Considerations and Research Authorization

Ahead of field work, an ethical approval was obtained from the Egerton University Research Ethics Committee (EUREC) to ensure compliance with research integrity standards (below), and also, a research permit was secured from the National Commission for Science, Technology, and Innovation (NACOSTI) to authorize the study (below).

3.6 Analytical Framework

3.6.1 Objective 1: To Characterize the *Prosopis juliflora* Management Interventions Being Implemented by Households in Baringo South Sub-County

Descriptive statistics (means, frequencies, percentages) and inferential tests (Chi-square, t-tests) were used to characterize *Prosopis juliflora* management interventions in Baringo South Sub-County, comparing adoption trends across various household characteristics (Gabriel *et al.*, 2023; Ndao *et al.*, 2019), and in addition, qualitative data from KIIs and FGDs underwent thematic analysis to contextualize the quantitative findings.

3.6.2 Objective 2: To Determine the Factors Influencing the Intensity of Adoption of the *Prosopis juliflora* Management Interventions Among Households in Baringo South Sub-County

Drawing from studies that have utilized count data models to analyse the intensity of adoption of various technologies (Bajgain *et al.*, 2024; Joshi & Bhandari, 2023; Korir *et al.*, 2015; Mwikamba *et al.*, 2024; Nkegbe & Shankar, 2014), the number of *Prosopis juliflora* management practices adopted by a household was interpreted as a measure of adoption intensity.

Given that the dependent variable was a count variable, count data models were employed, following the recommendation by Gujarati and Porter (2009). The analysis began with the standard Poisson regression model, however, this model exhibited under-dispersion i.e., its conditional mean was greater than its variance, violating the assumption of equal mean and variance (below). This issue was confirmed using a likelihood ratio test, as detailed in below. To address under-dispersion, the study adopted the Generalized Poisson model (GPRM) (Sellers & Morris, 2017; Toledo *et al.*, 2022), which performed better in terms of goodness-of-fit measures such as the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) (below), indicating its suitability over the standard Poisson model.

When dealing with count data that shows signs of under-dispersion, there are a few modelling options worth considering. Conway-Maxwell-Poisson (CMP or COM-Poisson) model (Ash *et al.*, 2021) is one of such models, and just like the Generalized Poisson Regression Model, it can handle both under- and over-dispersion, which makes it theoretically appealing. However, this model is not straight forward in practice as it lacks a closed-form expression for its mean, meaning that one has to rely on computationally heavy methods such as Monte Carlo simulations, high-dimensional numerical approximations, and so on (Desjardins *et al.*, 2023), thereby complicating the interpretation of its results in regression analysis.

Instead, the study opted for the GPRM, which offers a more manageable way to account for data dispersion (Handayani *et al.*, 2021). In this regression model, the outcome variable (y_i) is assumed to follow a Generalized Poisson distribution, with the Probability Mass Function (PMF) expressed as:

$$f(y_i;\theta_i,\delta) = \frac{\theta_i(\theta_i+\delta y_i)^{y_i-1}e^{-\theta_i-\delta y_i}}{y_i!}, \quad y_i = 0,1,2,\ldots \qquad (4)$$

Here, $\theta_i > 0$, and δ must fall within the range max $(-1,-\theta_i/4) < \delta < 1$ (Yadav *et al.*, 2021). The mean and variance of the distribution are given by:

$$\mu_i = E(Y_i) = \frac{\theta_i}{1-\delta}, \ \mathrm{Var}(Y_i) = \frac{\theta_i}{(1-\delta)^3} = \frac{1}{(1-\delta)^2}E(Y_i) = \phi E(Y_i) \qquad (5)$$

The expression $1/(1-\delta)^2$ functions as a dispersion parameter. When δ=0, the model simplifies to the standard Poisson distribution, where the mean equals θ_i and the variance matches the mean, what we call equi-dispersion.

The empirical model for implementing the Generalized Poisson regression model was estimated as follows:

$$Adpintensty_i = \beta_0 + \beta_1 HHsize + \beta_2 Education + \beta_3 Age + \beta_4 Sex + \beta_5 HHincome +$$

$$\beta_6 Credit + \beta_7 Grpmember + \beta_8 Distmarkt + \beta_9 Training + \beta_{10} Occupation + \beta_{11} Information + \beta_{12} Landsize + \beta_{13} Legalframework + \beta_{14} Technology + \mu_i \qquad (6)$$

The independent variables included were selected based on findings from prior research and economic theory, and they're detailed in To further explore the underlying factors influencing adoption intensity, qualitative data from Key Informant Interviews and Focus Group Discussions was analysed thematically and integrated with the objective's quantitative findings so as to enhance the robustness of the analysis by capturing perspectives that were not fully reflected in the quantitative data (Nassaji, 2015).

together with their hypothesized signs. To further explore the underlying factors influencing adoption intensity, qualitative data from Key Informant Interviews and Focus Group Discussions was analysed thematically and integrated with the objective's quantitative findings so as to enhance the robustness of the analysis by capturing perspectives that were not fully reflected in the quantitative data (Nassaji, 2015).

Table 3.2: Description of the variables for the count models and their expected signs

Variable code	**Variable description**	**Hypothesized sign**
Dependent variable		
Adpintensty	Number of *Prosopis juliflora* management interventions adopted	
Independent variables		
Sex	Dummy=1 if HH head male and 0 if female	+
Age	Age of HH head in years	+/-
HHsize	Household size	+
Education	Level of education of household head	+
Grpmember	Group membership (Dummy =1 if HH belongs to a civil society or community organisation, 0 otherwise)	+
Training	Dummy =1 if HH has received training on *Prosopis juliflora* management, 0 otherwise	+

Occupation	HHhead main occupation	+/-
Credit	Credit access (Dummy =1 if HH has access to credit, 0 otherwise)	+
Distmarket	Distance to nearest market in km	-
HHincome	Average monthly HH income in KES	-
Information	Access to information (Dummy =1 if HH has access to information, 0 otherwise)	+
Landsize	HH landholding size in acres	+
Legalframework	Presence of legal frameworks on *Prosopis juliflora* management	+
Technology	Access to technology (Dummy =1 if HH has access to technology, 0 otherwise)	+

3.6.3 Objective 3: To Evaluate the Net Economic Benefits of the *Prosopis juliflora* Management Interventions in Baringo South Sub-County

To achieve this objective, a Cost-benefit analysis (CBA) was employed as it involves assessing the economic value of alternative interventions by comparing their cost and benefit flows over a specified time frame (Atkinson & Mourato, 2015).

Theoretically, there are two commonly used CBA methodologies: deterministic cost benefit analysis and probabilistic cost benefit analysis. Probabilistic CBA was chosen as the most appropriate approach since the analysis accounted for all costs and benefits experienced by individual households during the implementation of the management interventions (Ng'ang'a *et al.*, 2021; Sain *et al.*, 2017). The analysis, which used the Benefit Cost Ratio (BCR) as the main indicator, provided a standardized ratio that facilitates direct comparisons across different interventions. This makes it more interpretable for diverse stakeholders, particularly in settings where investment scales will vary. A BCR value greater than 1 means the benefits exceed the costs, signifying a potentially viable intervention, and vice versa for BCRs less than 1.

Deterministic CBA was not considered for this study since it does not put into consideration variability and uncertainty to its calculations (Sain *et al.*, 2017). Incorporating these measures helps to avoid underestimation of the risks households face when adopting *Prosopis juliflora* management interventions.

10,000-iteration Monte Carlo simulations were run in Microsoft Excel using the @Risk software (Palisade Corporation, 1997). This large number of iterations was selected to ensure convergence and robustness of the simulation outputs (Jin *et al.*, 2024; Karatzetzou, 2024), so as to increase the reliability of the BCR estimates.

For the purpose of this study, the Program Evaluation and Review Technique (PERT) distribution was used to model the input variables. The distribution was preferred over the triangular for being smoother and offering a more realistic representation of skewed real-world data (Assad *et al.*, 2021). Moreover, it allows for specification of a minimum, most likely, and maximum value, placing more weight around the most likely value in a way that better approximates expert judgment.

In theory, the BCR is calculated by dividing the present value of expected benefits (PVEB) by the present value of expected costs (PVEC), expressed as follows:

$$BCR = \frac{PV(B_i)}{PV(C_j)}, \quad (7)$$

Where;

$$PV(B_i) = \sum_{t=0}^{T} \frac{1}{(1+r)^t} B_{it}, \text{ and } \quad PV(C_j) = \sum_{j=0}^{T} \frac{1}{(1+r)^t} C_{jt} \quad (8)$$

In the above expressions, T is the time horizon, r is the social discount rate, and t represents the time at which each benefit $(B_i, i = 1 \dots N)$ and cost $(C_j, j = 1 \dots M)$ occurs. The variables that were included in this analysis are outlined in Table 3.3, and in order to complement the quantitative findings from the BCR analysis, the study drew qualitative insights from key informant interviews and focus group discussions.

Table 3.3: Description of the variables for the CBA

Variable	Description
Benefit-Cost Ratio	The ratio of the present value of benefits to the present value of costs
Costs	Labour, equipment, processing, transport, marketing
Benefits	Income, crop yield

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.0 Introduction

The findings of this study, structured around the three specific objectives, are presented in this chapter. The chapter begins by describing how *Prosopis juliflora* is being managed in Baringo South Sub-County, followed by an econometric analysis exploring the factors that shape the tree's implementation intensity. The section concludes with the economic side of the analysis, weighing the costs and benefits of each strategy to get a clear sense of which ones actually offer value. These findings were discussed in relation to existing literature to derive relevant policy and management implications.

4.1 Characterization of *Prosopis juliflora* Management Interventions

This section presents the results of the analysis conducted to address the first specific objective which was to characterize the *Prosopis juliflora* management interventions being implemented by households in Baringo South Sub-County. The results are based on descriptive statistics derived from the socio-ecological household survey data and complemented by thematic insights from Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs).

4.1.1 Household Implementation of *Prosopis juliflora* Management Interventions

Households in Baringo South Sub-County implement a variety of interventions to manage *Prosopis juliflora*, and for this analysis 264 households reported implementing at least one management intervention.

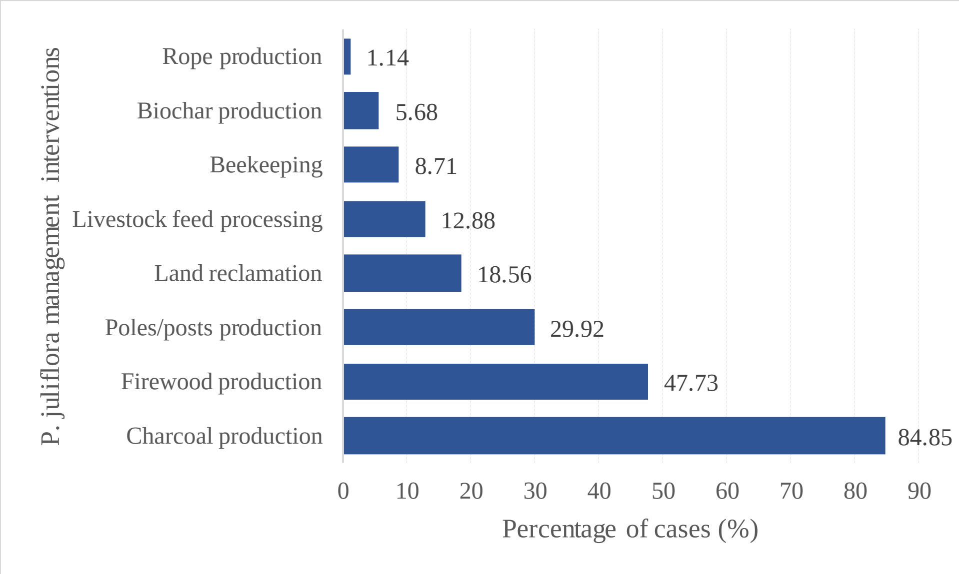

Figure 4.1: *Prosopis juliflora* management interventions implemented in Baringo South Sub-County (N=264)

As shown in Figure 4.1, charcoal production was the most common *Prosopis juliflora* management intervention, reported by 84.85% of the 264 households, and this underscores the high dependency on charcoal as both a coping mechanism and an income-generating strategy, especially considering the invasive dominance of *Prosopis juliflora* in the area. Mwalewa *et al.* (2022) reported that about 2 million tons of charcoal are consumed domestically in Kenya each year, suggesting that *Prosopis juliflora*, despite its invasive nature, offers affected communities a source of livelihood and an opportunity for poverty reduction. This has also been observed in some parts of Ethiopia, where charcoal production from invasive species has become a central livelihood strategy (Abate, 2021).

In the qualitative interviews, many participants described charcoal production as the main strategy that people use to engage with *Prosopis juliflora* in the area:

"*In this area, charcoal production is the main activity linked to Mathenge management. Charcoal burning from native trees was banned in 2018, and only Mathenge charcoal was allowed for sale. That's when the government stepped in and helped form Charcoal Producer Associations (CPAs). They set up collection points to make it easier to track sales and collect revenue, and to bring some order to the market. These regulations have been effective because they help streamline the charcoal trade and coordinate activities under Prosopis juliflora management.*" – Ilchamus ward FGD participant

Another strategy, mentioned by 47.73% of the respondents, was the use of *Prosopis juliflora* trees as firewood. In addition to charcoal production, these two interventions point towards the core of *Prosopis juliflora* management in energy-related practices. Both practices are relatively easy to implement, and require minimum upfront investment, hence yielding rapid returns, especially in places where energy demand is high and alternatives are limited (Wakie *et al.*, 2016). Nunes *et al.* (2021) equally noted that invasive species are mostly utilized for fuel since the investment threshold is low and the mark*et al*ready exists. However, the lessened adoption of firewood production compared to charcoal in this study probably has little to do with household preference and more to do with how the markets function. For example, charcoal generally fetches higher prices and is easier to transport, especially over longer distances (Ndegwa *et al.*, 2020), while firewood is bulkier and less profitable.

Poles/posts production, at 29.92%, and land reclamation, at 18.56%, were adopted at a moderate rate, since they are relatively more labour-intensive and sometimes require more specialized resources. The rates of adoption of poles/posts are almost similar to what Mwalewa *et al.* (2022) reported in Garissa and Tana River Counties, where about 29% of the households were found to produce them. On the other hand, land reclamation appeared to be an expensive option, even for those households appreciative of its long-run worth:

"The cost of removing Mathenge is very high. Once it invades land, clearing it becomes expensive because you must hire labourers to remove it before you can cultivate."
- KEFRI KII

The percentage of households implementing the intervention was 12.88% for livestock feed processing. This intervention is very important in addressing forage shortages that are becoming increasingly common in semi-arid regions like Baringo South Sub-County (Paliwal *et al.*, 2024; Seid *et al.*, 2020). However, its implementation has remained comparatively low in the region. In Mandera County, CARE (2022) reported a higher adoption of about 30%. This indicates a difference in forage scarcity, or perhaps in the level of awareness about the nutritional value of *Prosopis juliflora* pods in the two places.

Some interventions still had low implementation rates, such as beekeeping, reported by 8.71% of households; biochar production, at 5.68%; whereas in the case of niche uses like rope-making, for instance, the implementation rate was less than 1.2%. The low adoption of biochar production mirrors global trends where it remains a niche-practice possibly due to its technical complexity and financial demands (Kyalo *et al.*, 2025). These trends were echoed in the qualitative interviews, which revealed that while such initiatives are emerging, they remain limited to a few organized groups due to high technical and financial demands:

"*Biochar production started in Salabani around 2023 through an organization called Plant Village, however, it's expensive and usually done in groups rather than individual households."* – Ilchamus ward FGD participant

Another key informant also said:

"Biochar production is still a new initiative. Researchers are currently testing how to mix it with other chemicals to make fertilizer. As a chairperson, I see it as a very promising income-generating activity, although the challenge remains inadequate funds to advance its research and bring the product to market." – CPA chairperson KII

Out of 270 surveyed households, 6 did not implement any management intervention. A few recurring issues came up (Table 4.1) as to why this was so. The most common reason was lack of time or available labour, reported by 66.67% of the households. High implementation costs followed closely at 50%, and about a third cited limited access to the necessary resources (33.33%). Similar explanations have been documented in other regions across the globe, including in studies by Kyuma *et al.* (2020), Malila *et al.* (2023), and Shackleton *et al.* (2016).

About 16.67% of the households pointed to a lack of training or technical knowledge, and around the same proportion, others noted difficulties in accessing markets for *Prosopis juliflora*-based products. Qualitative data reinforced these finding:

"There is a general lack of commitment and investment in terms of time, money, and energy. Communities are often unwilling to eradicate Mathenge because they benefit from it economically, even though it's also a nuisance. This creates conflicting interests." – Ministry of Water KII

In an FGD with Ilchamus community members, participants described this in more detail:

"Managing Mathenge involves high labour costs and long processing times for products like charcoal and biochar. We also lack funding and markets, and the prices for Mathenge products are low. The sweet pods further harm the intestines and teeth of both children and livestock. Moreover, we lack proper storage facilities for products like charcoal and pods, which are easily damaged by weather." – Ilchamus ward FGD participant

Table 4.1: Reasons for not implementing *Prosopis juliflora* management interventions (N=6)

Reason	**Frequency**	**Percentage of cases**
Lack of resources	2	33.33
Lack of training or knowledge	1	16.67
High cost of implementation	3	50.00
Limited time or labour availability	4	66.67
Lack of market access for products	1	16.67

Further insights were gathered regarding the households' implementation history, motivations and challenges. In relation to implementation history (below), most households responded in a way that suggests that these practices are no longer new. About 44% had been at it for three to five years, and another 35% had continued for more than five. This points out that managing *Prosopis juliflora* is not just a response to an environmental problem, but a livelihood strategy that has gotten established in Baringo South Sub-County over time. Shackleton *et al.* (2019) observed that households often stick with utilization-based invasive species management because there are not many alternatives to control these species.

Regarding the motivation to continue implementing these management interventions, responses were mostly financial below. More than 82% of the respondents cited income as their main driver. This is hardly surprising especially in economies where there are limited opportunities and *Prosopis juliflora* presents an avenue to earn something tangible. Similarly, Eschen *et al.* (2021) found that an invasive species like *Prosopis juliflora* had prospects for financial benefits emanating from its management, which reflects the economic appeal of turning a nuisance into a source of livelihood. In contrast, Eshetu (2024) noted that environmental issues were dominant in other areas where such studies were conducted, with differences being explained by the poverty levels.

A focus group discussion held in Marigat ward reflected more on this:

"Mathenge has also brought some positive environmental effects; acting as a windbreak, it controls soil erosion, and thus has improved the local climate. We now have more frequent rains, fewer droughts, and reduced water scarcity, which has in turn improved people's health." – participant from Marigat ward FGD

Households also reported that carrying out *Prosopis juliflora* management interventions has its own challenges below. 80% of the respondents cited high labour costs, while lack of tools and equipment followed closely at 71%. This was also echoed in KIIs:

"We face many challenges including bad roads, harassment by tax collectors during charcoal transportation, and the government's ban on charcoal production." – CPA chairperson KII

Ather informant, engaged in pasture production, summed:

"Managing Mathenge requires a lot of money and time. For instance, clearing just one acre can take a month. The plant also forms dense thickets that are difficult to penetrate." – Pasture production KII

About 28% of the households reported a lack of training or technical support. In fact, Marshall *et al.* (2016), in their work regarding serrated tussock (*Nassella trichotoma*) control in Australia, also identified the lack of training programs as one of the major implementation barriers.

Other challenges included limited market accessibility, as was indicated by 17.80% of the total respondents. Mwalewa *et al.* (2022) noted similar issues in Garissa and Tana River counties, where low demand, high transportation costs, and limited entrepreneurial capacity made it harder for households to innovate or scale up *Prosopis juliflora* management.

Another challenge was conflicts over land or resources, at 8%. Qualitative feedback showed that in areas with communal land, disputes over entitlement and access to *Prosopis juliflora*-related benefits exist. Pod collection points also seemed to be conflict-hotspots as people occasionally claimed pods gathered by others, leading to disagreements.

4.1.2 Implementation of *Prosopis juliflora* Management Interventions by Administrative Ward

In this analysis, most households came from Marigat (58.71%, n=155), followed by Mochongoi (26.89%, n=71), Ilchamus (11.36%, n=30), and a handful from Mukutani (3.03%, n=8) (below). The differences across wards were statistically significant (Table 4.2), with the Pearson Chi-square statistic (χ^2 (114) = 242.25, $p<0.001$) confirming a strong association between administrative wards and the type *Prosopis juliflora* management interventions being implemented in the area.

Table 4.2: Household implementation of *Prosopis juliflora* management interventions by administrative ward (N=264)

Intervention	**Ilchamus (%)**	**Marigat (%)**	**Mochongoi (%)**	**Mukutani (%)**
Charcoal production (N= 224)	10.27	59.38	26.79	3.57
Firewood production (N= 126)	13.49	46.03	34.13	6.35
Poles/posts production (N= 79)	12.06	32.91	44.30	10.13
Land reclamation (N= 49)	0.00	51.02	48.98	0.00
Livestock feed processing (N= 34)	17.65	38.24	44.12	0.00
Beekeeping (N= 23)	13.04	13.04	69.57	4.35
Biochar production (N= 15)	0.00	40.00	46.67	13.33
Rope production (N= 3)	66.67	0.00	33.33	0.00

Overall Pearson Chi-square: χ^2 (114) = 242.2463, p = 0.000

About 60% of households reported to engage in charcoal production in Marigat. Mochongoi followed at 26.79%, and Ilchamus at 10.27%. There were very few households from Mukutani that reported to engage in these intervention, just 3.57%. Marigat's dominance likely reflects its proximity to urban and peri-urban markets, where charcoal demand is high (Siko *et al.*, 2021). The low uptake in Mukutani ward might be tied to its remoteness, sparse population, and weaker market connections.

Variations were also observed under firewood production, though with slightly different proportions. Marigat (46.03%) and Mochongoi (34.13%) led in the implementation rates, aligning with broader energy access issues. In Marigat, where pastoralism is common, firewood remains a primary energy source (Siko, 2019). Whereas Mochongoi's lower rate might reflect the availability of alternative fuels in its wetter highland zones.

The production of poles and posts was largely reported in Mochongoi at 44.30%, followed by 32.91% from Marigat. In Ilchamus and Mukutani, the adoption rate was lower and stood at 12.66% and 10.13%, respectively. This may indicate that the more agrarian land use in Mochongoi encourages the repurposing of *Prosopis juliflora* for fencing and construction purposes (Asienga *et al.*, 2014). In the case of Marigat, this may simply mean that fuel uses are more important for the average household than structural uses. In an interview, the CPA chairperson explained the appeal of *Prosopis juliflora* as follows:

"When used as fencing, Mathenge helps protect crops from animals because its thorns prevent goats and other livestock from passing through." – CPA chairperson KII

Land reclamation was reported in Marigat and Mochongoi, with nearly equal uptake, 51.02% and 48.98%, respectively. Absence in Ilchamus and Mukutani may reflect ecological or economic constraints. In Mochongoi, a mix of degraded lowlands and relatively wetter highlands creates pressure to reclaim land for farming and grazing, while the same pressure is faced by Marigat, especially on irrigated and pastoral lands (Adoyo *et al.*, 2022).

Livestock feed processing, biochar production, and beekeeping, were concentrated in Mochongoi ward. Some elements of uptake were also seen in Marigat, which is not surprising given that both have higher livestock densities and seasonal forage shortages in both wards (De Oto *et al.*, 2019). Mukutani did not have any representation of these interventions, probably due to the nomadic pastoralist ways of life that define the area and decrease dependency on processed feed. Beekeeping was also important in Mochongoi, possibly due to the area's diversity of flora and its cooler microclimate, conditions supporting year-round apiculture (Mainardi *et al.*, 2025). A beekeeper described *Prosopis juliflora* trees as follows:

"They flower all year round, providing bees with nectar throughout the seasons of the year. They provide shade for the hives and help keep the bees active even during the dry months." – Beekeeping KII

In a similar trend, biochar production had a higher uptake in Mochongoi and Marigat. Outside these wards, adoption was minimal, possibly due to ecological limitations or lack of training, and where it was adopted, smallholder farmers seemed to be using it to improve soil fertility (Mahmud *et al.*, 2025). Mukutani's low uptake may reflect limited arable land and fewer incentives for soil enhancement.

To conclude, rope production was reported only in Ilchamus (66.67%) and Mochongoi (33.33%). In Ilchamus, the practice likely reflects cultural preservation of artisanal crafts. Whilst in Mochongoi, it seems more incidental, perhaps a by-product of other uses rather than a primary activity.

4.1.3 Household-Level Characteristics and *Prosopis juliflora* Management Interventions Implementation

4.1.4.1 Categorical Socio-Demographic Variables

Table 4.3 summarizes how household-level characteristics shape the uptake of *Prosopis juliflora* management interventions in Baringo South Sub-County.

Out of 264 households that reported implementing at least one intervention, about two-thirds were male-headed (66.29%), while the remaining third were led by women (33.71%) (below). This reflects a broader reality since most *Prosopis juliflora* management activities, like clearing, cutting, or processing, are physically demanding. And in many cases, that alone can discourage participation by female-headed households (Tabe-Ojong, 2023). During an FGD in Ilchamus, one participant simply said:

"Men often have the energy to uproot Mathenge, but women usually have to hire additional labour, which increases costs." – Ilchamus ward FGD participant

In rural settings, men often have more access to tools, land, and decision-making spaces. Women, meanwhile, juggle caregiving, household responsibilities, and other unpaid labour that limits their time and flexibility (Akinwale & Oyeyemi, 2021; Elias *et al*., 2018; Ng'atigwa *et al.*, 2020; Sisay *et al*., 2024). Even so, female-headed households were actively involved in several interventions, especially those with lower entry barriers or where *Prosopis juliflora* was readily available near homesteads.

Most respondents were married or cohabiting (71.21%), with smaller proportions identifying as single (10.98%), widowed (10.23%), or separated/divorced (7.58%) (below). Married households adopted more interventions, possibly because they can pool labour and resources, and make joint decisions more easily (Kolvereid, 2018).

About 43% had completed secondary education, 33% primary education, and 20% had gotten up to tertiary education (below). Only a small fraction (3%), had no formal education. Interestingly, the highest adoption rates were among those with primary and secondary education. Though this may seem unintended, it falls in line with the argument of Paltasingh and Goyari (2018) that education can increase the likelihood of adopting a new technology.

As for occupation (below), most respondents identified themselves as agro-pastoralists (67.05%), followed by salaried employees (12.88%), small business owners (7.95%), casual labourers (6.06%), and unemployed (6.06%). The intervention adopters were very active among the agro-pastoralists because their livelihood is attached to land, and also, they're often the first to feel the impact of *Prosopis juliflora* invasion. For example, charcoal production was dominated by them at about 70.54%, arguably because they are already working closely with natural resources and have more experience with natural resource management on land (Wordofa *et al.*, 2021).

The other common intervention among the agro-pastoralists was land reclamation at 55.10%. This makes sense because when a household's livelihood depends on grazing and cultivation, reclaiming invaded land becomes a necessity. Mbaabu *et al.* (2020) further noted that pastoral and agro-pastoral communities are particularly vulnerable to *Prosopis juliflora* spread. Qualitative data supports this claim:

"We have faced many challenges from this plant as a pastoral community. Since Prosopis *juliflora was introduced in this area, livestock numbers have declined because the plant has spread widely and invaded farmlands, reducing agricultural productivity."* – CPA chairperson KII

Table 4.3: Socio-demographic characteristics of household heads by type of *Prosopis juliflora* management intervention (N=264)

	Interventions							
Socio-Demographic Characteristics	**Charcoal production (n=224)**	**Firewood production (n=126)**	**Poles/ Posts production (n=79)**	**Land reclamation (n=49)**	**Livestock feed processing (n=34)**	**Beekeeping (n=23)**	**Biochar production (n=15)**	**Rope production (n=3)**
Sex								
Male (%)	66.07	62.70	68.35	79.59	70.59	78.26	60	66.67
Female (%)	33.93	37.30	31.65	20.41	29.41	21.74	40	33.33
Marital status								
Single (%)	10.27	14.29	13.92	4.08	8.82	4.35	6.67	33.33
Married (%)	71.43	69.84	72.15	79.59	67.65	82.61	66.67	33.33
Widowed (%)	10.27	9.52	10.13	12.24	17.65	4.35	13.33	0.00
Separated/divorced (%)	8.04	6.35	3.80	4.08	5.88	8.70	13.33	33.33

Education Level* **								
None (%)	3.13	2.38	2.53	6.12	2.94	4.35	0.00	0.00
Primary (%)	36.61	33.33	35.44	10.20	32.35	30.43	46.67	33.33
Secondary (%)	41.52	47.62	43.04	42.86	32.35	21.74	46.67	66.67
Tertiary (%)	18.75	16.67	18.99	40.82	32.35	43.48	6.67	0.00
**Occupation ** **								
Unemployed (%)	6.25	7.14	6.33	6.12	5.88	4.35	0.00	33.33
Agro-pastoralist (%)	70.54	67.46	69.62	55.10	70.59	65.22	60	66.67
Salaried employment (%)	9.82	9.52	15.19	26.53	17.65	21.74	13.33	0.00
Casual labour (%)	5.36	6.35	3.80	8.16	0.00	4.35	6.67	0.00
Self-employed (%)	8.04	9.52	5.06	4.08	5.88	4.35	20	0.00

Note: (***) and (**) denotes chi-square statistical significance differences between *Prosopis juliflora* management interventions and socio-demographic characteristics, at 1% and 5% levels, respectively

4.1.4.2 Continuous Socio-Economic Variables

The results in Table 4.4 present the average results for the socio-economic characteristics of households, specifically, the age of the household head, household size, and monthly household income, disaggregated by the type of *Prosopis juliflora* management intervention being implemented by the households.

The sample used for this analysis (N = 264) had an average age of 42.2 years and a mean household size of 4.9 members, which is above Kenya's national average of 3.8 (KNBS, 2019). The average age indicates that most respondents were in their economically active years

(World Bank, 2019), suggesting a greater likelihood of involvement in *Prosopis juliflora* management activities. Furthermore, the mean monthly income was KES 16,849.43.

Table 4.4: Mean socio-economic characteristics of household heads by type of *Prosopis juliflora* management intervention (N=264)

Intervention	**Mean Household Head Age**	**Mean Household Size*** **	**Mean Household Monthly Income*** **
Charcoal production	42.7	4.8	15,621.65
Firewood production	41.4	4.4	14,587.30
Poles/posts production	43.1	4.2	15,993.67
Land reclamation	43.3	6	26,857.14
Livestock feed processing	43.9	5.1	20,632.35
Beekeeping	40.5	4.5	20,152.17
Biochar production	41.1	4.5	14,200
Rope production	28	4	12,000

Note: (***) denotes statistical significance of f-test comparisons between household characteristics and *Prosopis juliflora* management interventions at 1%.

The number of people living in single housing unit was found to significantly influence implementation of *Prosopis juliflora* management interventions ($p<0.01$), results consistent with findings by Okumu *et al.* (2018), where larger households were more likely to engage in the adoption of labour-intensive *Prosopis juliflora* management practices. However, our results differ from those of Ayenew *et al.* (2019), whose argument is that larger families lead to higher household expenses, reducing per capita income and, consequently, diminishing participation in environmental or natural resource management.

This variation underscores the importance of household size as a key factor influencing labour availability for environmental management activities for the reason that it's a key determinant of the available labour pool that can be mobilized for both farming and non-farming activities (Dimelu *et al.*, 2020). Consequently, households with more members are better positioned to engage in labour-demanding environmental management practices because the availability of family labour in larger households enhances their ability to implement and sustain such interventions effectively.

The findings on household monthly income also indicate that income significantly influences household implementation of these management interventions ($p<0.01$) since *Prosopis juliflora* management interventions may require more capital investment and thus tend to be adopted by higher-income households. This is in line with findings by Al-Assaf *et al*. (2020), who noted that households with relatively higher incomes (JOD 600–749) exhibited a statistically significant association with *Prosopis juliflora* management plans.

Qualitative findings support these results with households involved in livestock feed processing reporting use of *Prosopis juliflora* pods, sold whole or milled with maize cobs and pasture, as a key income source. Some noted that sales from pods, grass, and pasture seeds supported savings and investments:

"Pasture establishment works well because it completely eliminates Mathenge. From the pasture, I get grass seeds for sale or storage, and grass for feed or sale. However, the removal of Mathenge must be continuous to allow the grass to establish fully and prevent new growth." – Pasture production KII

4.2 Factors Influencing the Intensity of Adoption of *Prosopis juliflora* Management Interventions

To determine the factors influencing the intensity of adoption of *Prosopis juliflora* management interventions among households in Baringo South Sub-County, the study employed a Generalised Poisson regression model (GPRM). Prior to the analysis, a multicollinearity test was conducted on the data to ensure that the independent variables in the model were not highly correlated with each other, which can distort the coefficient estimates and make the model less reliable (Shrestha, 2020).

4.2.1 Multicollinearity Test

Multicollinearity arises when two or more predictor variables in a regression model exhibit a high degree of correlation, potentially even a perfect linear relationship (Ayanlowo *et al*., 2016), hence obscuring the statistical significance of individual predictors, even when the overall regression model appears significant. When independent variables are closely correlated, a lot begins to go wrong: the coefficient of determination (R^2) gets inflated, confidence intervals widen, the variance-covariance structure becomes distorted, and even the t-statistics lose their meaning (Alrweili, 2024; Lukman *et al*., 2021).

Owiti *et al*. (2024) point out that when multicollinearity occurs, the maximum likelihood estimators become unreliable, and the model's robustness gets compromised. To avoid this, the study ran a Variance Inflation Factor (VIF) analysis. The goal was to test whether the predictor variables were reasonably independent and suitable for inclusion in the model.

The results, shown in Table 4.5, were reassuring. VIF values ranged from 1.17 to 3.45, all below the commonly accepted threshold of 5. That suggests low levels of correlation among the continuous variables (Arabameri *et al.*, 2019).

Table 4.5: Variance inflation factor (VIF) Test

Variable	**VIF**	**1/VIF**
Access to technology	3.45	0.289660
Aware of *Prosopis juliflora* management legal frameworks	2.78	0.360240
Prosopis juliflora management training	2.54	0.393255
Access to credit	2.05	0.488624
Age	2.01	0.496944
Household size	1.90	0.527163
Group membership	1.83	0.545564
Household income	1.81	0.553155
Distance to market	1.67	0.599456
Education level	1.59	0.627111
Landholding size	1.51	0.660964
Access to information on *Prosopis juliflora* management	1.21	0.823821
Occupation	1.20	0.833844
Sex	1.17	0.857627
Mean VIF	**1.91**	

4.2.2 Description of Variables

In modelling the second objective, the dependent variable was the intensity of *Prosopis juliflora* management adoption. Figure 4.2 presents the distribution of households by the number of interventions adopted.

36.12% of households had adopted one intervention, and another 36.12% had gone for two. On average, households adopted two interventions, with a variance of 1.34, suggesting varied intensity of adoption across households. This kind of spread probably reflects differences in things like income, exposure to institutions, or even just how close a household is to a road or a market (Musafiri *et al.*, 2022).

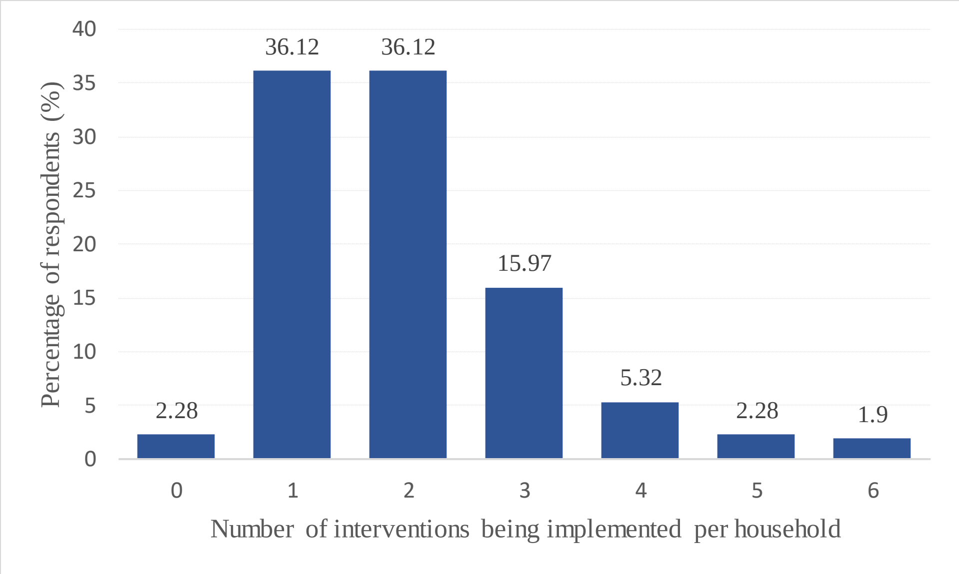

Figure 4.2: Intensity of adoption of *Prosopis juliflora* management interventions

The independent variables in the model included a mix of continuous and categorical variables, factors that, both in theory and in practice, tend to shape how people make decisions about adopting new technologies or environmental practices. Table 4.6 gives the breakdown. Most households were in their working prime, and household sizes and income levels were moderate (KNBS, 2022). A majority were male and identified as agro-pastoralists, and quite a few had completed at least secondary school. Landholding size averaged around 4 acres, which suggests that most households had access to a modest but workable amount of land, enough for farming, grazing or experimenting with *Prosopis juliflora* management.

On average, households were located far from the nearest market (about 10.5 km). This likely affects both the availability of inputs and the flow of information because if one is far from a market, they're also probably far from extension officers, training sessions, and other support systems. Still, despite the distance, many households reported string access to information and active participation in local groups. Such institutional engagement plays a role in shaping how *Prosopis juliflora* is managed, findings that echo what others have found: institutional factors often matter just as much, if not more, than technical ones when it comes to adoption (Eschen *et al.*, 2024).

Table 4.6: Independent variables (N=263)

Variable	
Continuous	**Mean**
Age (Years)	42.4
Household size	4.9
Household income (KES)	17,265.21
Landholding size (Acres)	4.02
Distance to market (Km)	10.5
Categorical	**Percentage**
Sex	
1. Male	66.16
2. Female	33.84
Education level	
1. None	3.42
2. Primary	32.70
3. Secondary	43.73
4. Tertiary	20.15
Occupation	
1. Unemployed	6.46
2. Agro-pastoralist	65.40
3. Salaried employment	14.07
4. Casual labour	6.08
5. Self-employed/ enterprise owner	7.98
Access to credit	
1. Yes	76.05
2. No	23.95
Prosopis juliflora management training	
1. Yes	64.64
2. No	35.36
Group membership	
1. Yes	67.30
2. No	32.70
Access to information on *Prosopis juliflora* management	

1. Yes	94.68
2. No	5.32
Access to technology	
1. Yes	73.76
2. No	26.24
Aware of *Prosopis juliflora* management legal frameworks	
1. Yes	81.75
2. No	18.25

4.2.3 Factors Influencing the Intensity of Adoption of *Prosopis juliflora* Management Interventions Among Households in Baringo South Sub-County

Two models were estimated: the standard Poisson model (PRM) and the Generalized Poisson model (GPRM). The results for the PRM indicated the presence of under dispersion, as evidenced by a variance value less than the mean value (below), violating the Poisson model's equi-dispersion assumption, suggesting that the GPRM model was more suitable. Furthermore, to evaluate which model fit the data, a likelihood ratio test comparing the GPRM and PRM (below) was conducted and the results strongly favoured the GPR model because the Akaike information criterion (AIC) and Bayesian Information Criterion (BIC) values were lower for the GPR model (AIC = 721.11, BIC = 796.13) than for the Poisson model (AIC = 796.47, BIC = 867.91), indicating a better model fit (Mohammed *et al.*, 2015).

The GPRM results are presented in **Error! Reference source not found.**Table 4.7, the Wald chi-squared statistic for the joint significance of all predictors was 233.88, with a p-value < 0.001, indicating that the model was statistically significant overall. Occupation, household size, landholding size, access to information on *Prosopis juliflora* management, *Prosopis juliflora* management training, distance to market, access to credit, and awareness of *Prosopis juliflora* management legal frameworks, significantly influenced the intensity of adoption of *Prosopis juliflora* management interventions among households in Baringo South Sub-County. The model estimates were presented as incidence rate ratios (IRRs), a measure of relative difference that aids in easier interpretation. They are similar to odds ratios in logistic regression, where values greater than 1.0 suggest an increased rate of occurrence, and values less than 1.0 indicate a decreased rate of occurrence (Frome & Checkoway, 1985).

For occupation, casual laborers (IRR = 0.76, $p<0.05$) significantly adopted *Prosopis juliflora* management interventions less intensively than unemployed individuals, as they often face tight schedules and limited financial flexibility. Thus, it's tougher for them to commit to interventions like those that require investment in time, tools, and sometimes, upfront costs. For example, according to Eschen *et al.* (2021), the most effective control against *Prosopis juliflora* is manual uprooting, but this is labour-intensive.

Larger household sizes were also associated with lower adoption intensity (IRR = 0.95, $p<0.01$). This means that for every additional household member, the number of interventions being implemented in that particular household decreased by 5%. Possibly, this is because with more household members to feed, financial and logistical pressure increases, meaning less time, fewer resources, and perhaps a stronger focus on immediate needs rather than on long-term land management. Danso-Abbeam *et al.* (2017) had similar findings. Apind (2015) also found such patterns in market participation. In contrast, Okumu (2019) reported a positive relationship between household size and *Prosopis juliflora* management, suggesting that more household members mean greater capacity to implement the interventions.

Landholding size was clearly and positively associated with the adoption intensity, with IRR = 1.04 and p-value < 0.01, implying that households owning more land tend to implement more interventions. Larger plots also offer more flexibility; space to experiment, diversify, and invest in long-term solutions. In their study, Mzyece and Ng'ombe (2020) similarly found that bigger farms are more likely to diversify, findings which are similar to Nyamweya (2017) who linked land size to improved farming practices. One key informant that the researcher had interviewed captured this well:

"I have managed to control the rapid spread of Mathenge, and now I use the cleared land for agriculture and pasture production. The sale of Mathenge products, pasture seeds, and grass has also enabled me to save and make some investments." – Pasture production KII

Access to information on *Prosopis juliflora* management was actually associated with lower adoption intensity (IRR = 0.77, $p < 0.05$). This is not something that one would expect because usually, more information leads to more action. But maybe the issue is not about access, but quality because if the information being provided is vague, outdated, or not followed up with practical support, it might not help much. Adoyo *et al.* (2022) found that delayed and unreliable information often discourages early intervention, allowing the invasion to worsen before people feel equipped to respond. A key informant echoed on this:

"Awareness of the management technologies is still low, and even where people know about these interventions, adoption is limited." – KEFRI KII

Similarly on training, households that had received some coaching on *Prosopis juliflora* management were less likely to adopt the interventions (IRR = 0.81, $p < 0.05$). This points to a gap between knowledge and action because it is possible that training programs are not tailored to local realities, or that they lack follow-up. To concur this, Kamiri *et al.* (2024) emphasized the absence of a coordinated strategy and the disconnect between technical solutions and community dynamics as the reason for low implementation of *Prosopis juliflora* management interventions. Furthermore, Eschen *et al.* (2021) and Mungoche *et al.* (2025) resonate with this, noting that without proper integration, even well-intentioned programs can fall flat. One focus group participant summed it up as follows:

. *"There is need for more training of community members on how to manage Mathenge, and for financial support to facilitate effective management."* – Ilchamus ward FGD participant

Distance to mark*et al*so mattered, but in a surprising way. Greater market distances increase transportation costs, which could make it harder to sell products, but also harder to ignore the problem (Ohen *et al*., 2014). In this study, households farther from markets were more likely to adopt more interventions (IRR = 1.03, $p < 0.01$), reflecting the severity of *Prosopis juliflora* infestation in remote areas, or perhaps the lack of external support which pushes households to rely more on their own strategies.

Access to credit had a negative effect on adoption intensity (IRR = 0.81, $p < 0.05$). This seems to the contrary with findings in literature, as credit is supposed to improve liquidity. Findings in this study suggest that households may use credit for more immediate needs, or other income-generating activities, rather than *Prosopis juliflora* management. Diiro and Sam (2015) noted a similar pattern with seed adoption. Likewise, Bosompen *et al.* (2024) reported that credit access among cassava farmers in Ghana actually reduced participation in value addition.

Table 4.7: GPR model results (N=263)

Variable	IRR
Sex	1.00
Age	1.00
Education level – None	1.00
Education level – Primary	1.01
Education level – Secondary	1.06
Education level – Tertiary	1.12
Occupation – Unemployed	1.00
Occupation – Agro-pastoralist	0.96
Occupation – Salaried employment	0.82
Occupation – Casual labour	0.76**

Occupation – Self-employed/enterprise owner		0.89
Household size		0.95***
Household income		1.00
Landholding size		1.04***
Access to information on *Prosopis juliflora* management		0.77**
Prosopis juliflora management training		0.81**
Group membership		0.89
Distance to market		1.03***
Access to credit		0.81**
Access to technology		1.11
Aware of *Prosopis juliflora* management legal frameworks		0.75***
_cons		5.00***
/atanhdelta	-0.50	Wald chi2(19) 233.88
delta	-0.46	Prob > chi2 0.0000

Note: (***) and (**) denotes significance at 1% and 5% levels, respectively

Likelihood-ratio test of delta=0: chi^2(1) = 77.36 Prob>=chi2 = 0.0000

On awareness of legal frameworks surrounding *Prosopis juliflora* management, the study found that it was also negatively associated with adoption (IRR = 0.75, $p < 0.01$). This is an unexpected result, as normally, awareness of environmental regulations is typically associated with increased adoption of sustainable practices (Pham *et al.*, 2023). But here, it may reflect frustration or confusion since the national management strategy on *Prosopis juliflora* control has been delayed, and without clear guidelines, households may hesitate the implementation of available strategies. Qualitative data backs this up:

"There is no Prosopis juliflora *policy that I have ever heard of."* – Beekeeping KII

And,

"So far, no clear policy has been put in place to guide the management of Prosopis juliflora*."* – CPA chairperson KII

4.3 Net Economic Benefits of *Prosopis juliflora* Management Interventions in Baringo South Sub-County

The findings of objective 3, which aimed to understand how the different *Prosopis juliflora* management strategies are actually paying off, are presented in this section. In order to achieve this, the study ran a probabilistic CBA, using Monte Carlo simulation in Microsoft Excel with the XLRisk add-in. The main metric used to assess this economic performance was the BCR.

4.3.1 Types of Costs Incurred in Managing *Prosopis juliflora*

The analysis began by identifying the types of costs that households typically incur when implementing *Prosopis juliflora* management interventions. Figure 4.3 gives a summary of this.

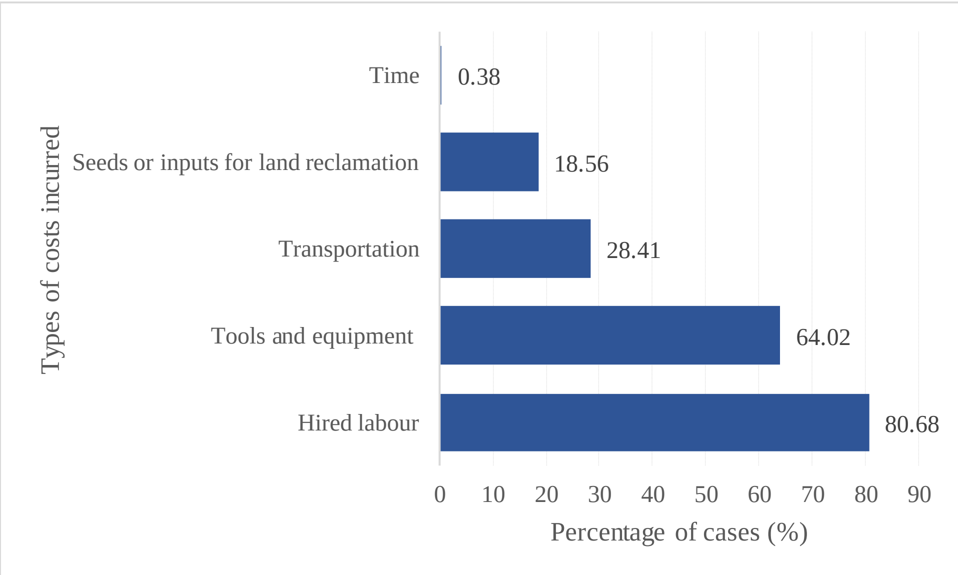

Figure 4.3: Costs incurred in managing *Prosopis juliflora*

Labour was the most cited cost, mentioned by over 80% of respondents. To give an example, uprooting *Prosopis juliflora* is not a light task. It involves digging, cutting, transporting, and often doing so under harsh conditions. For many households, especially those with limited resources, this means relying on family members or hiring help which adds to the financial strain (Eschen *et al.*, 2024). One KII respondent described it in the following way:

"It's very costly and labour-intensive to remove Mathenge. The tree's sharp, poisonous thorns injure people during handling, and transporting the products is another major challenge." – Pasture production KII

Besides labour, about a third of households mentioned costs related to tools and equipment (64.02%). These are not always specialized tools. Sometimes it is just machetes, axes, wheelbarrows, but even these can be expensive or hard to replace. Transportation costs also came up (28.41%), especially for interventions like charcoal or biochar production as moving bulky biomass over long distances to reach markets is not just tiring, it is expensive (Tuwei *et al.*, 2019). Other costs were less commonly mentioned but still relevant: around 19% of respondents cited expenses for seeds or inputs used in land reclamation, and a few pointed to the opportunity cost of time (0.38%). Time spent managing *Prosopis juliflora* is time not spent on other income-generating activities, and for households managing multiple responsibilities, that trade-off matters.

4.3.2 Overview of Intervention Costs and Benefits

To get an economic sense of *Prosopis juliflora* management, respondents were asked to estimate their monthly costs and benefits per intervention. These estimates presented as averages, minimums, and maximums, are summarized in Table 4.8.

Land reclamation stood out as it had the highest average monthly benefit, around KES 28,969, with some households reporting returns as high as KES 70,000. Although with a relatively high average cost of KES 4,976, the substantial net gains reflect the value of restoring land for agricultural or pastoral use. This finding is supported by Eschen *et al.* (2021), in their study on *Prosopis juliflora* removal and grassland restoration in Kenya. A key informant reported:

"Prosopis juliflora actually improves soil fertility. Once you uproot it and replace it with crops, they grow very well even without fertilizer. Pasture production also performs very effectively on land that has been cleared of Prosopis juliflora." – CPA chairperson KII

Biochar, which costs households about KES 3,447 a month to produce, resulted in average benefits of KES 11,200. The processing of livestock feeds was cheaper with a modest monthly cost of KES 1,312, and the benefits averaged KES 9,988. These two interventions appear to work quite well because they add value, either by improving soil or turning *Prosopis juliflora* pods into something marketable.

Charcoal remained the most widely adopted intervention. Households reported average monthly costs of KES 2,684 and benefits of KES 6,987 which is a decent return especially in areas where other options are scarce. The sector, however, increasingly comes under policy scrutiny (Kamiri *et al.*, 2024). Charcoal has become more environmentally friendly and better regulated. Its production is more complicated, though exemptions for *Prosopis juliflora*-based charcoal have helped communities continue to use it as a strategy for control. One key informant explained:

"For utilization, there's a policy that allows CPAs to undertake Prosopis juliflora charcoal production. Although there's a national ban on charcoal burning in Kenya, areas heavily invaded by Prosopis juliflora are exempted, allowing charcoal production as a means of controlling the plant's spread." – Lake Bogoria National Reserve KII

In the same way, firewood and poles/posts production contributed to household incomes, though with smaller margins as their average monthly benefits were KES 2,156 and KES 4,171, respectively. These interventions are still useful, but they don't offer the same level of return as the high-value interventions discussed above.

Table 4.8: Estimated monthly costs and benefits of *Prosopis juliflora* management interventions

	Cost (KES)			Benefit (KES)		
Intervention	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**
Charcoal production (N= 224)	2,684	400	7,000	6,987	1,945	16,800
Firewood production (N= 126)	873	100	2,000	2,156	400	4,800
Poles/posts production (N= 79)	3,059	500	6,000	4,171	1,200	7,500
Land reclamation (N= 49)	4,976	400	11,500	28,969	8,330	70,000
Livestock feed processing (N= 34)	1,312	50	5,000	9,988	800	20,000
Beekeeping (N= 23)	1,965	500	5,000	3,722	1,500	6,000
Biochar production	3,447	1,000	6,000	11,200	4,800	18,000

(N= 15)						
Rope production						
(N= 3)	1,667	1,000	2,000	1,067	1,000	1,200

Often promoted as a sustainable and ecologically friendly use of *Prosopis juliflora* (Kishoin *et al*, 2024), beekeeping had moderate returns. Households earned about KES 3,722 per month, against costs of KES 1,965. This intervention is promising, especially in areas with flora diversity, but not yet a major income source. On the other hand, rope production, had the lowest economic profile, with an average benefit of KES 1,067, barely above the cost range. This points to limited profitability, likely due to its confined market value and low scalability, hence making it a less attractive livelihood option.

4.3.3 Simulation-Based Economic Evaluation of Management Interventions

Given the uncertainty surrounding household estimates of costs and benefits, the study employed a Monte Carlo simulation so as to test the robustness of the economic analysis. One intervention, rope production, had to be left out of this analysis. The cost and benefit figures reported for it were identical across the board, with no variation between minimum, maximum, or most likely values. Such data doesn't work well in stochastic modelling as without variability, the simulation can't really do its job, which is to reflect uncertainty and risk in a meaningful way (Uusitalo *et al*, 2015).

4.3.3.1 Simulated Costs, Benefits, and Benefit-Cost Ratios

Table 4.9 displays the mean simulated monthly costs, benefits, and their corresponding Benefit-Cost Ratios for each of the evaluated *Prosopis juliflora* management intervention.

Table 4.9: Simulated costs, benefits, and benefit-cost ratios (in KES)

Intervention	Simulated Cost	Simulated Benefit	Benefit-Cost Ratio
Charcoal production	1566.667	7790.833	4.973
Firewood production	1016.667	1633.333	1.607
Poles/posts production	2583.333	3450	1.335
Land reclamation	5316.667	24188.333	4.550
Livestock feed processing	1175	8800	7.490
Beekeeping	1583.333	2583.333	1.632
Biochar production	3500	11800	3.371

The results indicate that livestock feed processing yielded the highest BCR at 7.490, followed by charcoal production (4.973), and land reclamation (4.550), suggesting that investments in livestock feed processing generate the greatest returns per unit cost. This is in line with what others have found in similar dryland contexts: Wanyoike *et al.* (2018) pointed to the viability of value-added livestock feed enterprises in arid-and semi-arid regions where resource constraints often push communities toward low-input, high return strategies. Meanwhile, Koech *et al.* (2021) specified the profitability of *Prosopis juliflora* charcoal, particularly in Kenya's ASALs, since market demand remains strong and production costs are relatively low.

The BCR of land reclamation was very high. The results are in agreement with the work done by Edrisi *et al.* (2020), who argue that landscape restoration using *Prosopis juliflora*-based interventions might be peculiarly effective. Households reported identifiable impact in Baringo South Sub-County, with land previously invaded by *Prosopis juliflora* now supporting crops and pasture, mostly without the use of chemical fertilizers. A key informant captured the transformation as follows:

"Restoration using grass is effective because it acts as a cover crop, preventing Prosopis juliflora from re-emerging. At the same time, it supports livelihoods since the grass can be harvested, stored, and used as livestock feed or sold. So, it provides both ecological and economic benefits." – KEFRI KII

For biochar production, the BCR stood at 3.371, indicating that it is not a niche practice but does have some real potential as a soil amendment and carbon sequestration tool. Further, Shyam *et al.* (2025) said biochar plays a dual role in improving soil fertility and building resilience against climate stress in dryland agriculture.

Beekeeping had a more modest BCR of 1.632, which is below that usually reported for areas with a better-developed honey value chain. This could signal local bottlenecks, such as insufficient infrastructure, or patchy demand and inefficiencies along the line of production, since Machio and Kiptoo (2024) realized better profitability in locations with improved access to markets with fewer constraints on inputs.

Firewood production came in with a modest return of 1.607. This renders it prone to changes in market dynamics since at times prices fluctuate. This additionally renders it less dependable for a long-term investment strategy due to regulatory pressures. Lastly, pole and post production had the lowest BCR at 1.335, indicating marginal profitability towards households that implement them. This accords with Bont *et al.* (2024) who reported high labour demands and production costs tied to timber-based enterprises. Muthike (2016) also indicated that *Prosopis juliflora* timber often has structural limitations that render it uncompetitive in formal construction markets.

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter summarizes the key finding linked to each specific objective presented in this study. It further sets a variety of policy recommendations that aim at strengthening both the economic and ecological dimensions of *Prosopis juliflora* management in Baringo South Sub-County, and lastly, discusses areas where further research could contribute to filling in the gaps and guiding future action.

5.1 Conclusions

i. The diversity of interventions being implemented by households within Baringo South Sub-County characterizes a practical way of responding to the species' contradictory nature, both as a nuisance and a resource. Charcoal production (84.85%) and firewood harvesting (47.73%) remain high, partly due to their ability to provide immediate needs for livelihood and harness market demand. Interventions such as livestock feed processing, land reclamation, and biochar production foretell a growing move toward practices with greater ecological and long-term livelihood benefits. From inferential statistics, it can be seen that several factors shape a household's decision on what intervention to implement.

ii. Households with more landholding and with better access to markets were more likely to adopt multiple interventions ($p < 0.01$), which is indicative of the enabling power of assets and proximity to demand. Negative associations of credit access, information, and training indicate that institutional support has not really translated into practical empowerment in Baringo South Sub-County, hence a call for more contextual and grounded extension services.

iii. The results of economic evaluation proved that *Prosopis juliflora* management is financially worthwhile because all the interventions showed BCRs greater than one. This shows that sustainable utilization of *Prosopis juliflora* is possible and at the same time, profitable. However, the variability in returns indicates that market inefficiencies and production challenges still need attention since profitability alone does not guarantee success if the systems around it are frail.

5.2 Recommendations

i. The high-value and restoration-oriented interventions should be strongly supported due to their ecological and economic benefits that apply to the households concerned. To make these more accessible and attractive, support should focus on developing local markets, introducing labour-saving technologies, and providing regular technical guidance.
ii. The government and partners should address the institutional and socio-economic barriers to *Prosopis juliflora* management through strengthening extension services, improving access to affordable credit, and adapting *Prosopis juliflora* management training to local realities.
iii. The National Strategy and Action Plan for the Management and Control of *Prosopis juliflora* (2023–2032) should be fast-tracked by the government, and implementation should go a step further to ensure that it strengthens the enabling environment so that the profitability of the interventions leads to long-term success.

5.3 Areas for Further Research

i. There is a need for studies that track how *Prosopis juliflora* management affects ecosystem restoration. Evidence of this nature would be invaluable in developing adaptive strategies, balancing recovery against utilization of the invasive species.

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APPENDICES

Appendix A: Social-Ecological Household Questionnaire

Introduction: Good morning/afternoon. You have been identified as a key stakeholder for the study on the economic value of the environmental management of *Prosopis juliflora* (*Mathenge*) here in Baringo South Sub-County. By filling this questionnaire, you will help towards the completion of this research study and achievement of its objectives. The aim of the study is to collect data on the *Prosopis juliflora* management interventions being implemented by households; factors influencing the intensity of adoption of the *Prosopis juliflora* management interventions among households; and to evaluate the net economic benefits of the *Prosopis juliflora* management interventions on the livelihoods of households. Therefore, be assured that the research is solely for academic purpose and the information you provide will be treated with strict confidentiality.

Interview Date:	
Name of enumerator:	
Administrative Ward:	
Respondent's name:	

SECTION A: HOUSEHOLD DEMOGRAPHIC CHARACTERISTICS

Characteristic	Coding
Relationship to HH head	1= Head 2= Wife/ Husband 3= Son/daughter 4= Son-in-law/daughter-in-law 5= Grandchild 6= Parent 7= Parent-in-law 8= Brother/sister 9= Other relative
Sex of HH head	1= Male 2 = Female
Marital Status of HH head	1= Single (never married) 2= Married 3= Widowed 4= Separated or divorced
Age of HH head	In years
Household size	Number of household members
Education level of HH head	1= None 2= Primary 3= Secondary 4=Tertiary

HH head main occupation	1=Unemployed 2= Farmer 3= Pastoralist 4= Agro-pastoralist 5= Salaried employment 6= Casual labour 7= Self-employed/enterprise owner 8=other(*specify*)______
HH average monthly income	In Kenyan shillings

SECTION B: AWARENESS AND PERCEPTION OF *Prosopis juliflora*

1) Are you aware of *Prosopis juliflora*?

1. Yes [ ] 2. No [ ]

2) If yes, are you aware of how it was introduced in Baringo South Sub-County?

1. Yes [ ] 2. No [ ]

3) If yes, who/what introduced it? (Check all that apply)

1. Government programs [ ] 2. Non-Governmental Organizations (NGOs) [ ] 3. Community initiatives [ ] 4. Other (specify) ______________________

4) When was *Prosopis juliflora* introduced to your community?

1. Less than 10 years ago [ ] 2. 10-20 years ago [ ] 3. More than 20 years ago [ ] 4. Not sure [ ]

5) How would you describe the growth and spread of *Prosopis juliflora* in your area?

1. Slow and manageable [ ] 2. Moderate [ ] 3. Rapid and uncontrollable [ ]

6) What factors do you think have contributed to its spread? (Check all that apply)

1. Adaptability to harsh conditions [ ] 2. Lack of control measures [ ] 3. Seed dispersal by livestock and wildlife [ ] 4. Other (specify) ______________________

7) Where is *Prosopis juliflora* most commonly found in your area?

1. Grazing land [ ] 2. Farmlands [ ] 3. Riverbanks or water sources [ ] 4. Homesteads [ ] 5. Other (specify) ______________________

8) What are the positive environmental impacts of *Prosopis juliflora* in your community? (Check all that apply)

1. None [ ] 2. Prevents soil erosion [ ] 3. Improves soil fertility [ ] 4. Acts as a wind break [ ] 5. Provides shade in arid areas [ ] 6. Other (specify) ______________________

9) What are the negative environmental impacts of *Prosopis juliflora* in your community? (Check all that apply)

1. Displaces native vegetation [ ] 2. Reduces biodiversity [ ] 3. Alters soil quality [ ] 4. Increases water loss or reduces water availability [ ] 5. Creates dense thickets that hinder natural habitats [ ] 6. Other (specify) ________________________

10) What are the positive livelihood impacts of *Prosopis juliflora* in your community? (Check all that apply)

1. None [ ] 2. Provides employment opportunities [ ] 3. Serves as source of firewood or timber [ ] 4. Provides pods or leaves for livestock feed [ ] 5. Generates income from selling products [ ] 6. Other (specify) ________________________

11) What are the negative livelihood impacts of *Prosopis juliflora* in your community? (Check all that apply)

1. Reduces agricultural productivity [ ] 2. Harms livestock [ ] 3. Increases labor requirements for land clearing [ ] 4. Creates conflicts over land use [ ] 5. Restricts movement of people and livestock due to dense thickets [ ] 6. Other (specify) ________________________

12) In your opinion, do the positive impacts of *Prosopis juliflora* outweigh the negative impacts in your community?

1. Yes [ ] 2. No [ ]

13) Why do you say so?

SECTION C: *Prosopis juliflora* MANAGEMENT INTERVENTIONS

14) Are you aware of any management interventions that have been introduced to control the spread of *Prosopis juliflora*?

1. Yes [ ] 2. No [ ]

15) Can you please mention any interventions that you are aware of?

1. Charcoal production [ ] 2. Firewood production [ ] 3. Pole/Posts production [ ] 4. Rope production [ ] 5. Livestock feed processing [ ] 6. Beekeeping [ ] 7. Land reclamation [ ] 8. Biochar production [ ] 9. Other (specify) _______

16) Who implements these management interventions in your area? (Check all that apply)

1. County government [ ] 2. NGOs [ ] 3. Community groups [ ] 4. Individual households [ ] 5. Other (specify) ________________________

17) Does your household implement any management practices for *Prosopis juliflora*?

1. Yes [ ] 2. No [ ]

18) If yes, which management practices is your household implementing? (Check all that apply)

1. Charcoal production [ ] 2. Firewood production [ ] 3. Pole/Posts production [ ] 4. Rope production [ ] 5. Livestock feed processing [ ] 6. Beekeeping [ ] 7. Land reclamation [ ] 8. Biochar production [ ] 9. Other (specify) _______

19) If no, what are the main reasons for not implementing? (Check all that apply)

1. Lack of awareness [ ] 2. Lack of resources [ ] 3. Lack of training or knowledge [ ] 4. High costs of implementation [ ] 5. Limited time or labour availability [ ] 6. Lack of market access for products [ ] 7. Other (specify) ______________________

20) How long have you been implementing the *Prosopis juliflora* management interventions?
1. Less than 1 year [ ] 2. 1-3 years [ ] 3. 3-5 years [ ] 4. More than 5 years [ ]

21) What motivated your decision to adopt the *Prosopis juliflora* management interventions? (Check all that apply)

1. Financial benefit [ ] 2. Training/support received [ ] 3. Environmental benefits [ ] 4. Availability of market for products [ ] 5. Community influence [ ] 6. Other (specify)

22) (For adopters) What challenges have you faced in the adoption of *Prosopis juliflora* management interventions? (Check all that apply)

1. Lack of tools or equipment [ ] 2. High labour costs [ ] 3. Limited market access for products [ ] 4. Insufficient knowledge or training [ ] 5. Conflicts over land or resources [ ] 6. Others (Specify) __________________

SECTION D: SOCIO-ECONOMIC AND INSTITUTIONAL FACTORS

23) Does your household own land?
1.Yes [ ] 2 . No [ ]
24) If yes, what type of land ownership?
1. Individual land [ ] 2 . Family land [ ] 3. Communal land [ ] 4. Rental [ ] 5. Other (specify) __________________________

25) What is your household landholding size in acres? __________________________
26) Do you have access to information on *Prosopis juliflora* management?

1. Yes [ ] 2. No [ ]

27) If yes, where do you often get information on *Prosopis juliflora* management? (Check all that apply)

1. Government [ ] 2. Non-Governmental Organizations (NGOs) [ ] 3. Community meetings [ ] 4. Mass media [ ] 5. Friends/relatives [ ] 6. Other (specify) ________________________

28) Did you have contact with extension/forest officers concerning *Prosopis juliflora* management in the last 12 months?

1. Yes [ ] 2. No [ ]

29) If yes, how many times did you have contact with the extension/forest service providers? __

30) What kind of extension/forestry services did you access? (Check all that apply)

1. *Prosopis juliflora* management trainings [ ] 2. Marketing Information [ ] 3. Equipment [ ] 4. Others,(*specify*) ____________________________

31) Did you receive any training related to *Prosopis juliflora* management in the last 12 months?

1. Yes [ ] 2 . No [ ]

32) If yes, how many training sessions did you receive? ____________________________

33) What type of *Prosopis juliflora* management training did you receive? (Check all that apply)

1. Charcoal production [ ] 2. Firewood production [ ] 3. Pole/Posts production [ ] 4. Rope production [ ] 5. Livestock feed processing [ ] 6. Beekeeping [ ] 7. Land reclamation [ ] 8. Biochar production [ ] 9. Other (specify) _______

34) How long was the training? ____________________________days

35) Do you think the training you received was adequate and relevant?

1. Yes [ ] 2. No [ ]

36) Why do you say so? ____________________________

37) Are you a member of any civil society or community organization?

1. Yes [ ] 2 . No [ ]

38) If yes, which civil society or community organization do you belong to?

1. Community-Based Organizations [ ] 2. ROSCAS [ ] 3. Welfare groups [ ] 4. Charcoal Producers Association [ ] 5.Self-Help groups [ ] 6. Beekeeping [ ] 7. Community Forest

Association [ ] 8. Youth groups [ ] 9. Cooperative societies [ ] 10. Chamas (social groups) 11. Other (specify) _______

39) Do you hold any leadership position in the civil society or community organization?

1. Yes [ ] 2 . No [ ]

40) What benefits do you gain from being a member of this civil society or community organization? (Check all that apply)

1. Access to training on *Prosopis juliflora* management [ ] 2 . Access to financial support or credit facilities [ ] 3. Opportunities for collective group (e.g. group marketing, cooperative activities) [ ] 4. Advocacy for community interests (e.g. influencing policy decisions) [ ] 5. Networking and collaboration 6. Others (Specify) ____________________

41) How far is your household from the nearest market? __________________Km

42) Do you have access to credit or financial services in your area?

1. Yes [ ] 2. No [ ]

43) Do you have access to technology that supports *Prosopis juliflora* management?

1. Yes [ ] 2. No [ ]

44) If yes, what type of technology do you have access to? (Check all that apply)

1. Tools and equipment for land clearing [ ] 2 . Machinery for processing *Prosopis juliflora* [ ] 3. Digital platforms for accessing market information [ ] 4. Advanced beekeeping tools [ ] 5. Improved transportation technology 6. Others (Specify) ____________________

45) Are you aware of any laws or regulations regarding the management or use of *Prosopis juliflora* in your area?

1. Yes [ ] 2. No [ ]

46) If yes, what type of legal frameworks are you aware of? (Check all that apply)

1. Regulations on harvesting *Prosopis juliflora* [ ] 2 . Rules on clearing or reclaiming land affected by *Prosopis juliflora* [ ] 3. Restrictions on selling *Prosopis juliflora* products [ ] 4. Others (Specify) ____________________

47) Do you think these legal frameworks are effective in managing *Prosopis juliflora*?

1. Yes [ ] 2. No [ ]

48) Why do you say so?

SECTION E: ECONOMIC VALUE OF *Prosopis juliflora* MANAGEMENT INTERVENTIONS

49) Overall, what type of costs do you incur in managing *Prosopis juliflora*? (Check all that apply)

1. Hired labour [ ] 2. Tools and equipment [ ] 3. Transportation [ ] 4. Seeds or inputs for land reclamation 5. Other (specify) ____________________

50) For the interventions that you are implementing, what are the estimated costs that you incur per month (in KES)?

Intervention	Cost
Charcoal production	
Firewood production	
Pole production	
Rope production	
Livestock feed production	
Beekeeping	
Land reclamation	
Biochar production	
Other (specify) ________	

51) What is the average monthly income that you get from selling *Prosopis juliflora* products? (If used at home, then specify what you could have sold the product for if you had not used it for home use)

Intervention	KES
Charcoal	

Livestock feed	
Honey	
Land reclamation products	
Poles	
Fuelwood	
Ropes	
Biochar	
Other (specify) ___________	

SECTION F: ENVIRONMENTAL AND LIVELIHOOD IMPACT

52) Have the management interventions improved your household's livelihood?

1. Yes [ ] 2. No [ ]

53) If yes, how has engaging in *Prosopis juliflora* management affected your household's livelihood?

1. No change [ ] 2. Increased income stability [ ] 3. Reduced dependence on a single income source [ ] 4. Increased food security [ ] 5. Improved savings or ability to invest [ ] 6. Reduced dependency on external support [ ] 7. Improved access to resources [ ] 8. Other (specify) ___

54) Have these management interventions contributed to environmental well-being in your area?

1. Yes [ ] 2. No [ ]

55) If yes, please specify/explain? ___________________________

56) To what extent are you satisfied with these management interventions?

1. Not at all satisfied [ ] 2. Slightly satisfied [ ] 3. Moderately satisfied [ ] 4. Very satisfied [ ] 5. Extremely satisfied [ ]

57) What challenges, if any, have hindered the success of these interventions in your area? (Check all that apply)

1. Lack of funding or resources [   ] 2. Insufficient community resources [ ] 3. Poor coordination among stakeholders [   ] 4. Lack of awareness or interest [   ] 5. Others (Specify)

____

58) How do you perceive the long-term viability of these interventions?

1 Very viable [ ] 2 . Somewhat viable [ ] 3. Not viable [ ]

The end

Appendix B: FGD Guide

Introduction: Good morning/afternoon. You have been identified as a key stakeholder for the study on the economic value of the environmental management of *Prosopis juliflora* (*Mathenge*) here in Baringo South Sub-County. By participating in this discussion, you will help towards the completion of this research study and achievement of its objectives. The aim of the study is to collect data on the *Prosopis juliflora* management interventions being implemented by households; factors influencing the intensity of adoption of the *Prosopis juliflora* management interventions among households; and to evaluate the net economic benefits of the *Prosopis juliflora* management interventions on the livelihoods of households. Therefore, be assured that the research is solely for academic purpose and the information you provide will be treated with strict confidentiality.

Name of FDG facilitator:	
Administrative Ward:	
Number of participants	
FGD Date:	

***Prosopis juliflora* MANAGEMENT**

1. How did you first become aware of *Prosopis juliflora* (*Mathenge*)?
2. Can you describe the overall impact of *Prosopis juliflora* in your area?
3. What specific groups (e.g., men, women) are most affected by the spread of *Prosopis juliflora*, and how?
4. Have there been any social or community conflicts related to *Prosopis juliflora* management? If yes, can you describe them?
5. What are the main strategies used to manage *Prosopis juliflora* in this community?
6. How effective are these management strategies?
7. What challenges do households face in adopting these strategies?

FACTORS INFLUENCING ADOPTION OF MANAGEMENT INTERVENTIONS

8. Do gender roles affect the adoption of these strategies?
9. Are aware of any laws or policies that influence how *Prosopis juliflora* is managed?
10. What role do local institutions, community groups, or government programs play in managing *Prosopis juliflora*?

11. What role do you think men and women can play in improving the management of *Prosopis juliflora*?

ECONOMIC BENEFITS AND COSTS

12. What are the main costs or burdens associated with managing or using *Prosopis juliflora*?
13. Are there any environmental benefits of managing *Prosopis juliflora* that you have noticed in your area?
14. Are there any socio-economic benefits of managing *Prosopis juliflora* that you have noticed in your area?
15. Do you think the benefits outweigh the costs of managing *Prosopis juliflora*? Why or why not?
16. What additional support would you like to see from institutions or the government in managing *Prosopis juliflora*?
17. What recommendations do you have for improving the management of *Prosopis juliflora* in your community?
18. What do you think would happen in the future if *Prosopis juliflora* is not effectively managed?

End of questions

Appendix C: KII Guide

Introduction: Same as FGD guide.

Name of interviewer:	
Name of respondent:	Contacts:
Institution:	
Position:	
Interview Date:	
Administrative ward	

STAKEHOLDER ENGAGEMENT AND COLLABORATION

1. What is involvement in activities related to *Prosopis juliflora* management?
2. What role does your organization play in supporting *Prosopis juliflora* management in this region?
3. How long has your organization been involved in *Prosopis juliflora* management?
4. How does your organization collaborate with other stakeholders in managing *Prosopis juliflora*?

SPREAD AND MANAGEMENT of *Prosopis juliflora*

5. What were the intentions of introducing *Prosopis juliflora* in this region? Have these intentions been realized?
6. How would you describe the current spread and distribution of *Prosopis juliflora*?
7. What are the key livelihood and environmental challenges faced by households due to the spread of *Prosopis juliflora*?
8. What are the main *Prosopis juliflora* management strategies being implemented in this region?
9. Which strategies have been most effective?

FACTORS INFLUENCING ADOPTION OF MANAGEMENT INTERVENTIONS

10. What are the challenges or barriers to implementing these management strategies?
11. Are there any policies or regulations governing the management and use of *Prosopis juliflora*? How effective are they?

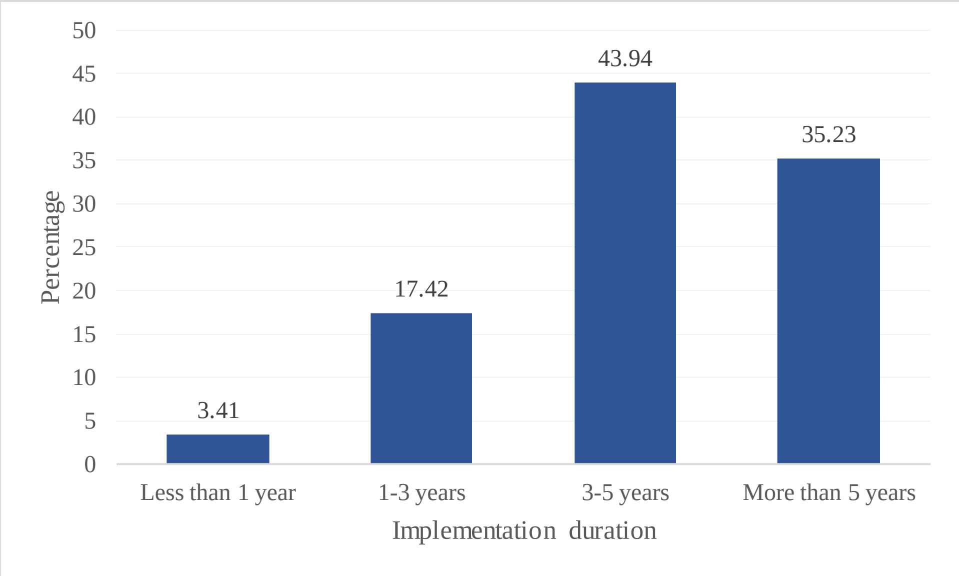
ECONOMIC BENEFITS AND COSTS

24. Have you observed any benefits of *Prosopis juliflora* management to the environment?
25. Have you observed any economic or social benefits derived from *Prosopis juliflora* management (e.g., employment, income generation)?
26. How sustainable do you think the current management interventions are in the long term?
27. What recommendations would you make to improve *Prosopis juliflora* management in this region?
28. What do you foresee happening in the future if *Prosopis juliflora* continues to spread unchecked?
29. Are there any final thoughts?

End of questionnaire. Thank you for your valuable contribution!

Appendix D: Data Analysis Output for Objective 1

a) <u>Implementation duration (N=264)</u>



b) <u>Motivation for implementing *Prosopis juliflora* management interventions (N=264)</u>

Motivation	Frequency	Percentage of cases
Financial benefits	218	82.58
Training/support received	68	25.76
Environmental benefits	157	59.47
Availability of markets for products	81	30.68
Community influence	31	11.74

c) Challenges faced in implementing *Prosopis juliflora* management interventions (N=264)

Challenges	Frequency	Percentage of cases
None	2	0.76
Lack of tools/equipment	188	71.21
High labour costs	213	80.68
Limited market access for products	47	17.80
Insufficient knowledge/training	74	28.03
Conflicts over land/resources	22	8.33

d) Household implementation per administrative ward (N=264)

```
. tab A3_ward if D4_adopted==1
```

A3. Administrative Ward	Freq.	Percent	Cum.
1. Ilchamus	30	11.36	11.36
2. Marigat	155	58.71	70.08
3. Mochongoi	71	26.89	96.97
4. Mukutani	8	3.03	100.00
Total	264	100.00	

e) Socio-demographic characteristics of household head: sex (N=264)

```
. tab B2_sex if D4_adopted==1
```

B2. Sex of household head	Freq.	Percent	Cum.
1. Male	175	66.29	66.29
2. Female	89	33.71	100.00
Total	264	100.00	

f) Socio-demographic characteristics of household head: marital status (N=264)

```
. tab B4_marital_status if D4_adopted==1
```

B4. Marital Status of household head	Freq.	Percent	Cum.
1. Single (never married)	29	10.98	10.98
2. Married or living together	188	71.21	82.20
3. Widowed	27	10.23	92.42
4. Separated or divorced	20	7.58	100.00
Total	264	100.00	

g) Socio-demographic characteristics of household head: education level (N=264)

```
. tab B5_education if D4_adopted==1
```

B5. Education level of household head	Freq.	Percent	Cum.
1. None	9	3.41	3.41
2. Primary	87	32.95	36.36
3. Secondary	114	43.18	79.55
4. Tertiary	54	20.45	100.00
Total	264	100.00	

h) Socio-demographic characteristics of household head: cccupation (N=264)

```
. tab B6_occupation if D4_adopted==1
```

B6. Household head main occupation	Freq.	Percent	Cum.
1. Unemployed	16	6.06	6.06
2. Agro-pastoralist	177	67.05	73.11
3. Salaried employment	34	12.88	85.98
4. Casual labour	16	6.06	92.05
5. Self-employed/enterprise owner	21	7.95	100.00
Total	264	100.00	

Appendix E: Data Analysis Output for Objective 2

a) Intervention summary

```
. summarize interventions, detail

                        interventions
-------------------------------------------------------------
      Percentiles      Smallest
 1%            0              0
 5%            1              0
10%            1              0       Obs                 263
25%            1              0       Sum of wgt.         263

50%            2                      Mean           2.003802
                        Largest       Std. dev.      1.157446
75%            3              6
90%            3              6       Variance        1.33968
95%            4              6       Skewness       1.205951
99%            6              6       Kurtosis        4.72965
```

b) Poisson regression results

```
. poisson interventions B2_sex B3_age i.B5_education i.B6_occupation B7_hhsize B8_avg_income E3_landsize E4_information E9_
> training E15_member E19_dist_market E20_credit E21_technology E23_legal_framework

Iteration 0:   log likelihood = -378.24328
Iteration 1:   log likelihood = -378.23438
Iteration 2:   log likelihood = -378.23438

Poisson regression                                      Number of obs =    263
                                                        LR chi2(19)   =  59.39
                                                        Prob > chi2   = 0.0000
Log likelihood = -378.23438                             Pseudo R2     = 0.0728

---------------------------------------------------------------------------------------------------
                    interventions | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
----------------------------------+----------------------------------------------------------------
                           B2_sex |  -.0106259   .1018978    -0.10   0.917    -.2103418    .1890901
                           B3_age |     .00349   .0056991     0.61   0.540      -.00768    .0146601
                                  |
                     B5_education |
                      2. Primary  |  -.0767579   .2910854    -0.26   0.792    -.6472749    .4937591
                    3. Secondary  |  -.0196063   .3026348    -0.06   0.948    -.6127596    .5735471
                     4. Tertiary  |   .0097315   .3266001     0.03   0.976     -.630393    .6498559
                                  |
                    B6_occupation |
               2. Agro-pastoralist  |  -.0389027   .1928066    -0.20   0.840    -.4167966    .3389913
          3. Salaried employment  |   -.241209   .2415063    -1.00   0.318    -.7145527    .2321347
                4. Casual labour  |  -.1691943   .2611352    -0.65   0.517    -.6810099    .3426212
5. Self-employed/enterprise owner  |  -.0825697   .2391426    -0.35   0.730    -.5512805    .3861411
                                  |
                        B7_hhsize |  -.0598685   .0238443    -2.51   0.012    -.1066025   -.0131345
                    B8_avg_income |   2.42e-06   5.72e-06     0.42   0.672    -8.79e-06    .0000136
                      E3_landsize |   .0419672   .0192947     2.18   0.030     .0041503    .0797842
                   E4_information |   -.121364   .2615386    -0.46   0.643    -.6339703    .3912423
                      E9_training |  -.2756769   .1553483    -1.77   0.076     -.580154    .0288002
                       E15_member |  -.0585137   .1302014    -0.45   0.653    -.3137037    .1966763
                  E19_dist_market |   .0239955   .0048127     4.99   0.000     .0145628    .0334282
                       E20_credit |  -.1639054   .1534016    -1.07   0.285     -.464567    .1367562
                   E21_technology |   .0915521   .1933244     0.47   0.636    -.2873567     .470461
              E23_legal_framework |  -.3717587   .2021621    -1.84   0.066    -.7679892    .0244718
                            _cons |    1.55554   .5970125     2.61   0.009     .3854172    2.725663
---------------------------------------------------------------------------------------------------
```

c) Poisson goodness of fit test results

```
. estat gof

         Deviance goodness-of-fit =  107.6181
         Prob > chi2(243)         =    1.0000

         Pearson goodness-of-fit  =  104.2349
         Prob > chi2(243)         =    1.0000
```

d) Generalized Poisson regression results

```
. gpoisson interventions B2_sex B3_age i.B5_education i.B6_occupation B7_hhsize B8_avg_income E3_landsize E4_information E9
> _training E15_member E19_dist_market E20_credit E21_technology E23_legal_framework, vce(robust) irr

Fitting Poisson model:

Iteration 0:   log pseudolikelihood = -378.24328
Iteration 1:   log pseudolikelihood = -378.23438
Iteration 2:   log pseudolikelihood = -378.23438

Fitting constant-only model:

Iteration 0:   log pseudolikelihood = -407.92733
Iteration 1:   log pseudolikelihood = -400.73917
Iteration 2:   log pseudolikelihood = -400.15103
Iteration 3:   log pseudolikelihood = -400.14746
Iteration 4:   log pseudolikelihood = -400.14746

Fitting full model:

Iteration 0:   log pseudolikelihood = -378.23438
Iteration 1:   log pseudolikelihood = -348.12369
Iteration 2:   log pseudolikelihood = -340.33717
Iteration 3:   log pseudolikelihood = -339.76221
Iteration 4:   log pseudolikelihood = -339.55691
Iteration 5:   log pseudolikelihood = -339.55632
Iteration 6:   log pseudolikelihood = -339.55632

Generalized Poisson regression                  Number of obs   =        263
                                                Wald chi2(19)   =     233.88
                                                Prob > chi2     =     0.0000
Dispersion     = -.4624792                      Prob > chi2     =     0.0000
Log pseudolikelihood= -339.55632                Pseudo R2       =     0.1514
```

interventions	IRR	Robust std. err.	z	P>|z|	[95% conf.	interval]
B2_sex	.9989837	.0665795	-0.02	0.988	.8766539	1.138384
B3_age	1.003269	.0035963	0.91	0.363	.9962454	1.010343
B5_education						
1. None	1	(empty)				
2. Primary	1.008953	.1759377	0.05	0.959	.7168716	1.42004
3. Secondary	1.059358	.1891897	0.32	0.747	.7464958	1.503342
4. Tertiary	1.116399	.2214325	0.56	0.579	.7568115	1.64684
B6_occupation						
1. Unemployed	1	(empty)				
2. Agro-pastoralist	.9640584	.1111634	-0.32	0.751	.7690475	1.208519
3. Salaried employment	.8190393	.1082593	-1.51	0.131	.6321123	1.061244
4. Casual labour	.761533	.1013869	-2.05	0.041	.5866293	.9885842
5. Self-employed/enterprise owner	.8900235	.1270822	-0.82	0.415	.6727635	1.177445
B7_hhsize	.9481084	.013297	-3.80	0.000	.9224017	.9745314
B8_avg_income	.9999993	3.25e-06	-0.21	0.832	.9999929	1.000006
E3_landsize	1.037475	.0122691	3.11	0.002	1.013705	1.061803
E4_information	.7698613	.100368	-2.01	0.045	.596266	.9939967
E9_training	.8066536	.0773818	-2.24	0.025	.668393	.9735143
E15_member	.886994	.0648558	-1.64	0.101	.7685676	1.023669
E19_dist_market	1.025142	.002885	8.82	0.000	1.019503	1.030812
E20_credit	.8083579	.0716711	-2.40	0.016	.6794132	.9617748
E21_technology	1.106267	.1221521	0.91	0.360	.8909876	1.373562
E23_legal_framework	.7473267	.083108	-2.62	0.009	.6009673	.9293304
_cons	4.99014	1.786742	4.49	0.000	2.473638	10.06675
/atanhdelta	-.5004605	.062082			-.622139	-.378782
delta	-.4624792	.0488035			-.5526156	-.3616492

```
Note: Estimates are transformed only in the first equation to incidence-rate ratios.
Likelihood-ratio test of delta=0:  chi2(1) =   77.36       Prob>=chi2 = 0.0000
```

e) Generalized Poisson goodness of fit test results

```
. estat ic

Akaike's information criterion and Bayesian information criterion
```

Model	N	ll(null)	ll(model)	df	AIC	BIC
.	263	-400.1475	-339.5563	21	721.1126	796.1279

Note: BIC uses N = number of observations. See **[R] BIC note**.

f) Likelihood-ratio test results

```
. lrtest poisson gpoisson, stats force

Likelihood-ratio test
Assumption: poisson nested within gpoisson

 LR chi2(1) =  77.36
Prob > chi2 = 0.0000

Akaike's information criterion and Bayesian information criterion
```

Model	N	ll(null)	ll(model)	df	AIC	BIC
poisson	263	-407.9273	-378.2344	20	796.4688	867.9118
gpoisson	263	-400.1475	-339.5563	21	721.1126	796.1279

Note: BIC uses N = number of observations. See **[R] BIC note**.

Appendix F: Thematic Analysis Output

Theme	Codes	Description
1. Ecological impact	- Soil erosion and fertility changes - weather changes	"*Prosopis juliflora* has improved soil fertility because it's rich in nitrogen. Wherever it's removed, the land becomes highly productive and yields increase. Converting its biomass into biochar and returning it to the soil further enhances fertility." – KEFRI KII "Mathenge has also brought some positive environmental effects. It acts as a windbreak, helps control soil erosion, and has improved the local climate. We now experience frequent rains, fewer droughts, and reduced water scarcity, which has in turn improved people's health." – Marigat FGD
2. Livelihood challenges	- Reduced agricultural productivity	"We have faced many challenges from this plant as a pastoral community. Since *Prosopis juliflora* was introduced in this area, livestock numbers have declined because the plant has spread widely and invaded farmlands, reducing agricultural productivity." – CPA Chairperson KII
3. Management strategies	- Uprooting and clearing - Charcoal production - Biochar production	"Biochar production started in Salabani around 2023 through an organization called Plant Village, however, it's expensive and usually done in groups rather than individual households" – Ilchamus FGD "I manage Mathenge by uprooting it and planting pasture grass or maize to prevent it from re-germinating. I also engage in charcoal production and sell pods during the

		season. The poles are another source of income, I cut and sell them at around 250 shillings each." – Pasture production KII
4. Effectiveness of interventions	- Continuous uprooting - Pasture as a cover crop - Biochar as an emerging innovation	"Biochar production is still a new initiative. Researchers are currently testing how to mix it with other chemicals to make fertilizer. As a chairperson, I see it as a very promising income-generating activity, although the challenge remains inadequate funds to advance its research and bring the product to market." – CPA chairperson KII
5. Economic and social benefits	- Employment and income generation - Beekeeping and honey production - Protective use	"As a beekeeper, I view Mathenge positively. It produces flowers year-round, providing bees with nectar in all seasons. They also offer shade for the hives, ensuring bees remain active even during the dry months." – Beekeeping KII "I have managed to control the rapid spread of Mathenge, and now I use the cleared land for agriculture and pasture production. The sale of Mathenge products, pasture seeds, and grass has also enabled me to save and make some investments." – Pasture production KII "When used as fencing, Mathenge helps to protect crops from animals because its thorns prevent goats and other livestock from passing through." – CPA chairperson KII
6. Barriers to adoption	- Labour and financial constraints	"We face many challenges including bad roads, harassment by tax collectors during charcoal transportation, and the

	- Policy inconsistency and enforcement gaps - Infrastructure - Gendered labour divisions	government's ban on charcoal production." – CPA chairperson KII "Managing Mathenge involves high labour costs and long processing times for products like charcoal and biochar. We also lack funding and markets, and the prices for Mathenge products are low. The pods further harm the intestines and teeth of both children and livestock since they are very sweet. Besides, we lack proper storage facilities for products like charcoal and pods, which are easily damaged by, say, weather." – Ilchamus FGD "Men often have the energy to uproot Mathenge, but women usually have to hire additional labour, which increases costs." – Ilchamus FGD "It's very costly and labour-intensive to remove Mathenge. The tree's sharp, poisonous thorns injure people during handling, and transporting the products is another major challenge." – Pasture production KII "There is a general lack of commitment and investment in terms of time, money, and energy. Communities are often unwilling to eradicate Mathenge because they benefit from it economically, even though it's also a nuisance, this creates conflicting interests." – Ministry of Water KII "Awareness of the management technologies is still low, and even where

		people know about these interventions, adoption is limited." – KEFRI KIII "The cost of removing Mathenge is very high. Once it invades land, clearing it becomes expensive because you must hire labourers to remove it before you can cultivate." – KEFRI KII
7. Stakeholder engagement	- Donor support and capacity building	"There is need for more training of community members on how to manage Mathenge, and for financial support to facilitate effective management." – Ilchamus FGD
8. Policy and governance	Absence of formal *Prosopis juliflora* policy Charcoal regulation and taxation	"There is no *Prosopis juliflora* policy that I have ever heard of." – Beekeeping KII "So far, no clear policy has been put in place to guide the management of *Prosopis juliflora*." – CPA chairperson KII "In this area, charcoal production is the main activity linked to Mathenge management. Charcoal burning from native trees was banned in 2018, and only Mathenge charcoal was allowed for sale, and this prompted the government to form Charcoal Producer Associations (CPAs) to establish collection points for easy revenue collection and to regulate the market. These regulations have been effective because they help streamline the charcoal trade and coordinate activities under *Prosopis juliflora* management." – Ilchamus FGD "For utilization, there is a policy that allows CPAs to undertake *Prosopis juliflora* charcoal production. Although there is a

		national ban on charcoal burning in Kenya, areas heavily invaded by *Prosopis juliflora* are exempted, allowing charcoal production as a means of controlling the plant's spread." - Lake Bogoria National Reserve KII

Appendix G: Research Ethical Clearance

EGERTON UNIVERSITY

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EGERTON

EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

EU/RE/DIR/009
Approval No. EUISERC/APP/406/2025 ***1st April* 2025**

Loveness Gloria Phiri
Address: 536-20115,
Egerton- Njoro, Kenya.
Telephone +254702544740/ +265993340992
Email: lovenessmphiri@gmail.com

Dear Loveness,

RE: ETHICAL APPROVAL: ECONOMIC VALUATION OF THE ENVIRONMENTAL MANAGEMENT OF PROSOPIS JULIFLORA (MATHENGE) IN BARINGO SOUTH SUB-COUNTY, KENYA.

This is to inform you that the ***Egerton University Institutional Scientific and Ethics Review Committee*** has reviewed and approved your above research proposal. Your application approval number is ***EUISERC/APP/406/2025***. The approval period is ***1st April 2025 – 2nd April 2026***
This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***Egerton University Institutional Scientific and Ethics Review Committee***.
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours.
v. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.

"Transforming Lives through Quality Education"

Appendix H: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **225314**

Date of Issue: **14/April/2025**

RESEARCH LICENSE

This is to Certify that Miss.. LOVENESS GLORIA PHIRI of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Baringo on the topic: ECONOMIC VALUATION OF THE ENVIRONMENTAL MANAGEMENT OF Prosopis juliflora (MATHENGE) IN BARINGO SOUTH SUB-COUNTY, KENYA for the period ending : 14/April/2026.

License No: **NACOSTI/P/25/418017**

225314

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See overleaf for conditions

Appendix I: Study Outputs

Pan-African Conference on Environment, Climate Change and Health: Science to Policy

Economic valuation of *Prosopis juliflora* (mathenge) management for sustainable land use in semi-arid Kenya.

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b. Department of Environmental Science, Egerton University, P.O. Box 536 – 20115, Njoro, Kenya

Summary

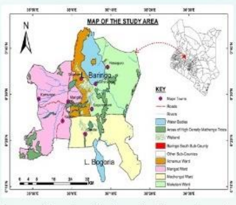
- *Prosopis juliflora* management interventions are economically viable and environmentally beneficial.
- Adoption of management interventions is significantly influenced by socio-economic and institutional factors.
- Policy focus should shift toward scaling up sustainable utilization and land reclamation initiatives.

Introduction

- *Prosopis juliflora* is a highly invasive species degrading rangelands, reducing biodiversity, and threatening livelihoods in Kenya's semi-arid areas.
- In Baringo South Sub-county, it has invaded over 18,000 ha, displacing farmland and grazing areas[1].
- Despite its harm, the species offers economic potential through utilization-based management (e.g., charcoal, feed, biochar, land reclamation).
- The study assessed the economic value and adoption of these interventions to inform sustainable land use and livelihood policies.

Methods

- A cross-sectional survey of 270 households in Baringo South Sub- County was conducted, to assess adoption and economic viability of management interventions.



Source: Egerton University, Department of Geography (2025)

Results

- Charcoal (84.9%) and firewood (47.7%) are the most adopted interventions, reflecting energy and income needs; land reclamation (18.6%) and feed processing (12.9%) provide ecological and forage benefits.

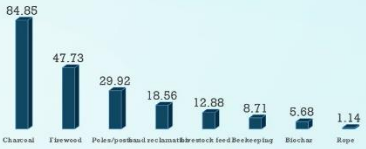


***Figure 1: Prosopis juliflora* management interventions implemented in Baringo South Sub-county (N=264)**

Source: Author's field survey data (2025)

- A Generalized Poisson regression model revealed that adoption intensity is positively and significantly influenced by land size (1%) and market distance (1%), underscoring the role of socio-economic and institutional factors.
- Probabilistic cost-benefit analysis (10,000 Monte Carlo simulations) showed most interventions had a BCR > 1. Feed processing (BCR=7.49), charcoal (BCR=4.97), and land reclamation (BCR=4.55) are among the most profitable.

Table 1: Simulated Benefit-Cost Ratios (in KES)

Intervention	Benefit-Cost Ratio
Charcoal production	4.973
Firewood production	1.607
Poles/posts production	1.335
Land reclamation	4.550
Livestock feed processing	7.490
Beekeeping	1.632
Biochar production	3.371

Source: Author's field survey data (2025)

References

Mbaabu, P. R., *et al.*, (2019). Spatial evolution of *Prosopis* invasion and its effects on LULC and livelihoods in Baringo, Kenya. *Remote sensing*, *11*(10), 1-24. https://doi.org/10.3390/rs11101217

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Research Article

Adoption Patterns and Determinants of *Prosopis juliflora* Management Interventions Among Households in Baringo South Sub-county, Kenya

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Abstract

Prosopis juliflora is a highly invasive species in Kenya's semi-arid lands, presenting significant ecological threats while simultaneously offering potential livelihood opportunities. This study aimed to examine the adoption patterns and determinants of its management interventions by using a cross-sectional research design, collecting data from 270 households in Baringo South Sub-County through a multistage sampling technique. The data were analysed using descriptive statistics and a Generalized Poisson Regression Model (GPRM) to identify adoption patterns and assess the intensity of adoption of the *Prosopis juliflora* management interventions, respectively. The study findings reveal that the most prevalent management interventions are low-value options, dominated by charcoal production (84.85%) and firewood production (47.73%), whereas there is limited adoption of higher-value alternatives such as livestock feed processing (12.88%) and biochar production (5.68%). The regression analysis showed that adoption intensity is positively influenced by landholding size ($p<0.01$) and distance to the market ($p<0.01$), and on the contrary, it is negatively associated with household size, access to credit, casual labour occupation, training, access to information, and awareness of legal frameworks. These findings highlight a critical need for targeted interventions to promote sustainable and diversified *Prosopis juliflora* management. The study recommends implementing tailored training programs, enhancing market access for higher-value products, and establishing supportive policy frameworks to improve both ecological restoration and livelihood opportunities for local communities.

Keywords

Prosopis juliflora, Invasive Species Management, Adoption Patterns, Adoption Intensity, Baringo South, Kenya

1. Introduction

Invasive alien plant species (IAPS) are increasingly recognized as one of the greatest threats to biodiversity, agricultural productivity, and human well-being worldwide, with the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services reporting that there are more than 37,000 alien species globally [1], of which about 3,500 are invasive. The economic toll of biological invasions is immense, exceeding USD 423 billion annually, with costs rising fourfold each decade since 1970 [2], where plants are reported to account for about 6% of invasive alien species. While some

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