HOUSEHOLD WILLINGNESS TO PAY OR PARTICIPATE IN THE CONTROL OF THE INVASIVE *Ipomoea* PLANT SPECIES IN KAJIADO CENTRAL SUB-COUNTY, KAJIADO COUNTY, KENYA

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A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Master of Science Degree in Agribusiness Management of Egerton University

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DECLARATION AND RECOMMENDATION

Declaration

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

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Recommendation

This thesis has been submitted to graduate School of Egerton University with our approval as University supervisors.

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DEDICATION

This thesis is dedicated to my beloved family for their unwavering love and support, and to Dawit Negassi for his constant encouragement and belief in my dreams.

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ABSTRACT

Communal grazing lands are crucial for the livelihoods and food security of pastoralist communities in Kajiado County, Kenya, who depend mainly on livestock. Over the past decade, changes in land use have allowed the invasive *Ipomoea* species to spread, shrinking available grazing areas and putting the long-term resilience of these communities at risk. Guided by Random utility theory and theory of Common Pool Resources, this research was needed to contribute empirical evidence to support policy formation on sustainable rangeland management. This study focused on estimating the household willingness to participate in control efforts and identify factors influencing their willingness. The specific objectives of this study were; to characterize households' willingness to pay or participate in the control of the invasive *Ipomoea* species; to estimate the mean level of willingness to pay or participate, and determine the factors influencing household willingness to pay. Primary data were collected from 267 households through a semi-structured questionnaire between April and May 2025 using a multistage sampling procedure across three wards in Kajiado Central Sub-County: Purko, Dalalekutuk, and Illdamat that were later cleaned and analyzed using SPSS version 27 and STATA version 17 respectively. The data were analysed using descriptive statistics for the first objective, while a double-bounded dichotomous choice CVM approach with a seemingly unrelated bivariate probit model was employed to estimate mean WTP/WTPa and identify its determinants. Out of 260 responses, 81.2% (211 households) expressed willingness to pay in cash, while 81.92% (213 households) were willing to participate through labour. The SUBP model results showed that the mean willingness to pay was KES 9,541.44 KES per year and 14.13 Labour days. key determinants of WTP/Pa included positive significance from extension access (18.4%), land tenure security (5.1%), and livestock ownership (1%), while age (-1.4%), Bid amounts and labor requirements (-6%) showed negative significance. The study concludes that pastoral households are largely willing to participate in efforts to control invasive *Ipomoea* and recommends that policymakers take these key factors into account when designing community-based strategies to manage the spread of invasive plants and strengthen the resilience of pastoral systems.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASALs	Arid and Semi-Arid Lands
ASTGS	Agriculture Sector Transformation and Growth Strategy
BETA	Bottom-Up Economic Transformation Agenda
CPR	Common Pool Resource
CVM	Contingent Valuation Method
CIDP	County Integrated Development Plan
DBDCF	Double Bounded Dichotomous Choice Format
FGD	Focus Group Discussion
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GOK	Government of Kenya
HH	Household
IAS	Invasive Alien Species
KCSAS	Kenya Climate-Smart Agriculture Strategy
KES	Kenyan Shilling
KII	Key Informant Interview
KLVC	Kenya Livestock Value Chain
KNBS	Kenya National Bureau of Statistics
KNIB	Kenya National Irrigation Board
KPHC	Kenya Population and Housing Census
MTV	Medium-Term Plan
MWTPP	Mean Willingness to Participate
RUT	Random Utility Theory
SDG	Sustainable Development Goal
SUBP	Seemingly Unrelated Bivariate Probit model
TCM	Travel Cost Method
TLU	Tropical Livestock Unit
WTP	Willingness to Pay
WTPa	Willingness to Participate

CHAPTER ONE
INTRODUCTION

1.1 Background to the study

Agriculture is a cornerstone of Kenya's economy, vital to its GDP and essential for national food and nutrition security. In 2021, the sector; which encompasses forestry and fishing represented 22.4% of the nation's GDP, underscoring its role as a major engine for economic growth (KNBS, 2023). Livestock sector plays a key role in Kenya’s economy, contributing 3.6% to the national GDP. The country has a large national herd, with over 21 million cattle, 23 million sheep, 34 million goats, 67 million chickens, and 840,000 pigs. Beyond its economic value, the sector provides employment and income for millions and supports food security by supplying meat, milk, and eggs (KLVC, 2022). To modernize the sector, the government has introduced strategic policies. The Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019–2029 seeks to make livestock value chains more productive and commercially viable by improving pastoralists’ access to markets, veterinary services, affordable credit, and infrastructure such as water and feed systems. Similarly, the Kenya Climate-Smart Agriculture Strategy (KCSAS) 2017–2026 promotes sustainable practices to build resilience to climate change, reduce greenhouse gas emissions, and use resources more efficiently. Both strategies emphasize inclusive, community-driven approaches that help livestock-dependent communities adapt and thrive amid climate variability and land degradation. The National Livestock Policy also aims to shift the sector from subsistence to commercial production, improving the livelihoods of smallholder farmers and pastoralists, especially in Arid and Semi-Arid Lands (ASALs). These areas make up 89% of Kenya’s drylands, cover 23 of the 47 counties, and are home to around 20 million people (38% of the population), who keep 60% of the country’s livestock. Despite its importance, the livestock sector faces challenges from urbanization, climate change, drought, changing land use, intensifying farming practices, and the spread of invasive weeds (State Department of Kenya of Livestock Report, 2022).

Invasive alien species (IAS) are causing increasingly severe economic losses worldwide, with total damages over the past 50 years estimated at more than US$1.288 trillion (Diagne *et al.*, 2021). The financial impact varies across regions. For instance, in Central and South America, losses between 1975 and 2020 totaled around USD 102.5 billion, with nearly 90% concentrated in Brazil, Argentina, and Colombia. In Africa, costs were estimated between US$18.2 billion and US$78.9 billion from 1970 to 2020 (Diagne *et al*., 2021; Heringer *et al.*, 2021; Schaffner *et al.*, 2022). The effects of IAS are especially severe in agriculture and livestock systems. In East Africa's semi-arid areas, invasive weeds have spread over large portions of grazing land, competing with native grasses for water and nutrients, slowing pasture recovery, and directly reducing livestock productivity. Some of these weeds are even toxic to animals (Schaffner *et al*., 2022). A striking example comes from the Afar region in Ethiopia, where *Prosopis juliflora* uses an estimated 3.1–3.3 billion cubic meters of water annually that could instead irrigate roughly 460,000 hectares of cotton and 330,000 hectares of sugarcane, with potential annual net benefits of about US$320 million and US$470 million, respectively (Shiferaw *et al*., 2021).

This study examines Kajiado County, a semi-arid area in southern Kenya where livestock production forms the backbone of the local economy and rural livelihoods. According to the County Integrated Development Plan (CIDP of Kajiado, 2023), the main livestock populations include sheep (718,950), goats (699,658), and cattle (411,840), along with smaller numbers of chickens, donkeys, pigs, and camels. Together, the agriculture and livestock sectors provide employment for roughly 75% of the county's population and supply about 40% of its food requirements. Trends in the cash value of key livestock products highlight the economic importance of this sector (CIDP of Kajiado, 2023). The value of chevon (goat meat) saw a substantial rise, climbing from KES 300 million in 2018 to over KES 1 billion in 2022. Conversely, the production value of beef experienced a slight decline during the same period, falling from KES 1.69 billion to KES 1.51 billion (CIDP of Kajiado, 2023). However, the sector faces challenges including severe drought, mismanagement of fodder, real estate developments, invasions by weeds particularly the invasive *Ipomoea* plant species, which has infested an estimated area of 3 million acres of pasture fields, threatening food security and livestock production policies in the (Creemers *et al.*, 2021). Even though there is limited research on the economic impacts of the invasive *Ipomoea* plant species on livestock in Kenya, the harmful and aggressive nature of the plant in Maasai pastoral grazing lands of both Tanzania and Kenya has been studied by several studies. In the Kajiado, the scale of the problem is severe. Preliminary data indicates that a high proportion of land is affected, with *Ipomoea* infesting approximately 80 % of grazing lands. The invasion of *Ipomoea* is widespread and poses serious challenges for livestock production. The weed directly contributes to livestock losses and increases costs for livestock keepers due to the additional effort required for weeding. Studies in the Maasai steppe rangelands show that *Ipomoea hildebrandtii* is most aggressive in grass woodland areas, with invasion rates reaching up to 90% (Mganga *et al*., 2021; Ojija & Manyanza, 2021). Research also shows that pasture productivity is significantly reduced in invaded areas, with non-invaded plots producing 0.289 ± 0.03 t DM/ha compared to 0.202 ± 0.02 t DM/ha in invaded plots.

While the agronomic impacts of *Ipomoea* are clear, less is known about how communities manage it. The success of any control program depends largely on local acceptance and participation. Past studies emphasize that sustainable natural resource management relies on community involvement and collaboration among stakeholders (Agrawal, 2003; Beyene, 2011; Debie & Singh, 2021; Ostrom, 1990). Despite the significant impact of *Ipomoea*, little is known about whether households are willing to contribute their own resources either money or labor to its control. This study aims to fill that gap by examining household willingness to pay and participate in managing *Ipomoea* in Kajiado Central Sub-county. The findings will help inform strategies that are both practical and acceptable to local communities.

1.2 Statement of the problem

Managing communal grazing lands well is essential for supporting the livelihoods of pastoralists in Kajiado County, Kenya. However, these lands are being heavily affected by the spread of the invasive *Ipomoea* plant, which has covered about 60–80% of pasture areas. This invasion threatens livestock production and the county's food security. Although collective action and community involvement are known to be important for managing shared resources, their success depends on how willing local households are to contribute money or labor to control efforts. At present, there is little or no evidence on how much households are willing to pay or participate in controlling *Ipomoea*. As a result, the value that communities place on restoring degraded pastures is not clear, making it difficult for policymakers to design practical, community-based control programs. Therefore, this study seeks to address this gap by empirically estimating households' willingness to pay or participate in the control of the invasive *ipomoea* in Kajiado Central Sub-county, herby providing an evidence base for effective and sustainable management of communal grazing lands.

1.3 Objectives

1.3.1 General objective

The broad objective of this study was to contribute to the enhancement of food security and environmental sustainability among rural pastoral households in Kajiado Central Sub-County by assessing their willingness to engage in and contribute to the collective management of the invasive *Ipomoea* plant species.

1.3.2 Specific objectives

This study addressed the following specific objectives: -

i. Characterise households that are willing or unwilling to pay or participate in the control of invasive *Ipomoea* plant species in Kajiado Central Sub-County, Kajiado County, Kenya.
ii. Estimate the household mean willingness to pay or participate in the control measures of invasive *Ipomoea* plant species in Kajiado Central Sub-County, Kajiado County, Kenya.
iii. Determine factors affecting a household's Willingness to pay or participate in the control measures of invasive *Ipomoea* plant species in Kajiado Central Sub-County, Kajiado County, Kenya.

1.4 Research questions

This study answered the following research questions:

i. What are the characteristics of households that are willing or unwilling to pay or participate in the control of invasive *Ipomoea* plant species in Kajiado Central Sub-County, Kajiado County, Kenya?
ii. What is the mean value of the households' willingness to pay or participate in the control of invasive *Ipomoea* plant species in Kajiado Central Sub-county, Kajiado County, Kenya?
iii. What are the determinants of households' willingness to pay or participate in the control of invasive *Ipomoea* plant species in Kajiado Central Sub-County, Kajiado County, Kenya?

1.5 Justification of the study

The justification for this research is to provide actionable evidence to key policymakers and extension officers within the Kajiado County Government. Secondly, it aims to offer Community leaders and individual households a tailored policy brief that translates the findings into practical strategies for community-level *Ipomoea* management. This study also supports the Kajiado County Integrated Development Plan (CIDP) 2023–2027, which emphasizes sustainable development in agriculture and livestock. At the national level, it contributes to the Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019–2029 by enhancing household food resilience in arid and semi-arid areas and advances Kenya's Climate-Smart Agriculture Strategy (2016–2026) by linking climate action with agricultural practices. By examining households' willingness to pay for or participate in controlling the invasive *Ipomoea* species, the research provides insights that can guide national agribusiness policies. Additionally, the study aligns with global Sustainable Development Goals, particularly SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land).

1.6 Scope and limitation of the study

Among the limitations of this study geographical scope was the major limitation as the study assumed Kajiado central as representative of Kajiado County due to its high invasion of *Ipomoea*. Another limitation was methodological potential loyalty bias, where by households may underreport or over-report their WTP due to distrust, protest response, or strategic misrepresentation. To mitigate this, the DBDC format was employed. The DBDC's two-stage bidding process mitigates strategic bias by encouraging respondents to reevaluate their initial responses, thereby improving the reliability of WTP estimates.

1.7 Operational definition of terms

Adult equivalent ratio: - is a measure used to standardize household members based on their age in order to estimate labour capacity in terms of adult units.

Dependency ratio: - is a demographic indicator that measures the proportion of individuals who are likely to be dependent on others for support (children and the elderly) compared to those who are of working age.

Initial bid: - is the first bid offer to the household for *Ipomoea* plant species control measures.

Invasive plant species: - is a plant that can cause great economic and environmental effect to biological diversity and human health in invaded regions.

***Ipomoea* plant species:** - One type of invasive plant species that is harmful to livestock and human beings

Income: -is a continuous variable which is On-farm Net income (crop +livestock) and off-farm (Net income from non-agricultural activities).

Follow-up bid: - is a bid subsequent offer made after the initial bid.

Livestock units: -is the total number of livestock owned by a household in a tropical livestock unit (TLU).

Labour day: - Refers to a contribution of time equivalent to one adult person working for an eight-hour day on activities related to the removal of the invasive *Ipomoea* species.

Land security: -is the perception and confidence of households that the land will continue to serve its role in supporting livestock keeping, without the risk of conversion to other forms of development.

Tropical livestock unit (TLU): - is standardized measurement to compare and aggregate different livestock types in tropical production systems by converting their numbers to a common unit based on metabolic weight**.**

Willingness to pay: -is an amount of money a respondent is willing to contribute in order to control *Ipomoea* plant species.

Willingness to participate: - It is the amount of labour day a Household will contribute to control *Ipomoea* plant species.

CHAPTER TWO
LITERATURE REVIEW

2.1 The Spread of the invasive *ipomoea* plant species

Ipomoea, an invasive sub-woody shrub native to East Africa countries and can grow up to 4 meters tall and features hairy stems. In Kajiado County, Kenya, it poses a significant threat to local ecosystems due to overgrazing and habitat degradation, with studies indicating that *Ipomoea* has proliferated in Kajiado's grazing lands after heavy rains. *Ipomoea* primarily invades degraded areas, such as overgrazed rangelands and roadsides. After invading Kajiado, the plant species out-competed with native plants and destroyed the ecosystem. Among Maasai pastoralists, common control measures include manually uprooting seedlings (about 81% of households) and burning uprooted seedlings (around 46%) to limit its spread (Ojija & Manyanza, 2021). A review by Weidlich *et al.* (2020) examined control strategies for invasive plants in ecological restoration. The reviewers classified control methods into non-chemical and chemical approaches. Non-chemical methods, making up roughly 57.7% of interventions, included prescribed burning in various ecosystems, mowing in chaparral and tropical forests, hand-pulling for smaller projects, cutting in tropical regions, and occasional harrowing. Chemical methods, accounting for about 42.3%, mainly involved herbicides, with glyphosate being the most commonly used, followed by i*mazapyr* and *triclopyr*. These included spraying and pre- or post-emergent applications to target invasive plants directly or prevent regrowth.

2.2 Valuation methods for non-market goods

Environmental problems like pollution and resource depletion often arise because environmental goods are not traded in markets, making their true value to society difficult to quantify. To address this, economists have developed valuation methods to assign dollar values to these amenities, a field that has expanded from focusing on air and water quality to a broader range of ecosystem services, especially after international initiatives like the Millennium Ecosystem Assessment. Since market prices often fail to reflect the full value of natural resources, economists gauge society's preferences through willingness to pay. The total economic value is categorized into use value (direct, indirect, or future option use) and non-use value. Non-use value reflects what people are willing to pay even if they never personally use the resource, driven by a desire to preserve it for its own sake (existence value) or for future generations (bequest value).

Among the various techniques economist developed for environmental valuation of environmental goods and services Contingent Valuation Method (CVM) was used as the appropriate method for this study after a critical review of alternatives (Arrow *et al.*, 1993; Mitchell & Carson, 1989). The Travel Cost Method (TCM) was not considered appropriate for this study because it assumes that the environmental good in question is a recreational site that involves measurable travel expenses. In contrast, the rangeland improvement assessed here represents a general enhancement to a livelihood resource rather than a specific place people visit. Likewise, the Hedonic Pricing Method (HPM) was excluded since it depends on the assumption that environmental quality differences are reflected in property market prices, which does not apply to communal grazing lands. This assumption fails in the context of Kajiado communal lands, where formal land markets are thin and the primary value of rangelands is expressed through livestock productivity, not real estate. In contrast, CVM is uniquely designed to elicit value for a hypothetical, non-excludable public good through a constructed scenario, making it the only method capable of capturing the total economic value households place on the collective control of the invasive *Ipomoea* (Centeno & Prieto, 2000).

Choice Experiment (CE) Method is a stated-preference method used to estimate the value of non-market goods by analyzing how individuals make trade-offs between multi-attribute alternatives. This allows researchers to decompose the value of a good into the marginal values of its constituent attributes (Mariel *et al.*, 2021). In this method Respondents are presented with list of attributes. In each set, they are typically shown two or more policy alternatives (described by varying levels of key attributes, including a cost attribute) and a status quo option. Their repeated choices reveal their preferences and the trade-offs they are willing to make. The advantages of using CE is it provides detailed information on the relative importance of different attributes of an environmental good. For example, it could determine whether households value a specific control method, the speed of recovery, or the resulting biodiversity more highly. However, in choice experiment the questions can be complex for respondents, especially if there are too many attributes or choice sets, potentially leading to unreliable answers. And implementing a CE is often more resource-intensive than a CVM study, both in design and in the time required for respondents to complete the survey (Sisay & Toru, 2023). Therefore, based on its established precedent for valuing non-market environmental goods and its specific suitability for capturing the total economic value of a public good like restored rangeland, this study employed a CVM framework.

An important feature of CVM is the incorporation of dual payment vehicles: a cash contribution (Willingness-to-Pay) and a labour-day contribution (Willingness-to-Participate). This approach is justified by the socio-economic context of the study area, where rural pastoral households often have limited cash liquidity but possess available labour, which is a primary asset (Endalew & Assefa, 2019). Using only a cash-based willingness to (WTP) estimate could underestimate the real value households attach to controlling *ipomoea*, since it overlooks common non-monetary contributions such as communal labour and resource sharing that are central to local management systems.

2.3 Types of contingent valuation method elicitation format questions

The choice of elicitation format in surveys is critically important, as different methods can yield significantly different WTP estimates. Regardless of the chosen technique, all survey designs must carefully prompt respondents to consider their budget constraints, available substitute goods, and the necessary trade-off between monetary sacrifice and the proposed environmental benefit (Tietenberg & Lewis, 2023). This ensures that stated preferences more closely reflect real-world economic decisions. Several distinct elicitation formats have been developed, each with inherent strengths and weaknesses.

2.3.1 Open-ended question format

This format of question simply asks individuals to state their maximum WTP without any suggested amounts. While straightforward, this approach frequently leads to a high number of zero bids or "protest" responses. Respondents often find it cognitively challenging to pinpoint a specific value for an unfamiliar environmental amenity, which can result in the systematic understatement of their true WTP (Ahmed *et al.,* 2015).

2.3.2 Bidding game format

This type of format presents an iterative series of offers. The interviewer adjusts the bid amount up or down based on the respondent's previous yes or no answers, converging on a final WTP value. Despite providing a more structured interaction, this method suffers from "starting point bias," where the initial suggested amount unduly influences the final result. Furthermore, the repetitive nature of the questioning can fatigue or annoy respondents, potentially leading to hasty answers just to conclude the interview, thereby compromising data quality (Cameron & Quiggin, 1994).

2.3.3 Payment card format

This alternative way of asking individuals about household willingness to pay is where respondents select their WTP from a pre-determined list of values. This simplifies the cognitive task for the respondent compared to open-ended questions. However, a significant drawback is that individuals may feel constrained by the listed options, anchoring their responses to the provided numbers rather than expressing their true, underlying valuation. This can artificially compress the range of WTP estimates.

2.3.4 Dichotomous choice format

This method was developed in response to the limitations of the above three direct elicitation methods and it has become the most widely adopted technique. In its basic form, known as single-bounded dichotomous choice**,** respondents are presented with a single, specific bid amount and must answer a simple yes or no regarding their willingness to pay. This take-it-or-leave-it scenario is highly intuitive for respondents, as it mimics real-market purchases and reduces the ability to strategically influence the survey's outcome (Cameron & Quiggin, 1994). To enhance statistical precision, the double-bounded dichotomous choice format introduces a follow-up question. If a respondent answer yes to the initial bid, they are immediately presented with a higher amount. Conversely, a no response is followed by a lower bid. This two-step process captures a bounded interval for each individual's unobservable WTP, providing significantly more information per respondent than the single-bounded approach (Haab & McConnell, 2002). This leads to greater statistical efficiency, more robust parametric estimates of mean WTP, and a better ability to distinguish between genuine zero valuations and protest bids.

In general, researchers have been employing various techniques mentioned above to elicit an individual's willingness to pay (WTP), each with distinct drawbacks. For instance, The open-ended format, which asks respondents to name their maximum contribution, frequently yields a high number of zero or protest bids, as individuals often struggle to articulate a value or may respond strategically (Ahmed & Gotoh, 2007). Similarly, the bidding game method, which iteratively adjusts an initial offer, is susceptible to starting-point bias and can frustrate participants, leading to unreliable answers (Ahmed *et al*., 2015; Venkatachalam, 2004). The payment card approach, while structured, introduces anchoring effects by presenting a predefined range of values, which can overly influence a respondent's selection away from their true valuation (Tietenberg & Lewis, 2023). In contrast, the dichotomous choice method, which presents a simple yes or no to a specific bid amount, is widely regarded for its practicality and reduced susceptibility to strategic bias. This method is primarily divided into two types: the single-bounded format, which uses one question, and the more efficient double-bounded dichotomous choice (DBDC) format, which uses a follow-up bid to refine the estimate. However, a critical limitation of the standard single-bounded approach is its statistical inefficiency and its inability to effectively resolve the prevalent issue of zero WTP responses. For these compelling reasons, the double-bounded dichotomous choice format is frequently selected for rigorous valuation studies, as it was for this research on *Ipomoea* plant species control measures. Therfore, this study adopted the DBDC format, as supported by researchers like Cameron and Quiggin (1994) and Oduor *et al.* (2023), to enhance the precision of the estimates and better mitigate the biases inherent in the other aforementioned techniques.

2.4 Empirical studies using contingent valuation method

A study by Lindhjem and Navrud (2009) investigated the willingness-to-pay (WTP) decisions of individuals in contingent valuation surveys, demonstrating through a split-sample web survey on forest biodiversity preservation in Norway that while mean WTP is not significantly different between samples when one is asked for household WTP and the other for individual WTP, within the same sample household WTP is significantly higher than individual WTP, particularly when respondents are asked the individual question first, with key explanations including access to a larger household budget and a lack of full income pooling rather than altruism, leading to a risk of overestimating aggregate welfare if individual WTP is inappropriately scaled up by household size. However, the study can be critiqued for its exclusion of zero and do not know responses which may bias the results, the potential for ordering effects and mental accounting to confound the pure measurement of the response unit effect, and the inherent challenge of inferring true household preferences from a single member's response without observing actual intra-household bargaining or consensus, leaving the true household WTP ultimately unverified.

Based on a contingent valuation study of biodiversity in German forests, Liebe *et al*. (2011) compellingly demonstrate that explaining individuals' willingness to pay (WTP) for public environmental goods requires integrating competing theories from economics, sociology, and psychology, as single-theory models are incomplete and potentially misleading. Their key finding was a critical distinction between the decision to pay in principle primarily driven by moral norms and use-value and the subsequent decision on the amount to pay determined mainly by income and environmental concern. While the study argues for theoretical pluralism in WTP research, its generalizability is limited by its focus on a single public good in one national context, and its reliance on stated preferences remains susceptible to hypothetical bias. Kong *et al*. (2014) examined farmers' willingness to pay (WTP) for ecological compensation in the Poyang Lake Wetland of China using the Contingent Valuation Method (CVM) together with Heckman's two-step model. While the Heckman model addressed selection bias effectively, it offers only a partial view of the complex decision-making process behind farmers' WTP. In another study, researchers assessed farmers' WTP for improved soil conservation practices in Ethiopia, expressed through labour contributions. Their study employed both single- and double-bounded dichotomous choice formats under the CVM approach. Using a Probit model, they identified the main factors influencing WTP, while a bivariate Probit model was applied to estimate the average labour contribution (Kasaye & Damte, 2015). The advantage of using double-bounded format by the authors increased the reliability of WTP estimates.

Lamsal *et al*. (2015) utilized CVM and regression analysis to establish local support for wetland conservation, linking willingness to pay (WTP) to the age and income of household heads, though their study overlooked detailing measures against survey bias or questionnaire pre-testing. Similarly, researchers applied CVM and logistic regression in Kenya, identifying factors affecting farmers' willingness to accept (WTA) and their readiness to engage in Payment for Ecosystem Services (PES) programs (Nyongesa *et al.*, 2016). In Ethiopia, Amare *et al.* (2017) employed an open-ended format and a Tobit model, finding a preference for labour over cash contributions, yet failed to specify the intended time commitment. A report by Udimal *et al.* (2017) also observed that larger families were more inclined to offer labour days, using logit and probit models for their analysis. A study by Van Oijstaeijen *et al.* (2020) investigated an economic assessment of smallholder farmers' willingness to contribute to water hyacinth control in Lake Tana, Ethiopia, using a robust contingent valuation method that effectively captures preferences for both cash and labor contributions, with the finding that households are willing to contribute over half a million euros annually demonstrating the significant perceived economic burden of the invasion. However, the study is limited by its exclusive focus on male household heads, which introduces a significant gender bias and potentially overlooks the preferences and disproportionate labor burdens of women, and its reliance on stated rather than revealed preferences may be influenced by strategic overstatement or the longstanding cultural tradition of compulsory community labor, casting some uncertainty on the real-world applicability of the extrapolated aggregate values despite the careful methodological design.

Lutta *et al*. (2020) applied a discrete choice experiment in Kenya's Tana River County to economically value pastoralists' preferences for grazing management, finding that their highest willingness-to-pay was for attributes securing resource availability and mobility, specifically increased water (KSh 2,088/year) and high forage biomass (KSh 1,528/year), while they required compensation to accept practices leading to overgrazing. This study provides crucial empirical evidence that pastoralists economically prioritize management systems that support seasonal mobility and reciprocal access, underscoring the need to align rangeland policies with local values; however, its context-specific findings from a stated-preference approach may limit generalizability and be subject to hypothetical bias.

A study by Clarke *et al*. (2021) investigated the factors influencing family forest owners' willingness to engage in community-led collective action for invasive plant management, the key motivators include perceived self-efficacy, concerns about invasive plants on neighboring properties, past experience in talking with or working alongside neighbors on removal efforts, the perceived need for collective action, and the influence of social norms, whereas most socio-demographic and landownership characteristics (e.g., age, income, management plans) were not significant predictors, and notably, perceived collective efficacy was also non-significant, leading the authors to suggest that promoting individual competence, facilitating neighborly interactions, and amplifying shared concerns are crucial strategies for fostering collective efforts. However, the study can be critiqued for its reliance on self-reported behavioral intentions rather than observed actions and its geographical limitation to Indiana which may limit generalizability.

A study by Nyangau *et al.* (2022) investigated Kenyan and Ugandan cereal, legume, and vegetable farmers' knowledge of major pests, current management practices, and their willingness to pay (WTP) for biopesticides, revealing that while chemical pesticides are the predominant control method despite widespread awareness of their negative health and environmental effects, a significant proportion of farmers especially vegetable growers are WTP a premium for biopesticides, with key determinants including higher education and income, male gender, awareness of pesticide risks, and risk-taking attitudes, whereas older age and larger household size decreased WTP. However, the study can be critiqued for its limited exploration of critical factors such as the relative efficacy and practical application requirements of bio pesticides compared to conventional chemicals, which are crucial for real-world adoption, its primary focus on socio-economic and attitudinal factors without deeply integrating the social dynamics and trust issues highlighted in other literature, and the potential for hypothetical bias inherent in the contingent valuation method, which may not accurately reflect actual purchasing behavior in a market setting.

Oduor *et al.* (2023) chose the Tobit model to handle zero WTP responses, identifying significant demographic factors, despite the noted risk by Haab and McConnell, (2002) that such censoring can inflate mean estimates through a "fat tails" problem. A report by Bamlaku *et al*. (2019) combined a double-bounded dichotomous choice with open-ended questions, using SUBP and Probit models to determine influencing factors and noting that the double-bounded method yielded a higher mean WTP, albeit with potential for strategic biases in the open-ended format. A report by Bamwesigye *et al*. (2020) and Getachew (2018) confirmed the influence of socioeconomic variables on WTP in Uganda and for soil conservation, with the latter advocating the double-bounded format and bivariate probit model for greater reliability in analyzing contribution decisions. According to Assefa *et al*. (2022) WTP was linked to income and awareness, but their study was limited by an underdeveloped results section. In addition, researchers reported that male-headed and younger households show a higher propensity to pay, attributing this to gendered domestic roles and the greater physical capacity and longer-term interests of the youth (Mamboleo & Adem, 2023).

A study by Malila *et al.* (2023) investigated the factors that influence smallholder farmers' willingness to adopt Sustainable Land Management (SLM) practices specifically designed to control invasive plant species (IPS) in northern Tanzania and provided valuable insights by identifying key factors farming experience, income, conservation awareness, and invasive species cover that influence the adoption of co-developed sustainable land management practices in northern Tanzania, with the counter-intuitive finding that higher infestation levels deter adoption being particularly noteworthy. However, the study is limited by its reliance on stated "willingness to adopt" rather than measuring actual adoption behavior, and its focus on manual removal methods may not fully represent the economic or practical feasibility for all farmers, especially those with large, heavily infested fields, potentially limiting the generalizability of its conclusions despite its robust participatory approach and clear methodological framework.

A study by Thuy *et al.* (2024) evaluated households' willingness-to-pay (WTP) for mangrove environmental services in northern Vietnam. The researchers used a contingent valuation method with a payment card technique and an interval regression model for their analysis. Their findings indicated an average annual WTP of 327,792 VND per household for five key services. The study identified attitudes, perceived behavioral control, and knowledge of mangroves as the most significant positive factors influencing WTP. However, while these factors were prominent, the study may not have fully explored other potentially critical variables, such as the level of household dependency on mangrove resources for livelihoods. This study by De Silva *et al.* (2024) provided empirical evidence on the determinants of environmental impact and green consumption, demonstrating that in the Netherlands, a higher individual ecological footprint is significantly associated with higher personal income, male gender, employment, rural residence, and lower educational attainment, while personality traits show no significant effect. Furthermore, their analysis of willingness-to-pay reveals that demand for greener alternatives in meat, electricity, and air travel is price-sensitive, whereas demand for car fuel is not, highlighting the challenges in decarbonizing transportation. However, the study's reliance on 2010-2011 survey data limits the timeliness of its findings in a rapidly evolving policy and consumer landscape, and its focus on a single developed nation may constrain the generalizability of the results to other socioeconomic contexts.

The majority of the willing-to-pay studies that were analysed used cash contributions as a form of payment and the studies revealed that the varying household income had a significant and beneficial impact on WTP because of the payment vehicles selected (cash contribution). Additionally, it was discovered in almost all of the reviewed research that the major livelihood activities had a large and beneficial impact on WTP. Despite this, bid amount, Education level, and Income were included as explanatory variables in most previous studies. Additionally, Independent variables included in most literatures were age, sex, past awareness, contact with extension services, and household size. Based on the reviewed studies, it was reported that family size, as negative and significant variable in relationship with WTP. In contrast to findings that larger families reduce willingness to pay, several studies indicate a positive correlation between household size and labor contribution, as a greater number of family members increases the available labor pool. This research utilized DBDC format to estimate households' willingness to pay (WTP) for controlling the invasive *Ipomoea* plant species. The study measured WTP using both cash and labor as payment vehicles. The double-bounded method is selected based on its demonstrated superiority in improving the precision of WTP estimates compared to other valuation techniques (Hanemann *et al.*, 1991). For data analysis, seemingly unrelated bivariate probit or bivariate probit models will be employed, as these are effective for simultaneously modeling both the decision to contribute and the level of labor contribution (Andualem, 2025).

2.5 Theoretical framework

2.5.1 Random utility theory

This study is linked with Consumer demand theory from neoclassical economics, which posits that households, as rational actors, seek to maximize utility under budget constraints (Hanemann *et al.*, 1991). While this framework effectively explains demand for market goods with observable prices, it requires extension to value non-market environmental goods like *Ipomoea* control. Random utility theory (RUT) addresses this gap by modeling choices under uncertainty, where households derive utility from both tangible and intangible attributes (Hanemann, 1984). In the context of invasive species management, RUT provides the foundation to measure WTP as a monetary proxy for welfare changes. The utility of a representative household is represented by the following function:

$U_i = U_i\,(l, p, q\,*)_i$…………………………………………………………………… (1)

Where U_i= Utility of the Household, l=is the Labour, p=is the characteristics of the household, $q\,*$=is the grazing land quality as perceived by the households. If the household decides to pay t (t ≥ 0) for (e), the indirect utility function can be represented u (p, q * +e, l – t) (Yu and Abler, 2010). Under the market equilibrium, eradicating the communal grazing land from *Ipomoea* weed, the indirect utility function becomes;

U (p, q*, l) = u (p, q * +e,l – t)……………………………………………………….(2)

Assume eradicating the communal grazing land from *Ipomoea* plant species and labour changes are insufficient, and we can take the first approximation of u (p, q * +e,l – t)

$U\ (p,q+e,1\text{-}t) \approx u\ (p,q,l) + (\frac{\delta u(p,q,l)}{\delta q})\ e - \frac{\delta u(p,q,l)}{\delta l})\ t$……………………………………………..(3)

Together the equation 1and 2 ,WTP = $t = \frac{\delta u(p,q,l)\delta q}{\delta u(p,q,l)\delta l})\ e$…………………………………………..(4)

This theory suggests that some households may have a zero willingness to pay (WTP) for *Ipomoea* eradication because of two reasons: first, if a person places no value on improving the quality of the communal grazing land (their marginal utility (δu (p, q, l) /δq) from eradication is zero), and second, if their available labor is so scarce and valuable that the opportunity cost of contributing it becomes prohibitively high (their marginal utility of labor (δu (p, q, l)/ δl) is extremely high).

In essence, people will not pay if they do not value the improvement or if their labor is too constrained to spare.

In the context of the Invasive *Ipomoea* plant species control, the theory intends to illustrate how households evaluate the advantages of participating in control measures relative to the associated costs. When households perceive greater benefits from weed control such as improved pasture availability or reduced livestock losses, they become more willing to contribute labour or monetary resources. This willingness helps community members to contribute their labour and effort toward the control measures of *Ipomoea* species. In long term, their participation helps shift their perception and encourage them to appreciate environmental conservation and take responsibility for it. In this way, the Random Utility Theory (RUT) explains how individual preferences can translate into collective action through greater willingness to contribute.

2.5.2 Theory of common pool resources

The theory of common pool resources helps explain how communities can manage shared resources more effectively. Sustainable management of common resources requires collective action and well-defined institutional arrangements to avoid overuse and degradation (Ostrom, 1990). For instance, the interaction between people determines their participation in the invasive *Ipomoea* plant species control measures otherwise problems such as the free-rider where some households benefit from others' efforts without contributing could exist in the society. Which will create barriers to collective action and reduce the effectiveness of communal efforts (Brunnhuber, 2022). The theory supports the valuation of common goods that are shared among multiple users. The common pool resource (CPR) theory, helps to strength collaboration among community members by promoting shared rules, local institutions, and equitable participation. Together these theories demonstrate how the individual decision making and collective action contribute to social transformation.

2.6 Conceptual framework

The figure below presents the conceptual framework of the study. In this model, the dependent variable was the willingness to pay (WTP) decisions. The explanatory variables were Socio-Demographic Factors, Economic Factors, and Institutional Factors. These factors collectively influence a rural household's decision to participate in control measures, either through financial contributions or labor. The framework operates on the core assumption that farmers are rational actors who will choose the option they believe will maximize their overall utility or income. In this particular case, rural households will pay or participate in control and eradication measures if they expect that the weed will disappear and the pastoral land will be free from any dangerous weed and they will continue raring the livestock so that their income will increase which will contribute to environmental sustainability and enhancing food security.

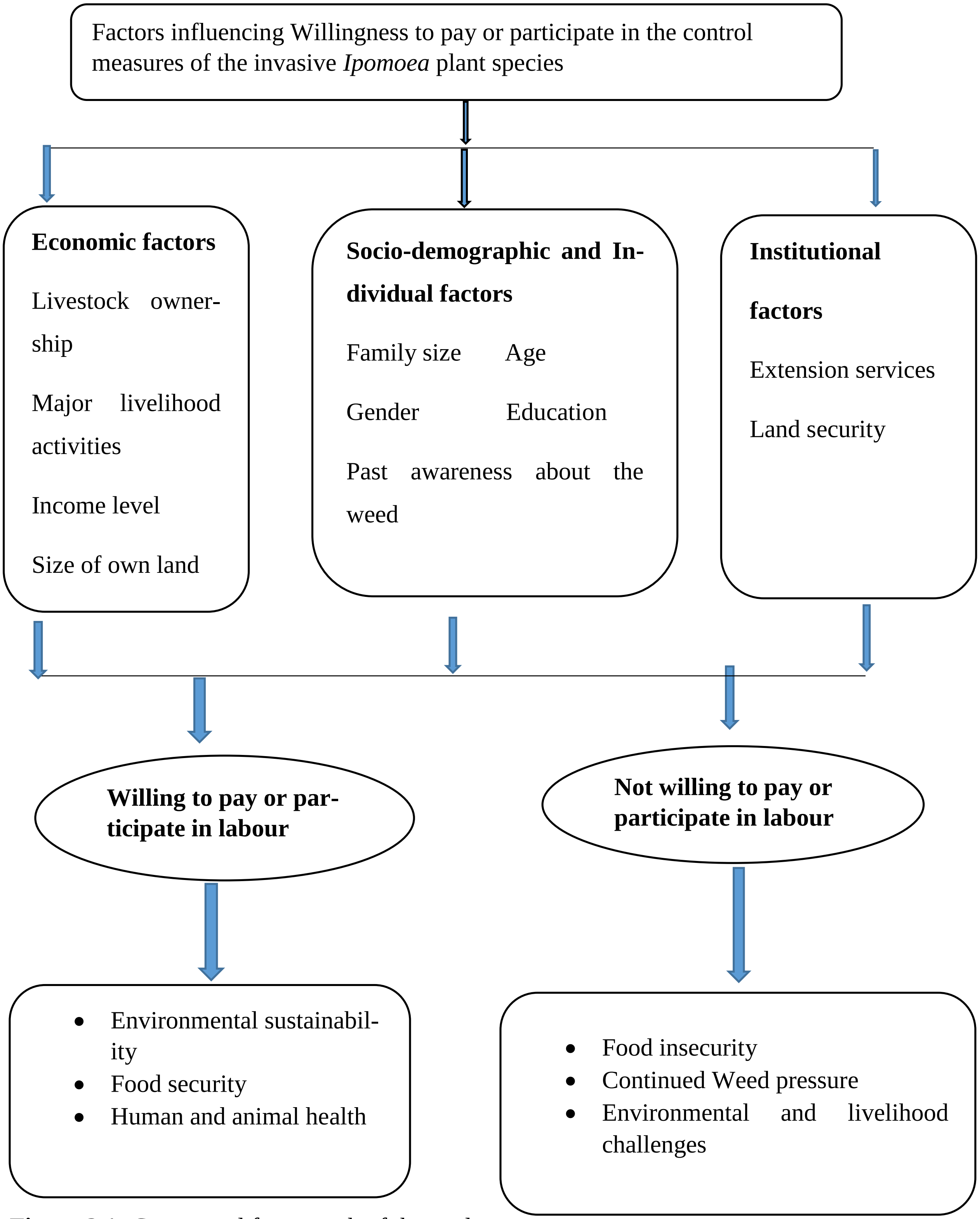

Figure 2.1: Conceptual framework of the study

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Description of the study area

This study took place in Kajiado, a region in Southern Kenya covering approximately 21,871.1 square kilometers (CIDP of Kajiado, 2023). The county is geographically defined by coordinates between Longitudes 36°5' and 37°5' East and Latitudes 1°0' and 3°0' South. It shares borders with several Kenyan counties, including to the North (Nairobi and Kiambu) and to the Nouth (Republic of Tanzania). Kajiado County is divided into five sub-counties, which also serve as political constituencies: Kajiado South, Kajiado North, Kajiado West, and Kajiado East. These sub-counties are further divided into 25 wards. This study focused on Kajiado Central Sub-County, which, according to the 2019 census, covers an area of 4,239 square kilometers and has 37,059 households, resulting in a population density of about 38 people per square kilometer. The local economy largely depends on livestock, with cattle, sheep, and goats being the main types of animals kept and they provide an significant source for household income, nutrition, and employment for the community (County Government of Kajiado, 2019).

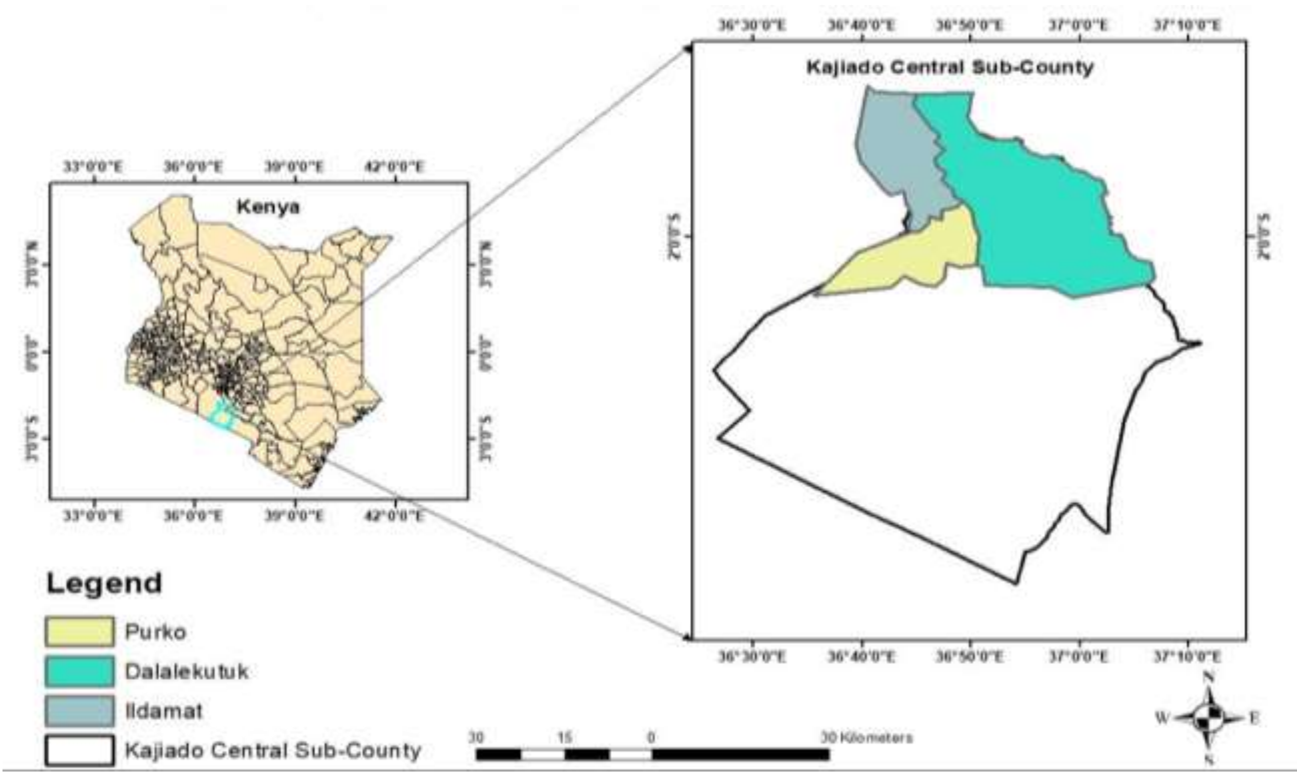

Figure 3.1: Map of the study area

3.2 Sampling procedure

In this study a multi-stage sampling technique was employed to sample livestock-keeping households. At the initial stage Kajiado County was identified as the region in Kenya most severely affected by the invasive *Ipomoea* plant species. Subsequently, Kajiado Central Sub-County was also chosen purposively for being the most heavily invaded area within the county. In the third stage, three specific wards (Purko, Dalalekutuk, and Illdamat) were selected. The justification for selecting these three wards for actual data collection was guided by both field observation and recommendations from County extension officer, who confirmed that these wards are the most severely invaded by invasive *ipomoea* plant species in Kajiado Central Sub-County. From direct observation, it was estimated that over 80% of the communal grazing land in these areas are invaded by *ipomoea* species. Therefore, these wards were considered the most suitable for capturing the willingness of households to participate in *ipomoea* control measures. In contrast, the two wards namely; Matapato North and South wards used for pre-test were relatively less invaded by the invasive *ipomoea* plant species.

3.3 Unit of analysis and sample size determination

This study focused on the heads of households and the reason was because they are typically responsible for making decisions regarding resource allocation, livestock management, and participation in communal or environmental activities. The required sample size was calculated using Cochran's (1963), a formula suited for determining sample size when the key variable is a proportion (in this case, the proportion of households willing to pay). The calculation assumed the population had maximum variability (p = 0.5) and was based on a 95% confidence level. A 6% margin of error was chosen to balance the need for reliable results with the practical limitations of time and resources for the study. Although a smaller margin of error (such as 5%) provides higher precision, it also requires a larger sample size, which would have been costly and time–consuming given the wide geographical coverage of the study area. The 6% margin of error was therefore considered adequate to obtain reliable and representative estimates of household characteristics and responses while remaining feasible within the available time and financial resources.

$$n = \frac{Z^2 \mathrm{pq}}{e^2} \quad (5)$$

Where: - n- Households sampled

Z^2- is the desired confidence interval, at 95%

e- is the margin of error (6% or 0.06)

p- is the estimated share of rural households willing to pay or participate in controlling the *ipomoea* plant species, and

q- is 1-p being the compliment, representing the share of households not willing to pay or participate. Following, the calculation the sample size for this study was $n = \frac{(1.96)^2 0.5(1-0.5)}{(0.06)^2}$

n=266.777≈ 267, Lastly, a total of 267 household heads were selected (Table 3.1).

Table 3.1: Number of sample households distribution

Ward	Study area	Total households	Sample households	Percentage(%)
Purko	Bissil	10,302	198	74.2%
Dalalekutuk	Enkorika	2748	53	19.8%
Illdamat	Illdamat	831	16	6.0%
Total		13,881	267	100

Source: (KNBS VOL 4, 2019)

3.4 Questionnaire design and administering the CV survey

Before conducting the actual data, Research assistants underwent a comprehensive training program to ensure they could effectively administer the survey and address respondent questions. A semi-structured questionnaire was used to collect data on household characteristics. Before the main survey, a pre-test with 22 households helped improve the questionnaire and set the initial bid values for the DBDC method (Siew *et al.*, 2015). Based on the pre-test results, four starting bids were set. If a respondent answered "yes" to the first bid, the follow-up bid was doubled; a "no" led to a halved follow-up bid. These starting bids were randomly assigned, and the final survey included 267 livestock-keeping households (Table 3.1).

3.5 Types, sources, and methods of data collection

The primary data for this study were gathered directly from sampled households using semi-structured questionnaires (Appendix 1). Additionally, secondary data were sourced from a variety of outlets, including sub-county agricultural offices, population census records, and relevant scholarly publications.

3.6 Data cleaning and analysis

SPSS 27 and STATA 17 were used for data cleaning and data analysis respectively. Descriptive statistics (mean, median, standard deviation) and econometric analysis to calculate the mean willingness to pay (WTP), and to identify the factors determining WTP for controlling the *Ipomoea* plant species.

3.7 Quality control methods

3.7.1 Validity of instruments

The study examined the instruments to ensure validity (Teddlie & Tashakkori, 2010). The instruments were checked by Supervisors and Research assistants to confirm clarity and understanding of the questions. A pre-test was test conducted using 22 respondents outside the sample population. Content Validity Index (CVI) was used to verify the validity of the questions. The CVI was calculated using the formula:

$$X = \frac{\text{Number of items considered valid}}{\text{Number of items on the draft questionnaire and the interview checklist}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

A CVI of 0.7 or higher was considered valid. Questions not meeting this criterion were revised or removed.

3.7.2 Reliability of instruments

Reliability indicates the consistency of a questionnaire in measuring a specific construct. To ensure the quality of the instruments used in this study, several steps were taken during fieldwork, data analysis. The instruments were pre-tested on a sample of 22 respondents from different wards within the Kajiado central sub-county (who were excluded from the final interview pool) to assess their reliability (Cronbach, 1951). The formula specified as: -

$$\text{Cronbach's Alpha} = \frac{(\text{n}/\ \text{n}-1)\ (\text{SD2} - \sum\text{Variance})}{\text{SD}^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

where n represents the number of items, SD the standard deviation of test scores, and ∑Variance the sum of variances for each item. A value of 0.7 or greater was considered indicative of greater reliability.

3.8 Analytical framework

3.8.1 Objective one: -To characterise households that are willing or unwilling to pay or participate in the control of *ipomoea* plant species in Kajiado Central Sub-County, Kajiado County, Kenya

For the first objective, the study used descriptive statistics including means, standard deviations, percentages, and frequencies to summarize and compare the profiles of households willing and unwilling to pay for *Ipomoea* control. Additionally, inferential statistics were applied.

3.8.2 Objective two: -To estimate the household mean willingness to pay or participate in the control of *ipomoea* plant species in Kajiado Central Sub-County, Kajiado County, Kenya

In environmental economics, Choice Experiments (CE) and the Contingent Valuation Method (CVM) are common approaches for estimating willingness to pay (WTP). Both rely on random utility theory, assuming that responses in hypothetical markets reflect true valuations of non-market environmental goods (Hanley *et al.*, 1998). Choice Experiment can reveal trade-offs between attributes and reduce bias but is often complex to design and administer. Contingent Valuation method on the other hand, is widely used and can capture both use and non-use values, with the practical advantage of simpler data collection. For this study, CVM was chosen, using a double-bounded dichotomous choice format. This hybrid design mitigates the complexities often associated with questionnaire design while capitalizing on the strengths of CVM. It allows the research to focus on the valuation of a specific environmental change; the control of *Ipomoea,* where an open-ended question is a suitable component for eliciting WTP, as supported by various scholars (Aadland & Caplan, 2006; Diamond & Hausman, 1994; Gillespie & Bennett, 2013). There are two formats under the Dichotomous Choice Technique namely, the single-bounded format and the double-bounded dichotomous choice (DBDC) format. The single-bounded formats give less information than the double-bounded dichotomous choice (DBDC) method. Therefore, this study used DBDC as it helps to elicit more information about respondents' WTP than the single bounded format (Haab & McConnell, 2002; Mitchell & Carson, 1989).

The use of the CVM according to Alejandro (2012) and Haab and McConnell (2002) specifies the first Bid or labour contribution t^1 and the second Bid or labour contribution t^2, where, the first (t^1) was a fixed predetermined Bid or labour day contribution chosen based on a pilot study and the second (t^2) was dynamic and depends on the households answer to the initial amount.

1. If the household respond yes to the first t^1 and no to the second t^2, then $t^2 > t^1$. In this case $t^1 \leq WTP < t^2$, the household's Willingness to pay or participate lies between the first t^1 and the higher second t^2

2. If the household respond yes to the first t^1 and yes to the second t^2, then $t^2 \leq WTP < \infty$. The household's willingness to pay or participate is greater than or equal to the higher Bid or labour contribution.

3. If the household respond no to the first t^1 amount and yes to the second t^2 amount, then $t^2 < t^1$. In this case $t^2 \leq WTP < t^1$. The household's willingness to pay or participate lies between the first t^1 and the lower second t^2.

4. If the household respond no to the first t^1 amount and no to the second t^2 amount, then $WTP < t^2$.the household's willingness to pay or participate is less than or equal to the lower Bid or labour contribution. The most general econometric model for the double–bounded dichotomous data comes from the formulation below (Haab & McConnell, 2002).

$$WTP_i = X_i\beta + e_i \quad \ldots\ldots (8)$$

Where WTP_i is the Household's willingness to pay or participate

i represents the Household's responses to the bid amount or labour contribution

i=1: represents the first household's response to the Bid amount or labour contribution and their characteristics

i=2: represents the second household's response to the Bid amount or labour contribution and their characteristics this continues until i=N, where N =267

X_i is a vector of independent variables (income, age, gender, major livelihood activities, past awareness, dependency ratio, livestock holding, family size, extension contact, size of own land)

$\mathbf{e_i}$ is the error term**,** the probability of observing each of the possible two responses (yes, yes), (yes, no), (no, yes), (no, no) can be represented by

$$\text{Pro (yes, No)} = \text{pro}(WTP_1 \geq t_1, WTP_2 < t_2) = \text{pro}(u_1+e_1>t_1, u_2+e_2<t_2) \quad \ldots\ldots (9)$$

$$\text{Pro (Yes, Yes)} = \text{pro}(WTP_1 \geq t_1, WTP_2 \geq t_2) = \text{pro}(u_1+e_1 \geq t_1, u_2+e_2 \geq t_2) \quad \ldots\ldots (10)$$

$$\text{Pro (No, Yes)} = \text{pro}(WTP_1 < t_1, WTP_2 \geq t_2) = \text{pro}(u_1+e_1<t_1, u_2+e_2 \geq t_2) \quad \ldots\ldots (11)$$

$$\text{Pro (No, No)} = \text{pro}(WTP_1 < t_1, WTP_2 < t_2) = \text{pro}(u_1+e_1<t_1, u_2+e_2<t_2) \quad \ldots\ldots (12)$$

Each household's contribution to the likelihood function becomes

$$L_i(u/t) = \text{pro}(u_1+e_1>t_1, u_2+e_2<t_2)^{yn} * \text{pro}(u_1+e_1 \geq t_1, u_2+e_2 \geq t_2)^{yy} * \text{pro}(u_1+e_1<t_1, u_2+e_2 \geq t_2)^{ny} * \text{pro}(u_1+e_1<t_1, u_2+e_2<t_2)^{nn} \quad \ldots\ldots (13)$$

Assuming the error terms are normally distributed with a mean of zero and variance of δ_1 and δ_2, the WTP_1 and WTP_2 have a bivariate normal distribution with mean μ_1 and μ_2 and δ_1 and δ_2 and with correlation coefficient ρ which is the covariance between errors of the two Bid or labour contributions. The probability that $WTP_1 < t_1$ and $WTP_2 < t_2$ i.e. the probability of no-no responses is $\text{pro}(u_1+e_1<t_1, u_2+e_2<t_2) = \Phi_{e_1e_2}\left(\frac{t_1-u_1}{\delta_1}, \frac{t_2-u_2}{\delta_2}, \rho\right)$……………………………...(14)

The probability of No- Yes is pro ($u_1+e_1<t_1$, $u_2+ e_2\geq t_2$) = $\Phi_{e_1e_2}(\frac{t_1-u_1}{\delta_1}, \frac{t_2-u_2}{\delta_2}, \rho)$……………….(15)

The probability of Yes –No is pro ($u_1+e_1>t_1$, $u_2+e_2<t_2$)= $\Phi_{e_1e_2}(\frac{t_1-u_1}{\delta_1}, \frac{t_2-u_2}{\delta_2}, \rho)$………………..(16)

The probability of yes- yes is pro ($u_1+e_1\geq t_1$, $u_2+ e_2\geq t_2$) = $\Phi_{e_1e_2}(\frac{t_1-u_1}{\delta_1}, \frac{t_2-u_2}{\delta_2}, \rho)$……………......(17)

$\Phi_{e_1e_2}$ is the standard bivariate normal cumulative distribution function with zero mean and unit variance and correlation coefficient ρ.

Defining y_{1i}=1 if the response to the first question is yes and 0 otherwise and y_{2i}=1 if the response to the second question is yes and 0 otherwise

$d_{1i}=2y_{1i}$ -1 and $d_{2i}=2y_{2i}$-1, i^{th} contribution to the bivariate probit likelihood function becomes

$L_i(u/t)= \Phi_{e_1e_2}[\, d_{1i}\frac{t_1-u_1}{\delta_1}, d_{2i}\frac{t^2-u^2}{\delta_2}, d_{2i}d_{2i}\rho]$……………………………………..……………..(18)

The double-bounded bivariate contingent valuation model, introduced by (Hanemann, 1984), is designed to enhance the statistical efficiency of the single-bounded approach. It achieves this by posing a follow-up question with a different bid amount—a higher one if the respondent agreed to the first bid, or a lower one if they disagreed. To calculate the mean willingness to pay (WTP), whether expressed in monetary terms or labor contribution, SUBP model was employed. Following Greene (2012), a seemingly unrelated bivariate probit model can be specified as follows:

$y^1 *= \alpha^1 + \beta^1 t^1 + e^1$……………………………………………………….................. (19)

$y_2 *= \alpha_2 + \beta_2 t_2 + e_2$…………………………………………………........................... (20)

E ($e_1|t_1, t_2$) =E ($e_2|t_1, t_2$) =0…………………………………………………………….. (21)

Var ($e_1|t_1, t_2$) =Var ($e_2|t_1, t_2$) =1……………….………………………………… ……….. (22)

Cov ($e_1, e_2|t_1, t_2$) =ρ……………………………..…...……….………………………… (23)

Where: -

$y^1 is$ ith respondents unobservable true WTP at the time of the first bid or labour contribution

WTP_1=1 if $y^1 *> Bid_{\,1}$, 0 otherwise and WTP_2= 1 $if\ y^2 *> Bid_2$,0 otherwise

$y_2 *$ is the i^{th} respondent's implicit underlying point estimate at the time the second Bid/labour contribution is offered

t_1 and t_2 are the 1st and 2nd Bid/labour day, respectively

b_1 and b_2 are coefficients of the 1st and 2nd Bid/labour day offered

e_1 and e_2 are error terms of the 1st and 2nd questions

Therfore, the mean willingness to pay or labour contribution can be calculated as follows: -using a formula specified by Haab and McConnell (2002).

$$\text{MWTP} = \frac{-\alpha}{\beta} \ldots\ldots \quad (24)$$

Where:- α:- is a coefficient for the constant term, and

β: - is a coefficient of the Bid or labour day

3.8.3 Objective Three: -To determine factors that affect a household's willingness to pay or participate in the control of *ipomoea* plant species in Kajiado Central Sub-County, Kajiado County, Kenya

Tobit model, Heckman's two-step model, and the logit model may be used to analyze the factors influencing households' willingness to participate. However, each model has their draw-backs. The Tobit model is suitable for open-ended WTP data with censoring at (Endalew & Assefa, 2019; Mganga *et al.,* 2021) but may produce biased estimates for fat-tailed distributions (Haab & McConnell, 2002). Heckman's model can correct for selection bias but may oversimplify the decision-making process. For binary outcomes, linear probability models are inappropriate as they can predict values outside the 0–1 range, whereas logit and probit models constrain probabilities and account for non-linear relationships (Gujarati, 2002). However, the DBDC format used in this study generates two interrelated binary responses, resulting in two latent variables. Standard probit or logit models, which handle only one binary dependent variable, are therefore inadequate. Consequently, SUBP model was selected. This model is specifically designed to jointly estimate two binary dependent variables, making it the most appropriate method for calculating mean WTP and identifying determining factors while overcoming the limitations of the Tobit and Heckman models (Cameron & Quiggin, 1994). The model is specified as follows:

$$Y_1 * = \beta^1 x_i + \varepsilon_i \ldots\ldots (25)$$

$$Y_2 * = \beta_2 x_i + \varepsilon_i \ldots\ldots (26)$$

$$Y = 1 \text{ if } Yi^* > I_i^* \ldots\ldots (27)$$

$$Y = 0 \text{ if } Y^*i < I_i^* \ldots\ldots (28)$$

Where ß' = vector of unknown parameters of the model, Xi = vector of explanatory variables, Y_i* = unobservable households' actual WTP for control of *Ipomoea* plant species, Yi = discrete response of the respondents for the WTP, I_i* = the offered initial Bid/labour contribution assigned arbitrarily to the i^{th} respondents, εi = unobservable random component distributed N (0, σ).

Table 3.2: Description of variables used and expected outcomes

Variables	Type of Variable and Measurement	Expected outcomes
Dependent variables		
WTP_1 and WTP_2	Is a dummy variable measured in Kenyan shillings, it takes 1 if yes,0 otherwise	
$Labour_1$ and $Labour_2$	Is a dummy variable measured in Number of days, it takes 1 if a household willing to participate , 0 otherwise	
Independent variables		
Major livelihood activities	Is a categorical variable which takes 1 Livestock keeper,2 Business,3 Salary earner and 4 casual labourer	+/-
Sex of the HH head	A dummy 1 if male, 0 if female	+/-
Dependency ratio	Is proportion of individuals who are likely to be dependent on others for support (children and the elderly) measured in Ratio	-
Size of own land	Is a continuous variable, the size of grazing land in Acres	-
Past Awareness	Is a dummy variable, 1 aware about *Ipomoea*, or 0 otherwise	+
Land security	It is a categorical variable from Very secure to Very insecure	+
Income level	Is the monthly income of the Household measured in Kenyan shillings	-/+
Education	It is continuous variable measured in years	+
Livestock units	Is continuous variable measured in Total Livestock unit (TLU)	+
Family size	The people living in a household, expressed in adult equivalents.	-/+

Age	A continuous variable measured in years.	-/+
Access to extension service	A dummy variable, which takes the value 1 if accessed, and 0 if no access	+

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Descriptive statistics

4.1.1 Household characteristics

From the total sample of 267 respondents, 81.15% provided valid responses that were retained for analysis, while 2.62% were excluded due to protest responses of unwillingness to contribute to *Ipomoea* plant species control measures. As per the standard guidelines for the Contingent Valuation Method (CVM) established by the National Oceanic and Atmospheric Administration (NOAA) panel, protest responses should be excluded to prevent bias in WTP estimation (Arrow *et al.*, 1993). Many scholars also apply this approach in their willingness to pay studies for different environmental goods (Getachew, 2018; Mulatya *et al.*, 2021). The study employed both cash and labor contributions as payment methods, surveying a total of 260 Households. Among the households, 18.85% expressed unwillingness to contribute cash, citing valid reasons, while 18.08% declined the offered labor days for genuine reasons. Most households were in Purko ward (74.62%), followed by Dalalekutuk (20.00%) and Ildamat (5.38%). Regarding household headship, 52.69% were male-headed, 8.94% female-headed, and 38.37% were women in male-headed households where the male was temporarily absent. These women were knowledgeable about household matters and participated in decision-making, so they were treated as co-heads and their responses represented their households (Table 4.2). The average age of household heads was 43.54 years, ranging from 20 to 80 years (Table 4.1). The majority of household heads were married 88.85%, followed by widowed 6.54%, single 4.23%, and divorced 0.38%. In terms of household resources, the average units of tropical livestock units (TLU) was 8.92 per household, ranging from: 0 to 90.1 TLU. The average land size was 33.96 acres range from 0 to 350 acres (Table 4.1). The primary source of livestock feed was grazing land (zero grazing), supplemented by crop residues and hay/silage. As one household head pointed out "we keep *our animals in one place and feed them there. The grazing areas are full of ipomoea plant species and it is dangerous for our livestock. Also there are many thieves, so we prefer to cut grass and bring it to the animals in the shade*" (Appendix 1). The average education level of the household heads was 4.86 years. The minimum was 0 (No formal education) to a maximum of 16 years in school. The average adult equivalent (AER) was 5.43. The average dependency ratio (DR) was 1.28, ranging from 0 to 6. The monthly income distribution of the Households was 39.23**%** earned 0–12,000 KES, 30.38%

earned 12,001–24,000 KES, 19.23% earned 24,001–36,000 KES, 7.69% earned 36,001–48,000 KES, and 3.46% earned 48,001–60,000 KES (Table 4.2). The major livelihood activity for the majority of respondents 57.69%, was livestock rearing. A further 3.08% were engaged in business activities, primarily livestock-related. The remaining respondents were casual laborers 8.08% and salary earners 1.15% (Table 4.2). These households reported diversifying their income sources due to the small number of livestock owned.

Table 4.1: Descriptive results of continues variables

Variable	Definition of Variable	Mean	SD	Min	Max
Hage	Age of the HH head	43.54	13.19	20	80
AER	Household size (in Adult equivalent)	5.43	2.31	1	19.3
TLU	Livestock units (Tropical livestock units)	8.92	10.87	0	90.1
eduyears	Education level of the Household head(Years)	4.86	5.34	0	16
DR	Dependency ratio	1.27	0.86	0	6
Land_size	Size of Own land(acres)	33.96	51.82	0	350
past_awarness	Past awareness about the weed(Years)	19.90	10.17	2	50

Table 4.2: Descriptive statistics for categorical variable

Variable	Definition of Variable	Categories	Frequency	Percentage(%)
Hgen	Gender of the household head	Male	137	52.69
		Female	123	47.31
Ext_access	Access to Extension service	Yes	33	12.69
		No	227	87.31
Cred_access	Credit service access of the Household head	Yes	29	11.15
		No	231	88.85
Land_secure	Land security of the Household head	Very Secure	48	18.46
		Somewhat Secure	34	13.08
		Neutral	21	8.08
		Somewhat Insecure	58	22.31
		Very Insecure	99	38.08
Major_livelihod	Major livelihood activity of the Household head	Livestock rearing	150	57.69
		Livestock Business	86	33.08
		Casual labourer	21	8.08
		Salary earner	3	1.15
RIncome	Household Income level In Kenyan shilling	0-12,000	102	39.23
		12,001-24,000	79	30.38
		24,001-36,000	50	19.23
		36,001-48,000	20	7.69
		48,001-60,000	9	3.46

4.1.2 Household implementation of *ipomoea* plant species control methods and the challenges faced

Out of the 260 households interviewed, 93.85% reported that they were aware of the health effects of *ipomoea* plant species on livestock, while 6.15% reported no awareness (Table 4.3).

Table 4.3: Awareness of households about the health effects of *ipomoea* plant species

Awareness of health issues on livestock	Frequency	Percentage
No	16	6.15
Yes	244	93.85
Total	260	100.00

Households who were aware of the health impacts were further asked to indicate the specific effects they had observed on their livestock. The most severe consequence reported by the majority (80.33%) was animal death due to consumption of the *Ipomoea* plant species. One household shared their concern, stating, "*This weed...it is more dangerous than drought. Drought comes and goes; we wait, and eventually the rain returns. But this weed takes over all the grazing lands, and it kills our animals"* (Appendix 1). Additionally, 32.79% of households mentioned reproductive issues, while 34.43% reported a noticeable reduction in milk production. Weight loss was identified by 38.93% of respondents, and bloating was noted by 15.57% of households. Less frequently mentioned effects included diarrhea (3.69% of households), vomiting (3.28%), and excessive salivation (15.98%) (Table 4.4).

Table 4.4: Health related effects of *ipomoea* plant species on livestock

Health effect	Yes	(%)	No	(%)	Total
Death	196	80.33	48	19.67	244
Weight loss	95	38.93	149	61.07	244
Milk reduction	84	34.43	160	65.57	244
Reproductive issues	80	32.79	164	67.21	244
Bloating	38	15.57	206	84.43	244
Vomiting	8	3.28	236	96.72	244
Diarrhea	9	3.69	235	96.31	244
Salivation	39	15.98	205	84.02	244

All Households surveyed reported that they had previously taken action to manage *Ipomoea* plant species. Manual uprooting was the most common practiced method, implemented by 96.15% of households. Cutting was reported by 30.00% of households, while burning was reported by 11.92% of households. Fencing was the least common method, with only 0.77% of households reporting its use. Notably, no households reported using biological control methods or herbicides (Table 4.5).

Table 4.5: Control methods implemented by household

Control method	Yes	(%)	No	(%)	Total
Cutting	78	30.00	182	70.00	260
Fencing	2	0.77	258	99.23	260
Manual uprooting	250	96.15	10	3.85	260
Herbicides	0	0	260	100.00	260
Biological Methods	0	0	260	100.00	260
Burning	31	11.92	229	88.08	260

Those Households who reported that they have implemented a control method to remove *Ipomoea* plant species were further asked for the challenges they have faced in implementing those methods as outlined in Table 4.6. Despite the widespread implementation of manual uprooting and cutting as control methods for *Ipomoea*, many Households reported that these strategies were not fully effective due to various challenges. A large number of households 80.38% stated that the process was time-consuming, especially given the plant's persistent regrowth after uprooting. One Livestock keeper explained "*You uproot it today, and in a short time, it grows back. So you keep doing the same work again and again it takes too much time*" (Appendix 1). Additionally, 82.69% respondents cited regrowth as a major challenge, while 48.46% households reported to the high cost of labor and tools required for consistent management. Access to effective chemical solutions was also a challenge raised by 26.15%. Households noted that no herbicide currently available to them that had been successful in eliminating *Ipomoea* plant species. 10.00% of the household raised a challenge related to livestock consuming the uprooted plants (Table 4.6). As one Female Household reported *"If you just cut the weed, it grows back very fast. But if you uproot it from the roots, it reduces regrowth. The problem is, once you uproot it and leave it on the ground, animals come and eat it and that's dangerous to animals. That's why we prefer to burn it after uprooting"* (Appendix 1).

Table 4.6: Challenges reported by households in implementation of *ipomoea* control

Challenge	Yes	(%)	No	(%)	Total
High cost of Labour	126	48.46	134	51.54	260
Time consuming	209	80.38	51	19.62	260
Limited availability of Herbicides	68	26.15	197	73.85	260
Regrowth of the Plant species	215	82.69	45	17.31	260
Eating uprooted *Ipomoea* by Animals	26	10.00	234	90.00	260

Several Households also highlighted difficulties in mobilizing collective action for *Ipomoea* Plant species control. Although the Plant affects much of the region grazing land, the level of infestation varies from one household to another, making it difficult to engage all community members equally. One Household head explained *"Yes, the weed is affecting all parts of Kajiado, but sometimes your neighbor's land is not as invaded as yours… so when we talk about working together, they ask, 'Why should I do the work for someone else?"* (Appendix 1).

4.1.3 Distribution of willingness to pay responses

The descriptive statistics summarize the socioeconomic and institutional characteristics of the surveyed households based on their willingness to pay for the control of the *Ipomoea* Plant species. The mean age of household heads who were willing to pay was 50.51 years, while for those not willing to contribute, the mean age was 41.92 years. In terms of education levels, the average number of years of schooling for those who were willing to pay was 5.21 years, while for those not willing it was 3.37 years. The mean household size, measured in Adult equivalent ratio (AE), was 5.28 for those willing to pay and 6.05 for those not willing. The average livestock units, measured in Tropical Livestock Units (TLU), was 9.56 for the willing Household heads and 6.14 for the non-willing. The dependency ratio, calculated based on household members under 15 and over 65 years of age, was 1.21 for the willing households and 1.52 for the non-willing households. Regarding land ownership, the average land size for households willing to pay was 36.97 acres, while for the non-willing households, it was 21 acres. Finally, the past awareness score related to the *Ipomoea* plant species was 19.22 for willing households and 22.80 for those not willing (Table 4.7). As the t-test result depicts there was a significant proportion difference in willingness to pay between Dependency ratio, past awareness about *ipomoea*, Family size, livestock units and education level of the household at 5% probability level and there was a significant difference between Age of the household and willingness to pay at 1% probability level.

Table 4.7: Descriptive results for continuous variables with willingness to pay

Variable	**WTP**		**NWTP**		**t-value**	**P-value**
	Mean	**SD**	**Mean**	**SD**		
Age (Hage)	50.51	11.54	41.91	13.05	4.24***	0.0000
Education years (Edu_years)	5.21	5.46	3.37	4.54	-2.25**	0.0256
Family size (AER)	5.28	2.20	6.05	2.66	2.10**	0.0363
Livestock units (TLU)	9.56	11.55	6.14	6.63	-1.99**	0.0474
Dependency ratio (DR)	1.21	0.83	1.52	0.91	2.33**	0.02
Size of own land (land_size)	36.97	55.59	21	27.60	-1.95	0.051
Past awareness about the weed (past_awarness)	19.22	9.87	22.80	11.00	2.23**	0.0132

Note: ***, ** shows significant variables at 1%,5% respectively.

TLU represents the standardized measure of livestock units

Dependency ratio was measured using $= \frac{\text{Below 15 age+Above 65 age}}{\text{Between 15 and 65 age}}$.................................(29)

Past awareness was measured in number of years since the household first observed the weed in their locality

The descriptive statistics for categorical variables show the distribution of willingness to pay among different household characteristics. In terms of Gender, among Male household heads, 86.86% were willing to contribute while 13.14% were not willing. Among Female household heads, 74.80% were willing to pay, and 25% were not willing. Regarding Land tenure security, Willingness to contribute increased with land tenure security, ranging from very insecure (72.73%) to very secure (100%) as outlined in the Table 4.8. Concerning extension service access, of those who reported having access, 90.91% were willing and 9.09% were not willing to contribute. Among those who did not have access, 79.73% were willing and 20.27% were not willing. In terms of Major livelihood activity Households willingness to pay varied from casual laborers (71.43%)

to livestock rearing (92.00%) as outlined in the Table 9. The monthly income distribution showed that among households earning 0-12,000 KES 27.5% were willing compared to 78.43% unwilling while for 12,001-24,000 KES the results were 24.05% willing and 75.95% unwilling for households earning 24,001-36,000 KES had 12.00% willing and 88.00% unwilling for households earning 36,001-48,000 KES showed 10.00% willing and 90.00% unwilling and 48,001-60,000 KES resulted 11.11% willing contrasted with 88.89% unwilling. Regarding credit access, among Households who reported having access to credit, 96.55% were willing and 3.45% was not. Among those without access, 79.22% were willing and 20.78% were not (Table 4.8). As the chi-square (χ^2) result depicts there was a significant proportion difference between willingness to pay and major livelihood activities and land security at 1% probability level and there was a significant proportion difference between gender and willingness to pay at 5% probability level.

Table 4.8: Descriptive results of categorical variables with willingness to pay

Variable	Category	WTP		NWTP		Total	χ^2	P-value
		N	%	N	%			
Gender (Rgen)	Male	119	86.86	18	13.14	137	6.17**	0.013
	Female	92	74.80	31	25.0	123		
Land security (land_secure)	Very insecure	72	72.73	27	27.27	99	16.23***	0.003
	Somewhat Insecure	46	79.31	12	20.69	58		
	Neutral	18	85.71	3	14.29	21		
	Somewhat secure	27	79.41	7	20.59	34		
	Very secure	48	100.00	0	0.00	48		
Extension service (Ext_access)	Yes	30	90.91	3	9.09	33	2.35	0.125
	No	181	79.73	46	20.27	227		
Major livelihood activities (Occ)	Casual labourer	15	71.43	6	28.57	21	27.71***	0.000
	Livestock Business	56	65.12	30	34.88	86		
	Salary earner	2	66.67	1	33.33	3		
	Livestock production	138	92.0	12	8.0	150		
Credit service (Cred_access)	Yes	28	96.55	1	3.45	29	5.06**	0.024
	No	183	79.22	48	20.78	231		
Income level (RIncome)	0-12,000	22	27.5	80	78.43	102	4.70	0.32
	12,001-24,000	19	24.05	60	75.95	79		
	24,001-36,000	6	12.00	44	88.00	50		
	36,001-48,000	2	10.00	18	90.00	20		
	48,001-60,000	1	11.11	8	88.89	9		

***, ** shows significant variables at 1% and 5% probability levels respectively

4.2 Contingent valuation results

4.2.1 Response patterns for the double bounded dichotomous choice method

A double-bounded dichotomous choice contingent valuation survey was conducted to assess willingness to pay for *Ipomoea* plant species control, using both cash payments and labor contributions as payment vehicles. The survey results indicated that 30.38% of households accepted both cash bids, 23.85% accepted the initial cash bid but rejected the subsequent bid, 26.92% rejected the first cash bid but accepted the second, and 18.85% rejected both cash bids (Figure 4.1). Regarding labor contributions, 35.77% of households accepted both offered labor days, 25.38% accepted the first labor contribution but rejected the follow-up labor contribution, 20.77% rejected the initial labor day but accepted the follow-up labor day, and 18.08% rejected both offered labor days (Figure 4.2).

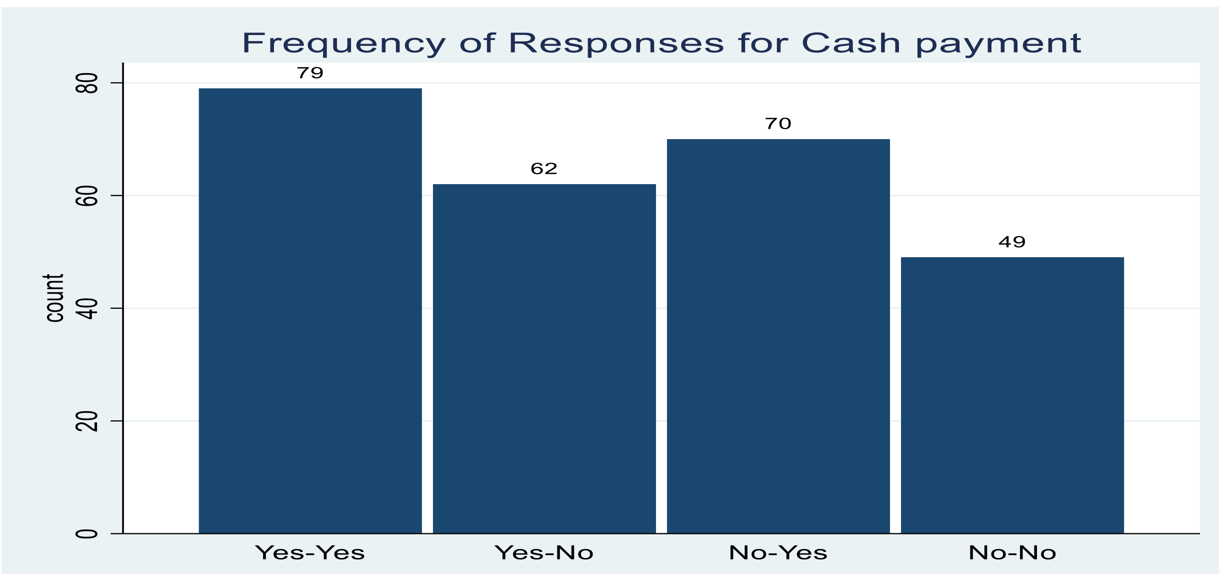

Figure 4.1: Response patterns in terms of cash payment

Note: - Households who answered “Yes-Yes” and “No –No” indicate they accept or reject both bids. The others are if they accept either the first or the second bid

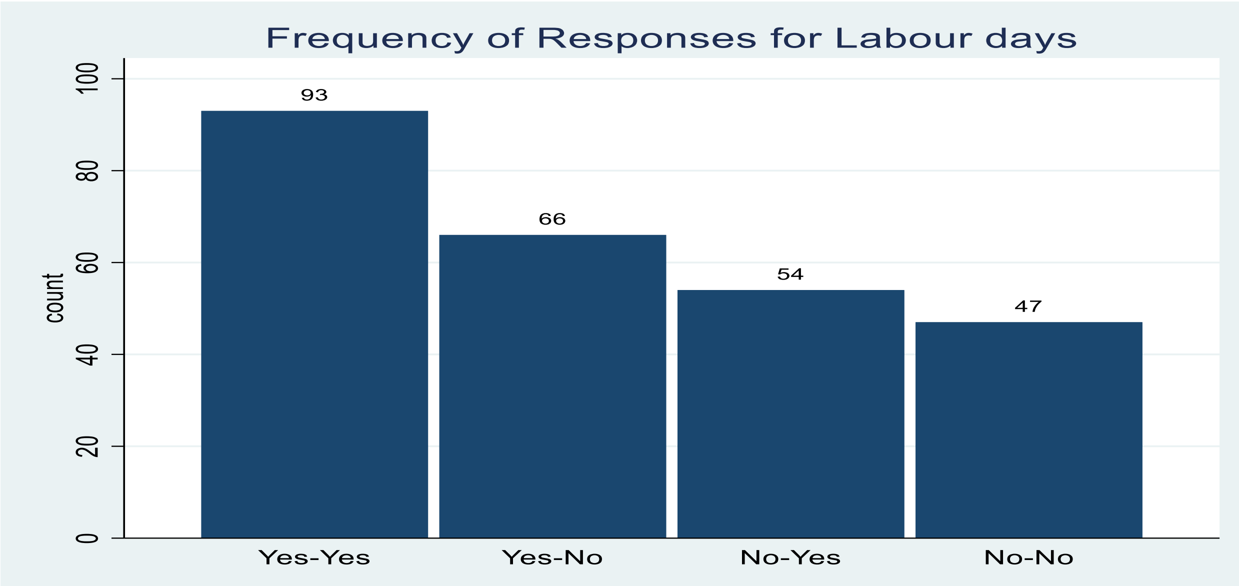

Figure 4.2: Response patterns in terms of labour days

4.2.2 Estimation of mean willingness to pay

The primary objective of estimating the empirical WTP model from the CVM survey is to determine the mean WTP distribution. Several conditions support this estimation. The highly significant Wald chi-squared statistic (Wald chi2 (2) = 105.56, Prob > chi2 = 0.0000) at the 1% level indicates that the model's coefficients are jointly significant. Similarly, the significant Likelihood Ratio test (chi2 (1) = 17.03, Prob > chi2 = 0.0000) confirms the interdependence between initial and follow-up responses in the DBDC method. The positive and significant Rho value ($\rho = 0.626$) suggests a positive relationship between WTP responses. The correlation coefficient being less than one implies that the random components of WTP are not perfectly correlated. This significant, yet imperfect, correlation suggests that the seemingly unrelated bivariate probit model is the appropriate model for estimating mean WTP. Previous studies support the methodological approach for estimating mean willingness to pay (WTP) and validate the use of the seemingly unrelated bivariate model, which accounts for correlated errors in contingent valuation studies (Asmare *et al.*, 2022; Belay, 2018; Sisay *et al.*, 2024; Workie, 2017). The mean willingness to pay (WTP) for proposed control measures against *Ipomoea* plant species is 9,541.44 KES per household annually. This value is calculated using parameter estimates and the formula provided by Haab and McConnell, (2002) as explained in Chapter Three. MWTP= $\frac{-\alpha}{\beta}$

The figure represents the average derived from initial and follow-up responses in two simultaneously modeled seemingly unrelated bivariate regression models.

The Mean WTP calculation is detailed below: -

$$\text{Mean WTP} = \frac{\text{WTP1+WTP2}}{2} \quad \text{or} \quad \text{Mean WTP} = \frac{-\alpha_1}{\beta_1} + \frac{-\alpha_2}{\beta_2}$$

$$\text{MWTP} = \frac{9516.87++9564.01}{2} = \frac{19{,}082}{2}$$

$$\text{MWTP} = 9541.44 \text{ KES}$$

Table 4.9: Seemingly unrelated bivariate probit parameter estimates for bids payment

	Varia-ble	Coefficient	Std. err	P>|Z|	$\frac{-\alpha}{\beta}$	MWTP	mean
WTP 1	**Bid1**	-0.0001455	0.0000301	0.000***	-(1.384996)/-	9518.8	9541.4
	constant	1.384996	0.2819575	0.000***	0.0001455	7	4
WTP 2	**Bid2**	-0.0003158	0.0000315	0.000***	-(3.020315)/	9564.0	
	constant	3.020315	0.2966435	0.000***	-0.0003158	1	
	Athrho	0.7355694	0.2170882	0.001***			
	Rho/P* **	0.6264608	0.1318913				

Number of observation = 260
Log likelihood= -305.47
Wald chi2(2)= 106.56
Prob > **chi2**= 0.0000

Likelihood-ratio test of rho =0 **chi2(1)** =17.032 **Prob** > **chi2** = 0.0000

Mean WTP = 9541KES per year **CI at 95%** (18,290.13 KES to 5262.405 KES)

Note: The p-values for all key coefficients in the model are reported as 0.000. This is a result of rounding values below 0.0005 and indicates that the coefficients for the bid amount in both the initial and follow-up questions (Bid1 and Bid2), the constants, and the correlation parameter (rho) are all statistically significant at a level of $p < 0.001$. This provides very strong evidence that the bid amount had a powerful and non-random influence on Households' decisions.

To determine the Mean willingness to contribute labor days, certain conditions must be met. Initially, the Wald chi-squared test (2) statistic of 176.38, with a p-value of 0.0000, is highly significant at the 1% level. This suggests that the model's coefficients are jointly significant. Likewise, the likelihood ratio test for rho = 0, yielding a chi-squared (1) value of 8.923 and a p-value of 0.0028, is also statistically significant at the 1% level. This confirms that the initial and follow-up questions in the DBDC method are interdependent. The positive and significant rho value (ρ =

0.657; chi2 (1) = 8.923) indicates a positive relationship between the willingness to pay responses (Table 4.10). The mean Labour days contribution derived from the model is presented below: -

$$\text{Mean WTP} = \frac{\text{WTP1+WTP2}}{2} \quad \text{or} \quad \text{Mean WTP} = \frac{-\alpha_1}{\beta_1} + \frac{-\alpha_2}{\beta_2}$$

$$= \frac{14.15+14.10}{2} \quad = \frac{28.25}{2}$$

= 14.13 Labour days

Table 4.10: Seemingly unrelated bivariate probit estimates for labour days

	Variable	Coefficient	Std. err	P>|Z|	$\frac{-\alpha}{\beta}$	MWTP	mean
WTPLabor1	**Labor1**	-0.2867471	0.0297747	0.000***	-(4.057844)/-0.2867471	14.15	14.13
	constant	4.057844	0.3956401	0.000***			
WTPLabor2	**Labor2**	-0.258569	0.0270714	0.000***	-(3.646712)/-0.258569	14.10	
	constant	3.646712	0.3754601	0.000***			
	Athrho	0.73849513	0.3635561	0.031**			
	Rho/P* **	0.6555394	0.2073244				

Number of observation = 260

Log likelihood= -228.27

Wald chi2(2)= 176.38

Prob > **chi2**= 0.0000

Likelihood-ratio test of rho =0 **chi2(1)** =8.923 **Prob** > **chi2** = 0.0028

Mean WTP = 14.125 Labour days per year **CI at 95%** (21.25 Labour days to 9.425 Labour days)

Note: - Labour day Refers to a contribution of time equivalent to one adult person working for an eight-hour day on activities related to the control of the invasive *Ipomoea* species.

The p-values for all key coefficients in the model are reported as 0.000. This is a result of rounding values below 0.0005 and indicates that the coefficients for the labour days in both the initial and follow-up questions (Labour1 and Labour2), the constants, and the correlation parameter (rho) are all statistically significant at a level of $p < 0.001$. This provides very strong evidence that the bid amount had a powerful and non-random influence on Households' decisions.

4.2.3 Reasons for accepting the presented bids and labour days

Among the households that expressed willingness to participate in the hypothetical intervention to control the spread of *Ipomoea* plant species, respondents were asked to state their reasons for supporting either cash contributions or labor-day participation. Out of the 211 households willing to contribute cash, the majority, 94.8%, stated that they needed more pasture for their livestock, highlighting the serious impact *Ipomoea* has had on forage availability. 55.5% believed the proposed control measure was worth the money. This result concur with the findings of Belay (2018) who found that Households were willing to pay for soil conservation of communal lands due to the reason that it worth that money, and 8.5% expressed a strong interest in managing communal grazing land. The 213 households willing to contribute labor, 93.9% cited the need for more pasture as a major motivating factor. Moreover, 64.3% believed the change would positively impact household welfare and food security, while 29.6% showed high interest in grazing land management. 67.1% mentioned a desire to improve the health of their livestock, which has been negatively affected by the spread of *Ipomoea* plant species. 8.0% noted that they have enough labor capacity to contribute to the hypothetical intervention. These figures appear to exceed the total number of willing households because respondents were allowed to provide multiple reasons, reflecting the complex and overlapping motivations behind their willingness to support the control efforts (Tables 4.11 and 4.12).

Table 4.11: Reasons given by households for accepting the offered cash bids for *ipomoea* control

Reason for Willingness to Pay	**Number of Households(n) who answered Yes**	**(%)**	**Number of Households(n) who answered No**	**(%)**	**Total**
I need more pasture for my livestock	200	94.8	11	5.2	211(100)
I think it is worth that Money	117	55.45	94	44.55	211(100)
I am highly interested in the management of the grazing land	80	37.91	131	62.09	211(100)

Table 4.12: Reasons given by households for accepting the offered labour days contribution for *ipomoea* control measures

Reason for Willingness to contribute labour	Number of House-holds(n) who answered Yes	(%)	Number of House-holds(n) who answered No	(%)	Total
I need more pasture for my livestock	200	93.90	13	6.10	213(100)
The change will be useful for my household food security	137	64.32	79	35.68	213(100)
I am highly interested in these management practices no matter what it costs	63	29.58	150	70.42	213(100)
I have enough labour availability	17	7.98	196	92.02	213(100)
I want to improve the health of my livestock	143	67.14	70	32.86	213(100)

4.2.4 Reasons for rejecting the offered bids and labour days

In addition to the households who expressed willingness to participate, the study also examined the reasons given by those who rejected the offered bids for the hypothetical intervention to control *Ipomoea*. 90.74% households reported they cannot afford to pay, This results agree with the findings of Asmare *et al.* (2022), Belay, (2018), and Jianjun *et al.* (2016) who identified low financial capacity as a reason and genuine response to willingness to pay for environmental goods. In this study also it was accepted as a genuine economic limitation. Five Households rejected the offer on grounds such as the government should fund the intervention 5.56% or that it was not their responsibility 3.70%. These five cases were also categorized as protest zeros, as they reflect a rejection of the payment scenario rather than a lack of means. The labor-day contribution, 87.04%

households cited reasons such as lack of time, being sole providers of income, or having no available labor, which were considered genuine responses. However, seven respondents rejected the Hypothetical intervention for reasons unrelated to ability or opportunity specifically, they stated that they did not need the change, believed the government should be responsible, or had other priorities. In this research, these seven responses were classified as protest zeros, as they reflect opposition to the implementation of the intervention rather than an inability to participate (Tables 4.13 and 4.14).

Table 4.13: Reasons given by households for rejecting the offered cash bids for *ipomoea* control measures

Possible reasons	**Type of Response**	**Action taken**	**Frequency**	**Percentage**
I cannot afford to pay	True response	Included	49	90.74
The government should handle the control	Protest response	Excluded	3	5.56
It is not my responsibility	Protest response	Excluded	2	3.70
Total			**54**	**100**

Table 4.14: Reasons given by household for rejecting the offered labour days contribution for *ipomoea* control

Possible Reasons	**Frequency**	**(%)**
I do not have time (I am the only provider for my family)	47	87.04
I do not need the change to be made	3	5.56
The government should take the responsibility for it	3	5.56
I have other priorities	1	1.85
Total	**54**	**100**

4.3 Econometrics results

4.3.1 Preliminary analysis for econometric model

Before conducting econometric analysis, Multicolinearity was checked. Variance Inflation Factors (VIF) (Appendix Tables 3 and 4) and pairwise correlation (pw corr) tests (Appendix Table 5) were used for continuous variables and dummy variables respectively. Based on Gujarati (2002), Multicolinearity is present if VIF is greater than 10. The analysis showed that there was no significant Multicolinearity among the dummy variables (Gender, Extension access, Major livelihood activities, and land security). Therefore, all 12 of the predictors that were hypothesized were used in the estimation of the Seemingly Unrelated Bivariate Probit (SUBP) model.

4.3.2 Determinants of household willingness to pay or participate in the *ipomoea* plant species control

Following the assessment of households' willingness to contribute to control measures for the *Ipomoea* plant and the identification of variations in their contribution levels, the subsequent critical step involved identifying the factors driving these differences. To achieve this, a seemingly unrelated bivariate probit (SUBP) estimation was employed, regressing the willingness to pay (WTP) of Households against factors anticipated to influence their contribution levels. Given that the SUBP model coefficients only indicate the direction (signs) and not the strength (magnitudes) of the explanatory variables' effects on the dependent variable, it is necessary to calculate the partial derivatives (marginal effects) to analyze the influence of each explanatory variable on the probability of a Household accepting the offered bid (Greene, 2012).

The bivariate probit model used in this study was statistically significant overall, confirming the model's suitability in examining factors influencing households' willingness to pay for the control of the invasive *Ipomoea* plant species. In both the cash-based and labor-based willingness to pay models, the Wald chi-square tests for joint significance yielded highly significant results (p-value = 0.0000), indicating that the explanatory variables, taken together, contribute meaningfully to explaining the probability of willingness to pay. Moreover, the rho (ρ) values in both models were significantly different from zero, as evidenced by the Wald test of rho = 0. Specifically, the rho value was 0.406 (p = 0.0351) in the cash WTP model and 0.493 (p = 0.0437) in the labor WTP model, suggesting that the two equations in each model (e.g., WTP1 and WTP2) are not independent. This validates the use of the bivariate probit model over separate univariate probit models, as it accounts for potential correlation between the unobserved factors influencing the two willingness-to-pay outcomes. In other words, households' responses to different bid versions (or different contribution types) are likely interrelated, and modeling them jointly improves estimation efficiency and accuracy.

The log pseudo-likelihood values of –267.6 (cash WTP) and –204.6 (labor WTP) also indicate good model fit, especially in the context of Contingent Valuation Method (CVM). Furthermore, the predicted joint probabilities (Pr (WTP1 = 1, WTP2 = 1)) were 0.45 (Table 4.16) in the labor model and 0.40 (Table 4.15) in the cash model, suggesting that a substantial portion of respondents were willing to support *Ipomoea* control under at least one contribution format. The model's result showed that eight out of twelve hypothesized variables had significant effect on the bid equations. Specifically, Extension access positively and significantly influenced the probability of accepting the initial bid at 5% probability level. Livestock ownership positively and significantly affected the acceptance of both initial and follow-up bids at 5 percent probability level. Conversely, initial bid, follow-up bid were significant at 1 percent significant level, the result aligns with previous studies by Berhanu *et al.* (2022), Ebrahim *et al.* (2024), Getachew *et al*. (2020) and Payal *et al.* (2024) and family size had negative and significant effect at 4.1 percentage point on household willingness to pay. Regarding labor participation, age negatively and significantly affected willingness to pay at 1 percent probability level in the follow-up responses. This result of the study concur with previous study by Bamlaku *et al.* (2019) but contrast to Mubialiwo *et al.* (2021) that Age has a positive influence on households willingness to pay. The details are discussed in the tables below (Tables 4.15 and 4.16).

The study found that the offered bid amount had a negative and statistically significant effect on household willingness to pay for controlling the invasive *Ipomoea* plant species. In the bivariate probit model, both Bid1 and Bid2 coefficients were negative and highly significant at the 1% level, indicating that as the proposed monetary contribution increased, households were less likely to accept the bid. Specifically, the joint marginal effects show that a one-unit increase in the bid amount decreased the probability of willingness to pay by approximately 0.0038% to 0.0070%, holding all other variables constant (Table 4.15). This outcome aligns with the economic law of demand, which suggests that as the cost of a good or service increases, the likelihood of purchase or support tends to decrease. In this study, higher financial contributions from households reduced the likelihood of supporting the *Ipomoea* control initiative. This likely reflects the economic constraints faced by rural households, where even small increases in required payments can strongly influence decisions, particularly in pastoral communities. This finding is consistent with previous studies, such as Jianjun *et al.* (2016) and Sisay *et al*. (2024), which also found a negative relationship between bid amounts and willingness to pay for environmental services. The results also showed that access to extension services positively influenced households' willingness to pay for controlling the invasive *Ipomoea* plant. In the bid-based bivariate probit model, households with extension access were 18.4 percentage points more likely to support the control program in the WTP1 equation at the 5% significance level compared to those without access (Table 4.15). This suggests that households who receive agricultural extension services are better informed about the negative effects of *Ipomoea* on land, livestock, and livelihoods. Similar findings were reported by Sisay and Toru (2023) and Tilahun and Tadesse (2022), showing that access to advisory services increases community involvement in conservation and invasive species management (Workie, 2017).

The results from the model showed that a household's major source of livelihood affects their decision to participate in the control initiatives. In Kajiado County, as livestock keeping is the major livelihood activity and the marginal effects also showed that a change in the major source of livelihood leads to an approximate 5.7 percentage point increase in the likelihood of a household being willing to pay for *Ipomoea* control, *Ceteris paribus* (Table 4.15). This results agree with the expected hypothesis and concur with earlier research by Lutta *et al.* (2022) who found that pastoralists who rely mainly on livestock are more willing to pay for conservation measures than those with more diverse sources of income, such as farming. The rationale is that pastoralists whose livelihood is entirely dependent on livestock derive greater direct benefit from sustainable grazing practices. These practices ensure more consistent biomass and water availability for their animals throughout the year, making the investment more valuable to them than to individuals with alternative income sources.

Table 4.15: Determinants of rural households' WTP for *ipomoea* control measures

Variables	First response WTP1		Second response WTP2		Joint Marginal effects
	Coefficient	**R.Standard error**	**Coefficient**	**R.standard error**	
Bid1	-0.0002***	0.0000			-0.0000376
Bid2			-0.0003***	0.0000	-0.0000701
Age	0.0032	0.0085	0.0005	0.0087	0.00083
Gender*	-0.0781	0.1988	-0.0475	0.1964	-0.0274
Education level	-0.0030	0.0209	-0.0007	0.0201	-0.0008
Income	0.0000	7.72e-06	0.0000	7.67e-06	8.06e-06
Livelihood activities	0.1231*	0.0652	0.1415**	0.0666	0.0569
Extension access*	0.6988**	0.2789	0.1829	0.2541	0.1839
Size of land	0.0032*	0.0018	0.0028	0.0018	0.0013
Land security	0.1165*	0.0591	0.1211*	0.0558	0.0512
Past awareness	-0.0048	0.0095	-0.0000	0.0102	0.0012
Livestock holding(TLU)	0.0262**	0.0106	0.0189*	0.0101	0.0098
Family size(AE)	-0.1377***	0.0436	-0.0467*	0.0410	-0.0407
Dependency ratio	-0.1105	0.1084	-0.1368	0.0998	-0.0531
cons	0.95449	0.6071	2.2009	0.6968	
Number of Observation =260					
Log pseudo likelihood = -267.61494					
Wald chi2(26) = 152.40					
Prob > chi2 = 0.0000					
Rho =0 .406					
Wald test of rho=0: chi2(1) = 4.44083		Prob > chi2 = 0.0351			
y = Pr (WTP1=1, WTP2=1) (predict, p11) 0.402					

***, **, * shows significant variables at 1%, 5%, and 10% probability levels, respectively

Land tenure security also played a positive and statistically significant role. Households that felt secure in their land ownership were 5.1 percentage points more likely to be willing to pay at 10% probability level for both responses. This finding supports the notion that secure landholders are more likely to invest in land improvement or environmental conservation, since they are more confident in the long-term benefits of such management. Furthermore, Land size showed a small but significant positive effect on willingness to pay. The joint marginal effect shows that a one-unit increase in land size in acres will increase the household willingness to pay for *ipomoea* plant species by 0.01% (Table 4.15). Larger landholders were slightly more likely to contribute money, likely because they are more exposed to the spread of *Ipomoea* and may also have greater capacity to contribute financially. This result concur with previous studies by Belay (2018) who suggested that farmers with larger landholdings have a greater financial incentive to conserve communal land, as they benefit more from its services. Consequently, these farmers are more willing to contribute labor to conservation efforts than those with smaller farms.

The results show that Livestock Ownership (TLU) had a positive and significant influence on the willingness to pay for *ipomoea* plant species control measures. Households with more livestock units (TLU) were significantly more willing to pay for *ipomoea* plant species than Households with less livestock units (TLU). This is expected, as *Ipomoea* has toxic effects on livestock, and livestock keepers may be more affected by the economic losses caused by the invasive plant. Therefore, an increase in Tropical Livestock Unit by one more increases the households' WTP by almost 1% and it was happened to be significant at 5% and 10% probability level for the first and second response, respectively, *citrus paribus* (Table 4.15). The results are consistent with the findings of Amare *et al.* (2017), Belay (2018) and Dessie (2018) who suggested that a higher Tropical Livestock Unit (TLU) does not directly reflect a household's intention to rehabilitate land. Instead, it often indicates a need for more fodder either from their own share or by purchasing from others with smaller herds or it may be a result of economies of scale in livestock management. These results are supported by other studies indicating that each unit increase in Tropical Livestock Unit (TLU) raises the likelihood of farmers accepting conservation bids. For rural households, livestock serves as a key indicator of wealth, and those with larger herds are consistently found to contribute more labor to environmental conservation than those with smaller holdings (Berhanu *et al.*, 2022; Getachew *et al.*, 2020).

Conversely, household size (Adult Equivalents) had a negative and statistically significant effect on willingness to pay. A one-unit increase in adult-equivalent size reduced the probability of agreeing to pay by about 4.1 percentage points. This may be due to larger families facing tighter household budgets or prioritizing other pressing needs over environmental management. The study result is consistent with the findings of Jianjun *et al*. (2016) and Zegeye *et al*. (2023) who found that larger family sizes can reduce participation in environmental conservation. They argue that a greater number of dependents spreads financial resources thinner, lowering per capita income and diminishing the household's capacity or willingness to pay for environmental goods. Furthermore, larger families may lead to reduced individual labor contribution per member, making the household head less willing to commit to conservation activities (Table 4.15).

Table 4.16: Determinants of rural households' willingness to participate in terms of labour for *ipomoea* plant species control measures

Variables	First response WTPLabr1		Second response WTPLabr2		Joint Marginal effects
	Coefficient	Robust standard error	Coefficient	Robust standard error	
Labor1	-0.3025***	0.0246			-0.0600
Labor2			-0.2552***	0.0337	-0.0600
Age	-0.0128	0.0114	-0.0495***	0.0098	-0.0142
Gender*	0.1629	0.2522	0.3924	0.1925	0.1239
Education level	-0.0008	0.0237	-0.0340	0.0197	-0.0082
Income	-2.70e-06	0.0000	0.0000	8.11e-06	2.22e-06
Livelihood activities	0.0727*	0.0833	-0.0462**	0.0675	0.0035
Extension access*	0.2832**	0.3228	-0.0542	0.2702	0.0366
Size of land	-0.0016*	0. 0025	0.0005	0.0018	-0.0002
Land security	-0.0358*	0.0680	0.0652*	0.0618	0.0082
Past awareness	0.0112	0.0115	0.0185	0.0099	0.0066
Livestock holding(TLU)	-0.0017**	0.0125	0.0051*	0.0113	0.0009
Family size(AE)	-0.0658***	0.0504	0.0292*	0.0444	-0.0061
Dependency ratio	0.1118	0.1256	0.0487	0.0957	0.0336
cons	4.6469	0.7767	4.93026	0.7694	

Number of Observation =260

Log pseudo likelihood = -204.577

Wald chi2(26) = 260.78

Prob > chi2 = 0.0000

Rho =0 .493

Wald test of rho=0: chi2(1) = 4.068 Prob > chi2 = 0.0437

y = Pr (WTP1=1, WTP2=1) (predict, p11) 0.45

***, **, * shows significant variables at 1%, 5%, and 10% probability levels, respectively

The study also examined the determinants of household willingness to contribute labor toward the control of the invasive *Ipomoea* plant species. The bivariate probit model revealed that the offered labor bid amounts (Labor1 and Labor2) had a strong negative and statistically significant effect on labor willingness to contribute, significant at the 1% level (Table 4.16). This indicates that as the required number of labor days increased, the likelihood of a household agreeing to participate declined. Specifically, Keeping the effect of other factors constant, the joint marginal effects showed that each additional unit increase in labor bid reduced the probability of willingness to contribute by about 6 percentage points. This aligns with basic economic theory, where increased opportunity cost (time or labor) reduces voluntary participation. The result is inconformity with the results of (Endalew & Assefa, 2019; Getachew, 2018).

Age was also found to significantly affect labor contribution. It was statistically significant (at the 1% level) in one of the labor equations (WTPLabr2), with results indicating that older household heads were less likely to participate in labor-based control activities. Keeping the effect of other factors constant, the marginal effect suggested that a one-year increase in age reduced the probability of contributing labor by approximately 1.4 percentage points. This is expected, as older individuals may have reduced physical capacity, making it less feasible to engage in physically demanding weed control work (Table 4.16). This result is in agreement with the finding of Bamlaku *et al.* (2019) and Zegeye *et al.* (2023) which explains that younger households would appreciate the value of environmental management than older households. Additionally a study by Iqbal (2020), Musa *et al.* (2020), and Yang *et al*. (2022) about willingness to pay for mangrove forest conservation in different countries found that people preferences for environmental service decreases as they get older. However, The results contradict with the findings of Jianjun *et al.* (2016) and Zegeye *et al.* (2023) who indicated household head as having a positive effect on the WTP for natural resource or environmental management as Older households have awareness than the younger households.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

i. Households' willingness to pay or participate in the control of *ipomoea* plant species according to the descriptive statistics shows 81.15% were willing to pay cash in KES and 81.92% were willing to contribute labour. This shows A large proportion of Livestock-keeping Households in Kajiado-Central sub-county are aware of the threat posed by the *ipomoea* plant species and are willing to support its control.

ii. The contingent valuation method gave the mean willingness to pay values of household contribution using Seemingly unrelated bivariate probit model through both cash (9141.44 KES) and labour (14.13 Labour days). These values highlight the commitments households are willing to rehabilitate the invaded grazing lands.

iii. Several factors significantly influenced households' willingness to pay (WTP) or participate in *Ipomoea* control measures. Positive determinants included: size of land owned, livestock ownership, access to extension services, and the household's primary livelihood activities. Conversely, two factors demonstrated statistically significant negative effects: family size and both the initial and follow-up bid amounts in the contingent valuation survey.

5.2 Recommendations

i. Extension service providers should offer targeted training, especially for households with limited awareness and fewer resources.

ii. The County government and NGOs should support cost-sharing mechanisms based on the estimated mean values and design feasible incentive-based programs to support weed management and Policy makers should also consider interventions which offer both options (Cash payment and Labour days contribution). This dual approach would allow households to choose based on their capability and availability. Increase overall participation and equity, especially for those who are cash-constrained but labour-rich, or vice versa.

iii. Since Livestock holding and Land size were positively associated with contribution levels, interventions by the community national government should initially engage these households as entry points for community mobilisation.

5.3 Areas for further research

i. This study assessed household willingness to contribute labour only in terms of the number of labour days. However, future research could expand this by considering the types and source of labour such as family labour, hired labour. This would provide a more comprehensive understanding of the nature and value of household contribution toward the invasive *ipomoea* plant species control initiatives.

ii. Future research and policy should investigate potential economic uses for *Ipomoea* plant species.

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APPENDICES

Appendix A: Questionnaire for households' interview

Department of Agricultural Economics and Agribusiness Management

Kajiado Central Sub-County Livestock-keeping households' questionnaire

Dear Sir / Madam

My name is Kidist Abebe I am a postgraduate student at Egerton University, Njoro Campus. In partial fulfillment of the requirements for the Master of Science degree in Agribusiness management, I am conducting research entitled: "Households Willingness to Pay or Participate in the control of the invasive *ipomoea* plant *spp*. in Kajiado central sub-county, Kajiado County, Kenya". I would like to kindly request your assistance in providing information, by filling in the questionnaire provided below, as your views are considered important to this study.

Please note that your participation is voluntary and that any information given will be treated with utmost confidentiality and will only be used for this study.

Thank you.

Yours faithfully,

Kidist Abebe

Survey questionnaire

This questionnaire has been developed to collect data to analyze the willingness to participate in the control of *Ipomoea* plant species in your area. You have been selected as one of the households for this study. The information gathered will be used solely for research purposes and will be greatly appreciated. Your assistance in providing accurate information will contribute significantly to the success of this study. Please note that your responses will remain confidential and will not be linked to your name. We kindly ask you to respond based on your livestock data and practices during the period from April 2025 to May 2025.

Instructions for the enumerators

1. Introduce yourself and tell the purpose of the study before starting the interview
2. Tick the box on the closed questions as indicated
3. Ask interview questions clearly

Enumerator's Name: _____

Time ……/……/ 2025

Date of interview: _____

Section 1: - Respondent's details

1.1 Sub-county………….

☐Kajiado Central-sub county

1.2 Ward………………….

☐ Purko

☐Dalalekutuk

☐Illdamat

1.3. Household head’s Name: _____

1.4. Household head’s Age: _____

1.5. Gender: Male ☐ Female☐

1.6. Education Level: _____

1.7. Marital status: ……………….

☐Single

☐Married

☐Divorced

☐ Widowed

1.8. Household Size………………………………….. Note that family members refer to persons currently living in the roof

1.9. Number of Female household members………………….

1.10. Number of Male household members ……………………..

1.11. Number of household members aged below 15……………………..

1.12. Number of household members aged between 15-65………………………

1.13. Number of household members aged above 65………………………….

1.14.	Household head income	………….KES/month
1.15.	Year of experience in livestock keeping	…………..years
1.16.	Did you get extension service advice from any sector institution (regarding *Ipomoea* control) in 2024/2025?	Yes ☐ No☐
1.17.	If yes, how often do you receive extension services for your livestock activities?	**………..**Times/ year
1.18.	Do you or anyone of your family members participate in off/non-farm income in the last production year?	Yes☐ No☐

If yes to 1.18, why do you or some members of your family are engaged in off/non-farm activities?

Excess labour☐

Attractive income from off farm activities☐

Shortage of land ☐

Other(specify)………………………………………………………………………………….

1.19. Household head main occupation

☐Livestock rearing

☐Livestock Business

☐Casual labourer

☐Salary earner

☐other please specify……………………………………….

Section 2: Household resource endowment between February ,2025 to March,2025.

2.1. What types of animals do you currently keep?

☐Cattle

☐Goats

☐ Sheep

☐ Pig

☐Poultry

☐ Camel

☐ Donkey

2.2. Do you have your own land? Yes ☐ No☐

If yes to No 2.9. How many acres of land do you have currently? ………….in acres.

Section 3: Livestock production and feeding

3.1. What is/are the main feed source(s) for your livestock? Please rank your top three source of feed.

1st choice

☐ Communal grazing land (zero grazing)

☐ Fodder crops

☐ Hay/silage

☐ Crop residues

☐ Supplementary feeds

☐ Agro-industrial by-products

☐ Kitchen waste

2nd choice

☐ Communal grazing land (zero grazing)

☐ Fodder crops

☐ Hay/silage

☐ Crop residues

☐ Supplementary feeds

☐ Agro-industrial by-products

☐ Kitchen waste

3rd choice

☐ Communal grazing land (zero grazing)

☐ Fodder crops

☐ Hay/silage

☐ Crop residues

☐ Supplementary feeds

☐ Agro-industrial by-products

☐ Kitchen waste

3.2. How would you describe your sense of land security in communal grazing areas?

☐ Very insecure

☐ Somewhat insecure

☐ Neutral

☐ Somewhat secure

☐Verysecure

3.3. what are the major problems you are facing while livestock keeping?

Water scarcity☐

Feed shortage☐

Diseases☐

Predation (Loss due to wild animals and thieves) ☐

Limited grazing land ☐

Overgrazing ☐

Lack of cash☐

Others

If others please, specify……………………………………………………………….

3.4. Are you aware of any health issues in animals due to the *ipomoea* plant species?

No☐

Yes☐

3.4.1. If yes, what health issues have you observed in your animals due to consumption of *ipomoea* plant species?

☐ Salivation

☐ Vomiting

☐ Diarrhea

☐ Bloating

☐ Weight loss

☐ Reduced Milk

☐ Reproductive issues

☐ Others

3.4.1.1. If others, please specify…………………………………………………

3.5. How would you rate the negative impacts of ipomoea species?

☐ No impact

☐ Mild

☐ Moderate

☐ Severe

☐ Very severe

Section 4: General information about *Ipomoea* plant species and household experience with control methods

4.1 When did you first see *Ipomoea* in the area? (Year) ………………………

4.2. Do you agree that there is a need to control the spread of *Ipomoea* in your Ward?

Strongly agree ☐ Agree ☐ Neutral ☐

Disagree ☐ Strongly disagree☐

4.3. Have you ever implemented any practice/s or method in the past to control the spread of *Ipomoea* plant spp?

Yes☐ NO☐

4.4. if yes, which method have you used? (select all that apply)

Manual removal☐

Herbicides application☐

Biological control☐

Burning☐

Fencing non-invaded areas ☐

Others (Please specify) ………………………………

4.5. What challenges did you face when using this method? (select all that apply)

High cost☐

Lack of information or skills☐

Limited availability of herbicides or tools☐

Re-growth of the plant species☐

Environmental concern ☐

Others (please specify) ………………………………………………………….

4.6. If the government or any other company established a program to remove *Ipomoea*, would you implement management practices to keep the cleared area free from *Ipomoea*?

Yes☐ No ☐

Section 5: Questions about awareness and perception of environmental impacts

5.1 Are you aware of any negative environmental impacts caused by the *ipomoea* plant species in your area?

Yes☐

No ☐

5.2. If yes, what negative effects have you observed caused by ipomoea plant species?

Takes over land used for grazing ☐

Drains water from the land ☐

Kills other plants ☐

Makes land more prone to fire ☐

Others specify ……………………………………………………………….

5.3. Has the spread of *ipomoea* plant species impacted the food security of your household?

Less pasture for livestock

Livestock health issues

Increased costs for feed

Others, specify…………………………………………………………………….

5.4. How likely do you think it is that controlling the *ipomoea* plant species will increase your food security?

Strongly unlikely ☐

Unlikely ☐

Neutral ☐

Likely ☐

Very likely ☐

Section 6: Contingent valuation scenarios and questionnaire of willingness to pay or participate in the control practices of *Ipomoea* plant species.

Scenario

Good morning, and thank you for taking the time to speak with us. As you know, the *Ipomoea* plant species have taken over large portions of our communal grazing lands, making it harder for your livestock to find good pasture. This has likely affected the health and productivity of your animals, as well as your income. In light of these reasons, the county government has declared that the plant is a threat to livestock keepers, and the government will use all means to control it. The government has also launched physical uprooting to do so. The government has stated that community participation, including youth at the community level, is essential to physically uproot and appropriately dispose of it. So, we would like to ask you about your willingness to contribute money or labour for its control measures. Would you be willing to pay or participate in the control of *Ipomoea* plant species in your area?

Willingness to pay/contribute questions

6.1. Would you be willing to pay X KES per year (X bid randomly to be chosen)?

(Bids are: 4500,8000,10000,12000)

Yes☐ No☐

6.2. If yes to 8.1. would you be willing to pay BX KES per year? Where BX > X.

Yes☐ No ☐

6.3. If no to 8.1., would you be willing to pay CX KES per year? Where CX < X

Yes ☐ No ☐

6.4. What is the maximum you are willing to pay per year? …………………KES

6.5. Would you be willing to contribute X Labour-days per year (X bid randomly to be chosen)?

(Bids are: 8,10,14,20) Yes☐ No☐

6.6. If yes to 8.5., would you be willing to contribute BX man-days per year? Where BX > X

Yes☐ No ☐

6.7. If no to 8.5., would you be willing to contribute CX man-days per year? Where CX < X

Yes ☐ No ☐

6.8. What is the maximum you are willing to contribute per year? …………….. man-days.

6.10. If no to 8.1. and 8.5., Why (Why not willing to pay or participate)?

1. I do not need the change to be made 2. I don't have time for it

3. The government should take the responsibility for it 4.I can't afford to pay

5. Others specify……….

6.11. If Yes, what is the main reason for your willingness to pay or participate?
1. I think it is worth that time

2. I am highly interested in these management practices no matter what it costs

3. The change will be useful for my household and me

4. I have enough labour availability

5. I want to improve the health of my livestock

6. Others specify………………………………………………………………………………

Qualitative questionnaire

1. Where do you get feed for your livestock**?**
2. How has the *ipomoea* plant affected your Household's livelihood?
3. Can you describe any changes in the environment or community due to the spread of *ipomoea*?
4. Have you experienced any health or animal-related problems that you associate with *ipomoea*? If so, please explain.
5. What methods have you or others in your community used to manage or control the *ipomoea* plant?
6. How effective do you think these methods have been? What are the challenges?
7. Do people in your community work together to remove or control the *ipomoea* plant? Please explain.

THANK YOU VERY MUCH FOR YOUR COOPERATION

Appendix B: STATA outputs

Appendix Table 1: Descriptive statistics for categorical explanatory variables

Variable Name	Definition of Variables	Categories	Frequency	Percentage(%)
Hgen	Gender of the Household head	Male	137	52.69
		Female	123	47.31
Ext_access	Extension service access of the Household head	Yes	33	12.69
		No	227	87.31
Cred_access	Credit service access of the Household head	Yes	29	11.15
		No	231	88.85
Land_secure	Land security of the Household head	VS	48	18.46
		SS	34	13.08
		N	21	8.08
		SI	58	22.31
		VI	99	38.08
Major_livelihod	Major livelihood activity of the Household head	Livestock rearing	150	57.69
		Livestock Business	86	33.08
		Casual labourer	21	8.08
		Salary earner	3	1.15
RIncome	Household Income level In Kenyan shilling	0-12,000	102	39.23
		12,001-24,000	79	30.38
		24,001-36,000	50	19.23
		36,001-48,000	20	7.69
		48,001-60,000	9	3.46

Appendix Table 2: Descriptive statistics for continuous variables

Variable	Obs	Mean	Std. dev.	Min	Max
Hage	260	41.55	12.68513	18	75
eduyears	260	4.857692	5.340793	0	16
land_size	260	33.95769	51.82397	0	350
past_awarn~s	260	19.94615	10.52543	2	50
TLU	260	8.915462	10.86812	0	90.1
AER	260	5.425769	2.308301	1	19.3
DR	260	1.270867	.8553438	0	6

Appendix Table 3: Multicollinearity test (VIF test) for continuous variables for Bid values

Source	SS	df	MS			
				Number of obs	=	260
				F(10, 249)	=	10.80
Model	12.0325827	10	1.20325827	Prob > F	=	0.0000
Residual	27.7328019	249	.111376714	R-squared	=	0.3026
				Adj R-squared	=	0.2746
Total	39.7653846	259	.153534304	Root MSE	=	.33373

WTP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
Bid1	-.0000723	9.89e-06	-7.31	0.000	-.0000917	-.0000528
Bid2	.0000461	9.08e-06	5.08	0.000	.0000282	.000064
Hage	-.0028154	.0019857	-1.42	0.157	-.0067262	.0010955
eduyears	-.00206	.0048236	-0.43	0.670	-.0115603	.0074402
HIncome	6.99e-06	1.85e-06	3.77	0.000	3.34e-06	.0000106
land_size	.0003352	.0004232	0.79	0.429	-.0004982	.0011686
past_awarness	-.0021973	.0023174	-0.95	0.344	-.0067614	.0023669
TLU	-.0019476	.0021363	-0.91	0.363	-.0061552	.00226
AER	-.0091245	.0099837	-0.91	0.362	-.0287878	.0105388
DR	-.0358923	.0247793	-1.45	0.149	-.0846961	.0129115
_cons	1.174	.1183637	9.92	0.000	.9408786	1.407122

Variable	VIF	1/VIF
Bid1	1.75	0.571266
Bid2	1.71	0.585674
Hage	1.60	0.626561
eduyears	1.54	0.647952
past_awarn~s	1.29	0.774732
TLU	1.25	0.797718
HIncome	1.24	0.806153
AER	1.24	0.809701
land_size	1.12	0.894176
DR	1.04	0.957268
Mean VIF	1.38	

Appendix Table 4: Multicollinearity test (VIF test) for continuous variables for labour days

Source	SS	df	MS			
				Number of obs	=	260
				F(10, 249)	=	8.31
Model	9.95269641	10	.995269641	Prob > F	=	0.0000
Residual	29.8126882	249	.119729672	R-squared	=	0.2503
				Adj R-squared	=	0.2202
Total	39.7653846	259	.153534304	Root MSE	=	.34602

WTP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
Labor1	-.0315981	.005569	-5.67	0.000	-.0425665	-.0206298
Labor2	.0087095	.0065536	1.33	0.185	-.0041981	.0216171
Hage	-.0016684	.00209	-0.80	0.425	-.0057848	.002448
eduyears	-.0000811	.0049982	-0.02	0.987	-.0099253	.0097631
HIncome	8.34e-06	1.90e-06	4.39	0.000	4.60e-06	.0000121
land_size	.0004477	.0004378	1.02	0.307	-.0004146	.0013099
past_awarness	-.0028991	.0024054	-1.21	0.229	-.0076366	.0018383
TLU	.0002024	.0021926	0.09	0.927	-.004116	.0045208
AER	-.0137819	.0102986	-1.34	0.182	-.0340653	.0065015
DR	-.0419177	.0256745	-1.63	0.104	-.0924846	.0086492
_cons	1.195123	.1348368	8.86	0.000	.9295573	1.460689

Variable	VIF	1/VIF
Hage	1.64	0.607972
eduyears	1.54	0.648725
Labor1	1.41	0.707052
past_awarn~s	1.29	0.773020
Labor2	1.23	0.812361
TLU	1.23	0.814095
AER	1.22	0.818020
HIncome	1.22	0.821582
land_size	1.11	0.898108
DR	1.04	0.958552
Mean VIF	1.29	

Appendix Table 5: Multicolinearity test (pwcorr test) for dummy variables

	Hgen	Ext_ac~s	landse~1	landse~2	landse~3	landse~4	landse~5
Hgen	1.0000						
Ext_access	-0.0604	1.0000					
landsecuri~1	0.1613	0.0341	1.0000				
landsecuri~2	-0.0636	-0.0100	-0.4202	1.0000			
landsecuri~3	-0.0830	-0.0706	-0.2324	-0.1588	1.0000		
landsecuri~4	-0.0705	0.0577	-0.3042	-0.2078	-0.1150	1.0000	
landsecuri~5	-0.0141	-0.0325	-0.3731	-0.2550	-0.1410	-0.1846	1.0000
Liveli_act~1	0.2344	0.0021	0.1726	-0.1607	-0.0884	-0.0060	0.0237
Liveli_act~2	-0.1024	0.1752	-0.0106	0.0286	-0.0320	0.0649	-0.0514
Liveli_act~3	-0.0547	-0.0282	0.0583	-0.0571	-0.0361	-0.0731	0.0772
Liveli_act~4	-0.1709	-0.0243	-0.1942	0.1784	0.1110	0.0320	-0.0540

	Liveli~1	Liveli~2	Liveli~3	Liveli~4
Liveli_act~1	1.0000			
Liveli_act~2	-0.0760	1.0000		
Liveli_act~3	-0.2084	-0.0320	1.0000	
Liveli_act~4	-0.8210	-0.1262	-0.3461	1.0000

Appendix Table 6: Willing and non-willing respondents in terms of bid amount

dependent variable	Freq.	Percent	Cum.
Yes-Yes	79	30.38	30.38
Yes-No	62	23.85	54.23
No-Yes	70	26.92	81.15
No-No	49	18.85	100.00
Total	260	100.00	

Appendix Table 7: Willing and non-willing respondents in terms of labour days

dependent variable to labour	Freq.	Percent	Cum.
Yes-Yes	93	35.77	35.77
Yes-No	66	25.38	61.15
No-Yes	54	20.77	81.92
No-No	47	18.08	100.00
Total	260	100.00	

Appendix Table 8: Mean willingness to pay estimates in terms of bid amount

Seemingly unrelated bivariate probit — Number of obs = 260; Wald chi2(2) = 106.56; Prob > chi2 = 0.0000

Log likelihood = -305.47257

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
WTP1						
Bid1	-.0001455	.0000301	-4.83	0.000	-.0002045	-.0000865
_cons	1.384996	.2819575	4.91	0.000	.8323694	1.937622
WTP2						
Bid2	-.0003158	.0000315	-10.02	0.000	-.0003776	-.000254
_cons	3.020315	.2966435	10.18	0.000	2.438905	3.601726
/athrho	.7355694	.2170882	3.39	0.001	.3100843	1.161054
rho	.6264608	.1318913			.3005138	.8213832

LR test of rho=0: chi2(1) = 17.0317   Prob > chi2 = 0.0000

Appendix Table 9: Mean willingness to pay estimates in terms of labour Days

Seemingly unrelated bivariate probit — Number of obs = 260; Wald chi2(2) = 176.38; Prob > chi2 = 0.0000

Log likelihood = -228.27449

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
WTPLabr1						
Labor1	-.2867471	.0297747	-9.63	0.000	-.3451045	-.2283897
_cons	4.057844	.3956401	10.26	0.000	3.282404	4.833284
WTPLabr2						
Labor2	-.258569	.0270714	-9.55	0.000	-.311628	-.20551
_cons	3.646712	.3754601	9.71	0.000	2.910823	4.3826
/athrho	.7849513	.3635561	2.16	0.031	.0723944	1.497508
rho	.6555394	.2073244			.0722682	.9046969

LR test of rho=0: chi2(1) = 8.92295   Prob > chi2 = 0.0028

Appendix Table 10: The joint probability of accepting both bid values and marginal effects for bid amounts

```
Seemingly unrelated bivariate probit                 Number of obs =     260
                                                     Wald chi2(26) = 152.40
Log pseudolikelihood = -267.61494                    Prob > chi2   = 0.0000
```

	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
WTP1						
Bid1	-.0001658	.0000331	-5.01	0.000	-.0002306	-.0001009
Hage	.0032142	.0085436	0.38	0.707	-.0135311	.0199594
eduyears	-.0029763	.0209478	-0.14	0.887	-.0440333	.0380806
HIncome	.000018	7.72e-06	2.33	0.020	2.85e-06	.0000331
land_size	.0032207	.0018127	1.78	0.076	-.0003321	.0067735
past_awarness	-.0047843	.0095038	-0.50	0.615	-.0234113	.0138427
TLU	.0262062	.0106053	2.47	0.013	.0054202	.0469922
AER	-.1376964	.0436052	-3.16	0.002	-.2231611	-.0522318
DR	-.1104521	.1083676	-1.02	0.308	-.3228488	.1019445
Hgen	-.0781427	.1987555	-0.39	0.694	-.4676963	.311411
land_secure	.1165355	.0591322	1.97	0.049	.0006386	.2324324
Ext_access	.6988271	.2789015	2.51	0.012	.1521902	1.245464
Major_livelihod	.1230766	.0652201	1.89	0.059	-.0047524	.2509056
_cons	.95449	.607126	1.57	0.116	-.235455	2.144435

WTP2						
Bid2	-.0003424	.0000498	-6.87	0.000	-.0004401	-.0002447
Hage	.0004933	.0086594	0.06	0.955	-.0164788	.0174655
eduyears	-.0006821	.0201089	-0.03	0.973	-.0400948	.0387307
HIncome	.0000204	7.67e-06	2.66	0.008	5.38e-06	.0000355
land_size	.0028362	.0017767	1.60	0.110	-.000646	.0063183
past_awarness	-.0000104	.010187	-0.00	0.999	-.0199766	.0199558
TLU	.0189038	.010097	1.87	0.061	-.0008859	.0386935
AER	-.0464703	.0409647	-1.13	0.257	-.1267597	.0338191
DR	-.136848	.0997835	-1.37	0.170	-.3324201	.0587241
Hgen	-.0474964	.1964349	-0.24	0.809	-.4325017	.337509
land_secure	.1211327	.0558131	2.17	0.030	.0117411	.2305243
Ext_access	.1829031	.2541033	0.72	0.472	-.3151302	.6809364
Major_livelihod	.1414985	.0666292	2.12	0.034	.0109077	.2720894
_cons	2.200905	.6967752	3.16	0.002	.8352509	3.56656
/athrho	.4327086	.2053353	2.11	0.035	.0302588	.8351585
rho	.4075825	.1712243			.0302496	.6832361

Wald test of rho=0: chi2(1) = 4.44083 Prob > chi2 = 0.0351

Marginal effects after biprobit
y = Pr(WTP1=1,WTP2=1) (predict)
= .40160241

variable	dy/dx	Std. err.	z	P>|z|	[95% C.I.	]	X
Bid1	-.0000376	.00001	-4.40	0.000	-.000054	-.000021	8625
Hage	.00083	.0028	0.30	0.767	-.004657	.006317	43.5385
eduyears	-.0008147	.00656	-0.12	0.901	-.013664	.012035	4.85769
HIncome	8.26e-06	.00000	3.59	0.000	3.7e-06	.000013	18325
land_~ze	.0013115	.00058	2.27	0.023	.000177	.002446	33.9577
past_a~s	-.0010871	.00338	-0.32	0.748	-.007709	.005535	19.8962
TLU	.0098161	.00354	2.77	0.006	.002872	.01676	8.91546
AER	-.0407476	.01434	-2.84	0.004	-.06885	-.012645	5.42577
DR	-.0530865	.03401	-1.56	0.119	-.119748	.013575	1.27087
Hgen*	-.0274373	.06568	-0.42	0.676	-.156169	.101294	.473077
land_~re	.0512462	.01814	2.83	0.005	.015697	.086796	2.51538
Ext_ac~s*	.1838505	.08846	2.08	0.038	.010478	.357223	.126923
Major_~d	.0569023	.02238	2.54	0.011	.013034	.10077	3.90385
Bid2	-.0000701	.00001	-6.92	0.000	-.00009	-.00005	8898.08

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Appendix Table 11:- The joint probability of accepting both bid values and marginal effects for labour days

Seemingly unrelated bivariate probit

Number of obs = 260
Wald chi2(26) = 260.78
Prob > chi2 = 0.0000

Log pseudolikelihood = -204.57657

	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
WTPLabr1						
Labor1	-.3025089	.0245774	-12.31	0.000	-.3506797	-.2543381
Hage	-.0127773	.0113916	-1.12	0.262	-.0351044	.0095498
eduyears	-.0008261	.0236953	-0.03	0.972	-.047268	.0456158
HIncome	-2.70e-06	.0000101	-0.27	0.789	-.0000225	.0000171
land_size	-.0015523	.0025254	-0.61	0.539	-.0065019	.0033974
past_awarness	.0112193	.0115369	0.97	0.331	-.0113926	.0338313
TLU	-.0016715	.0124839	-0.13	0.893	-.0261395	.0227966
AER	-.0657849	.0504205	-1.30	0.192	-.1646072	.0330375
DR	.1117803	.1255634	0.89	0.373	-.1343194	.35788
Hgen	.1629421	.252194	0.65	0.518	-.3313491	.6572332
land_secure	-.0357989	.0679753	-0.53	0.598	-.1690281	.0974303
Ext_access	.2832469	.3228451	0.88	0.380	-.3495178	.9160116
Major_livelihod	.0726841	.0832755	0.87	0.383	-.0905329	.235901
_cons	4.646862	.7767465	5.98	0.000	3.124467	6.169257

WTPLabr2						
Labor2	-.2552492	.0336687	-7.58	0.000	-.3212387	-.1892597
Hage	-.0494947	.0097935	-5.05	0.000	-.0686896	-.0302998
eduyears	-.0339579	.0196876	-1.72	0.085	-.0725449	.004629
HIncome	.0000117	8.11e-06	1.45	0.148	-4.17e-06	.0000276
land_size	.0005406	.0018373	0.29	0.769	-.0030605	.0041417
past_awarness	.0185059	.009888	1.87	0.061	-.0008742	.0378861
TLU	.0050557	.011286	0.45	0.654	-.0170644	.0271758
AER	.0292147	.0444034	0.66	0.511	-.0578144	.1162438
DR	.0487327	.0957086	0.51	0.611	-.1388528	.2363181
Hgen	.3924398	.1924608	2.04	0.041	.0152236	.7696559
land_secure	.0652096	.0617759	1.06	0.291	-.055869	.1862882
Ext_access	-.0541911	.2702118	-0.20	0.841	-.5837965	.4754144
Major_livelihod	-.0462421	.0674774	-0.69	0.493	-.1784955	.0860112
_cons	4.93026	.7694439	6.41	0.000	3.422177	6.438342
/athrho	.5395079	.2674872	2.02	0.044	.0152427	1.063773
rho	.4926154	.2025761			.0152415	.7871037

Wald test of rho=0: chi2(1) = 4.06808 Prob > chi2 = 0.0437

Marginal effects after biprobit
y = Pr(WTPLabr1=1,WTPLabr2=1) (predict)
= .45453145

variable	dy/dx	Std. err.	z	P>|z|	[95% C.I.	]	X
Labor1	-.0600128	.00719	-8.35	0.000	-.074104	-.045922	13
Hage	-.0141807	.00363	-3.91	0.000	-.021295	-.007066	43.5385
eduyears	-.0081541	.00721	-1.13	0.258	-.022283	.005975	4.85769
HIncome	2.22e-06	.00000	0.71	0.478	-3.9e-06	8.4e-06	18325
land_~ze	-.0001807	.00071	-0.26	0.798	-.001566	.001205	33.9577
past_a~s	.0065801	.00361	1.82	0.068	-.000498	.013658	19.8962
TLU	.000858	.00441	0.19	0.846	-.007786	.009502	8.91546
AER	-.0061765	.01574	-0.39	0.695	-.037036	.024683	5.42577
DR	.033642	.03469	0.97	0.332	-.034342	.101626	1.27087
Hgen*	.123938	.07331	1.69	0.091	-.019739	.267615	.473077
land_~re	.0082417	.02113	0.39	0.696	-.03317	.049653	2.51538
Ext_ac~s*	.0365831	.0932	0.39	0.695	-.146077	.219243	.126923
Major_~d	.0035387	.02435	0.15	0.884	-.044193	.051271	3.90385
Labor2	-.0600592	.0091	-6.60	0.000	-.0779	-.042218	13.3308

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Appendix C: Field photographs

Appendix Figure 1: Pastoral livestock in Bissil area, Kajiado Central Sub-County

Appendix Figure 2: Livestock grazing in areas invaded by *ipomoea*

Appendix Figure 3: The invasive *ipomoea* plant species in Kajiado Central-Sub county

Appendix Figure 4: Field observation by the researcher- Drying of uprooted *ipomoea* plant species in preparation for burning in Purko, Kajiado.

Appendix D: Ethical approval letter

EGERTON UNIVERSITY

TEL: (051) 2217808
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EGERTON

EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

EU/RE/DIR/009
Approval No. EUISERC/APP/421/2025 ***23rd April*** **2025**

Kidist Abebe Mersha
P.O.Box 536-20115,
Egerton- Njoro, Kenya
Telephone: +254705115646/ +251953860644
Email: kidiabebe03@gmail.com

Dear Mersha,

RE: ETHICAL APPROVAL: HOUSEHOLD WILLINGNESS TO PAY OR PARTICIPATE IN THE CONTROL OF THE IPOMOEA PLANT SPECIES IN KAJIADO CENTRAL SUB-COUNTY, KAJIADO 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/421/2025***. The approval period is ***23rd April 2025 – 24th 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.

"Transforming Lives through Quality Education"

v. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.

vi. Submission of a request for renewal of approval at least 60 days prior to the expiry of the approval period. Attach a comprehensive progress report to support the renewal.

vii. Submission of an executive summary report within 90 days upon completion of the study to ***Egerton University Institutional Scientific and Ethics Review Committee***.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

EGERTON UNIVERSITY
Date. 23/04/2025
RESEARCH ETHICS

Yours sincerely.

Prof. Kennedy N. Ondimu PhD
CHAIRMAN, EUISERC
KNO/BK/

Appendix E: Research permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 215737

Date of Issue: 20/March/2025

RESEARCH LICENSE

This is to Certify that Miss.. KIDIST ABEBE MERSHA of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kajiado on the topic: HOUSEHOLD WILLINGNESS TO PAY OR PARTICIPATE IN THE CONTROL OF THE Ipomora PLANT SPECIES IN KAJIADO CENTRAL SUB-COUNTY, KAJIADO COUNTY, KENYA for the period ending : 20/March/2026.

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215737

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

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See overleaf for conditions

Appendix F: Publication

Agricultural Sciences, 2025, 16(9), 1016-1035
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Household Willingness to Pay for the Control of *Ipomoea* Plant Species and Its Influencing Factors: Evidence from Kajiado Central Sub-County, Southern Kenya

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Abstract

Communal grazing lands are essential for livelihood and food security in pastoralist regions like Kajiado County, Kenya, where communities heavily depend on livestock production. However, with progressive land-use change, biological invasions have increased over the past decade. The invasive *Ipomoea* plant species in Kajiado County has led to the loss of grazing land, threatening the long-term livelihood and food security of the community. This study aimed to (1) characterize households' willingness to pay for the control of the *Ipomoea* species, (2) estimate households' mean willingness to pay, and (3) determine the factors influencing households' willingness to pay. Data from 267 households were collected using a multistage sampling procedure across three wards in Kajiado Central Sub-county: Purko, Dalalekutuk, and Illdamat, that were later cleaned and analysed using SPSS version 27 and STATA version 17, respectively. The data were analysed using descriptive statistics, and a double-bounded dichotomous choice under the CVM approach with a Seemingly Unrelated bivariate probit model was employed to estimate mean WTP and the factors influencing households' WTP. Out of 260 valid responses, 81.15% expressed willingness to pay cash in Kenyan shilling. The model results showed that the mean willingness to pay was 9541.44 KES per year. The results showed that initial and follow-up bid amounts, livestock ownership, access to extension services, the household's primary livelihood activities, and family size were significant variables that influence WTP. The study recommends that policymakers should consider these variables and community participation when designing effective strategies for managing the spread of invasive plant species and enhancing the resilience of pastoral systems.