MOSHI CO-OPERATIVE UNIVERSITY

IMPACT OF CLEAN COOKING ENERGY AND AFFORESTATION ON ENVIRONMENTAL CONSERVATION AT HOUSEHOLD LEVEL IN TANZANIA: A CASE OF MOSHI DISTRICT COUNCIL

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BY

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DECEMBER, 2025

DECLARATION

I, **Advella Ntangeki,** declare that this Dissertation is my own original work and that it has not been presented and will not be presented to any other learning institution for a similar or any other academic award.

Signature ________________________ Date _______________________________

CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the Moshi Co-operative University a Dissertation titled "***Impact of Clean Cooking Energy and Afforestation on Environmental Conservation at Household Level in Tanzania: A Case of Moshi District Council***" *in partial fulfilment of the requirements for the award of Master of Project Planning and Management of Moshi Co-operative University.*

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TABLE OF CONTENTS

DECLARATION i
CERTIFICATION ii
TABLE OF CONTENTS iii
LIST OF TABLES v
LIST OF FIGURES vi
LIST OF APPENDICES vii
LIST OF ABBREVIATIONS viii
ABSTRACT ix
CHAPTER ONE 1
INTRODUCTION 1
1.1 Background Information 1
1.2 Statement of the Problem 4
1.3 Study Objectives 5
1.4 Research Questions 5
1.5 Significance of the Study 6
CHAPTER TWO 7
LITERATURE REVIEW 7
2.1 Definitions of Key Terms 7
2.2 Theoretical Framework 10
2.3 Empirical Literature Review 12
2.4 Research Gap 29
2.5 Conceptual Framework 29
CHAPTER THREE 31
METHODOLOGY 31
3.1 Research Design 31
3.2 Geographical Coverage 31
3.3 Population, Sample and Sampling Techniques 32
3.4 Types and Sources of Data 35
3.5 Data Collection Methods 36
3.6 Data Analysis Methods 37
3.7 Measurement of Study Variables 42
3.8 Data Validity and Reliability 42

3.9 Diagnostic Test 44
3.10 Ethical Considerations 45
CHAPTER FOUR 47
FINDINGS AND DISCUSSION 47
4.1 Chapter Overview 47
4.2 Demographic Information of Respondents 47
4.3 Gender of respondents 48
4.4 Tree Planting Practice and Its Contribution to Environmental Conservation 54
4.5 Determinants of Tree Harvesting Practice and Its Contribution to Environmental Conservation 57
4.6 Cost and Benefits of Clean Cooking Energy Adoption and Its Contribution to Environmental Conservation 60
CHAPTER FIVE 66
SUMMARY, CONCLUSION AND RECOMMENDATIONS 66
5.1 Introduction 66
5.2 Summary of the Key Findings 66
5.3 Conclusion 68
5.4 Recommendations 69
5.5 Areas for Further Studies 70
REFERENCES 71
APPENDICES 90

LIST OF TABLES

Table 1: Sampling frame 34
Table 2: Operational definition of variables and their measurement 42
Table 3: Reliability test 43
Table 4: Multicollinearity test 45
Table 5: Demographic information of respondents.. 48
Table 6: Binary Regression results on determinants of tree planting practice at the household level in Moshi District Council... 54
Table 7: Determinants of tree harvesting practice 57
Table 8: Costs of adopting clean cooking energy 60
Table 9: Benefit-cost ratio analysis of clean cooking energy 62

LIST OF FIGURES

Figure 1: Conceptual Framework 30

LIST OF APPENDICES

Appendix 1: Planting Behaviour 90
Appendix 2: Letter of Introduction 94
Appendix 3: Questionnaire for Households 95
Appendix 4: Interview guide for KII 100
Appendix 5: Permission letters 101
Appendix 6: Proofreading certificate 104
Appendix 7: Plagiarism report 105
Appendix 8: Manuscript 107

LIST OF ABBREVIATIONS

BCR	Benefit Cost Ratio
CBNRM	Community-Based Natural Resource Management
FAO	Food and Agriculture Organisation
LPG	Liquefied Petroleum Gas
NGOs	Non-Governmental Organisations
NTFP	Non-timber Forest Product
RDT	Resource Dependency Theory
SDG	Sustainable Development Goal
SPSS	Statistical Package for Social Sciences
TFS	Tanzania Forest Services Agency
TNBS	Tanzania National Bureau of Statistics
TPB	Theory of Planned Behaviour
TZS	Tanzanian Shilling
WHO	World Health Organisation

ABSTRACT

Clean cooking energy and afforestation practices are essential components in promoting environmental conservation, especially at the household level. The number of Tanzanians using clean cooking energy has increased slightly from 1.5% in 2010 to 6.9% in 2021. This study aimed to analyse the impact of clean cooking energy and afforestation on environmental conservation at the household level in Tanzania: a case study of Moshi District Council. Specifically, the study intended to examine the determinants of tree planting practice and its contribution to environmental conservation at the household level, explore determinants of tree harvesting practice and its contribution to environmental conservation at the household level and determine the costs and benefits of clean cooking energy adoption and its contribution to environmental conservation at the household level in Moshi District Council. A cross-sectional research design was employed. The sample included 381 respondents and 4 key informants, for a total of 385. A survey questionnaire, interviews, and document review were used to gather data, and respondents were chosen by simple random and purposive selection. This study employed a Binary Logistic Regression Model and a Cost-Benefit technique to analyse the data. The findings showed a positive statistically significant association between fruit trees provision, increasing biodiversity, education, marital status and tree planting practice with $p < 0.05$. Moreover, forest management practices, forest protection targets, education, household size and timber production have a statistically significant relationship with tree harvesting practice ($p < 0.05$). Regarding the adoption of clean cooking energy, the cost-benefit analysis showed a BCR of 1.1. The study concluded that when households understand the ecological importance of trees, such as their role in preserving diverse plant and animal species, stabilising ecosystems, and improving climate resilience, they are more inclined to plant and conserve them. With regard to tree harvesting practices, forest management influences household decisions. Again, the cost-benefit analysis for clean cooking energy adoption showed a BCR of 1.1, meaning that using clean cooking energy saves money, time spent going and returning, and time spent gathering firewood, and reduces health risks associated with medical expenses. This study recommended that, given the strong influence of education on both tree planting and harvesting practices, LGAs should integrate environmental education into their local development agendas.

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Access to clean cooking energy and afforestation practices are essential components in promoting environmental conservation, especially at the household level (Bakehe & Hassan, 2023). Clean cooking energy refers to fuels and technologies that produce little to no harmful emissions, such as liquefied petroleum gas (LPG), biogas and improved cook stoves (Wright *et al.,* 2020). In contrast, traditional cooking methods using firewood and charcoal contribute significantly to deforestation, indoor air pollution and greenhouse gas emissions. Afforestation is the process of planting trees in areas that were not previously forested, complementing clean energy use by enhancing carbon sequestration, restoring degraded lands, and supporting biodiversity (Oraon *et al.,* 2023).

The global effort to promote clean cooking energy and afforestation practices is evidenced by the 7th Sustainable Development Goal (SDG), which, according to the UNDP (2020), aims to achieve universal access to sustainable modern energy by 2030. Approximately 2.4 billion people globally lacked access to clean cooking energy in 2021. Of these, 40 per cent and 55 per cent reside in sub-Saharan Africa and developing Asia, respectively (IEA *et al*., 2023). Due to cost constraints, about 75 million people who recently gained access to electricity may lose it, and 100 million have reverted to using biomass cooking fuels despite previously switching to clean cooking fuels (IEA *et al*., 2023).

In Africa, the importance of clean cooking energy and afforestation has been increasingly recognised in light of Earth's finite resources and the adverse impacts of human activities (Kalogiannidis *et al.*, 2023). By adopting clean cooking technologies, such as solar cookers or biogas systems, households reduce their reliance on traditional biomass fuels like wood or charcoal, which are major drivers of deforestation and indoor air pollution (Waswa *et al.,* 2020). Afforestation improves local economies by providing resources such as food and wood, thereby contributing to food security and creating income opportunities (Chiou *et al.,* 2021; McElwee *et al.,* 2021; Barnard *et al.,* 2021).

In Sub-Saharan Africa, about 900 million households depend on solid biomass as their primary cooking energy source, specifically firewood (73%), dung (2%), or crop residue (1%), which are highly dependent on forest products (Matsubara, 2024). Use of charcoal and firewood should focus on expected environmental implications, including, but not limited to, inefficient and incomplete combustion of local biomass. The effective use of clean cooking energy aims to eliminate deforestation, forest degradation, and destruction (Matsubara, 2024). More than 390 million people in Sub-Saharan Africa still cook using environmental fuels and inefficient technologies. Traditional cooking methods are a critical contributor to household air pollution, with prolonged exposure to indoor smoke increasing health risks, which later result in unexpected increases in death rates (Dagnachew *et al.,* 2020).

In East Africa, particularly in Kenya, households are focusing on more accessible solutions, such as improved biomass cooking stoves and solar cooking systems, to address the immediate need to reduce reliance on traditional wood fuel and decrease deforestation (Apondo, 2022). In countries such as Ghana, Nigeria, and Senegal, government-led afforestation programmes were launched to combat deforestation driven by logging, agricultural expansion, and urbanisation (United Nations Environment Programme, 2021). It has been observed that about 90% of households in East Africa still depend on traditional biomass fuels such as firewood, charcoal, dung, and crop residues for cooking. (Stephen and Oluwaseun, 2024).

In Tanzania, maintaining stable afforestation is challenging, primarily due to limited resources and infrastructure (Minja, 2022). The widespread reliance on traditional biomass for cooking in home kitchens contributes significantly to deforestation and air pollution (Pratiti, 2021). The number of Tanzanians using clean cooking energy has increased slightly from 1.5% in 2010 to 6.9% in 2021 (Mandari, 2021). The adoption of clean cooking energy in Tanzania remains significantly below the global average due to high costs, limited awareness, and inadequate infrastructure (Alananga, 2024). Adoption of clean cooking energy and afforestation faces challenges such as high costs, limited awareness, limited access, inconsistent policies, inadequate investment, limited project implementation capacity, and a lack of research, innovation, and technology development (Falcone, 2023).

Clean cooking energy refers to cooking methods that use fuels such as liquefied petroleum gas (LPG) and technologies such as biogas, ethanol, and electricity, as well as improved cook stoves that burn biomass more efficiently (Ayub *et al.,* 2021). These clean cooking energies and afforestation significantly reduce harmful emissions and improve energy efficiency. According to URT (2024), biomass accounts for 82% of Tanzania's primary energy use, 90% of which is used for cooking (63.5% firewood, 26.2% charcoal), and 10% other energies (5.1% Liquefied Petroleum Gas, 3% electricity, and 2.2% solar cookers and improved cook stoves). The use of unclean cooking energy directly contributes to environmental degradation. It is estimated that 469,420 hectares of forest were cleared annually for human activities, including cutting trees for firewood and charcoal for cooking, leading to increased drought and ecological impacts across the country (Tanzania Forest Conservation Group Report, 2022).

In Moshi District Council, a life-cycle costing of alternative biomass-based cooking energy value chains and afforestation depends on total economic costs, including labour, for several biomass-based cooking energy solutions across their entire value chains (Okoko *et al.,* 2018). According to the data, the main source of expense is fuel provision (the gathering and processing of feedstock), whereas upgraded stoves account for only a small portion of the overall Cost per meal, rarely exceeding 5% (Okoko *et al.,* 2018). Perceived benefits, land tenure, and long-term environmental outlooks influence tree-planting and harvesting practices. Additionally, cost-benefit considerations play an essential role in households weighing the upfront costs of clean energy or seedlings against long-term gains like reduced fuel expenses, improved health, and increased agricultural productivity (Batra, 2023), which ultimately shape conservation practice at the household level.

The Government has made efforts at the district level, where education programmes on environmental conservation and tree-planting programmes are implemented by the Moshi District Council, in adherence to the Ministry of Natural Resources and Tourism regulation of 2021, which aligns with environmental conservation, particularly the planting of 1,500,000 seedlings annually (URT, 2021). Despite efforts to adopt clean cooking energy and promote afforestation for environmental conservation, very few studies have been conducted in the Moshi District Council setting on the costs and benefits of these measures. Therefore, to fill this gap, the current study aimed to analyse the impact of clean cooking energy and afforestation on environmental conservation at the household level in Tanzania, to determine the costs and benefits of clean cooking energy and afforestation practices, and their contribution to environmental conservation at the household level in Moshi District Council.

1.2 Statement of the Problem

In Tanzania, fuelwood collection, charcoal production, agriculture, and livestock grazing significantly contribute to forest degradation, leading to reduced forest cover, biodiversity loss, soil erosion, and diminished ecosystem services. In the Kilimanjaro region, where the Moshi District Council is located, agricultural land and grassland have increased from 7% to 14%, while forest area decreased from 85% to 51% between 1998 and 2018, indicating that people still depend on charcoal, which contributes to deforestation (Luzabeth, 2023). People's perceptions and prices of charcoal are the main factors influencing the overdependence on charcoal (Mhache, 2021), thereby contributing to forest degradation in Kilimanjaro, which is primarily linked to poverty, welfare, and limited economic opportunities. The reliance on traditional biomass for cooking, exacerbated by high gas prices, reflects not only an energy crisis but also the economic constraints households in the region face (Dagar *et al.,* 2020).

Efforts have been done by the Government to prevent forest degradation such as encouraging and educating the public through various sustainable programmes and campaigns about clean cooking energy (Barnard *et al.,* 2021), towards afforestation and its impacts the health and well-being of community members, making the need for a shift to sustainable cooking solutions in these households both urgent and essential (Barnard *et al.,* 2021). Despite the growing awareness of the importance of sustainable energy sources, the adoption of clean cooking technologies remains limited at the household level. The dependence on biomass fuels not only increases deforestation but also increases carbon emissions and air pollution (Mosses *et al.,* 2023). This reliance on conventional fuels undermines local and national efforts. Furthermore, there is little literature on the link between low rates of tree planting, high levels of tree cutting, and challenges related to the use of clean cooking energy, creating a research gap. Therefore, by examining the effects of afforestation and clean cooking energy on environmental conservation at the household level in Tanzania, particularly in Moshi District Council, this study aims to close this gap.

1.3 Study Objectives

1.3.1 General objective

The general objective of this study was to analyse the impact of clean cooking energy and afforestation on environmental conservation at the Household level in Tanzania: a case study of Moshi District Council.

1.3.2 Specific objectives

Specifically, this research intended to:

i) Examine determinants of tree planting practice and its contribution to environmental conservation at the household level in Moshi District Council.
ii) Explore determinants of tree harvesting practice and its contribution to environmental conservation at the household level in Moshi District Council.
iii) Determine the costs and benefits of clean cooking energy adoption and its contribution to environmental conservation at the household level in Moshi District Council.

1.4 Research Questions

From the objectives, the following research questions were derived:

i) What are the determinants of tree planting practice and its contribution to environmental conservation at the household level in Moshi District Council?

ii) What are the determinants of tree harvesting practice and its contribution to environmental conservation at the household level in Moshi District Council?
iii) What are the costs and benefits of clean cooking energy adoption and its contribution to environmental conservation at the household level in Moshi District Council?

1.5 Significance of the Study

The findings of this study are expected to be of great importance to various stakeholders, including policymakers, as they provide valuable insights into the relationship between clean cooking energy and afforestation, offering data-driven recommendations for formulating policies that promote sustainable energy use at the household level. It highlights the need for policies that support the widespread adoption of clean cooking technologies, thereby reducing deforestation and improving environmental conservation.

Government; this study supports the Government's efforts to achieve environmental conservation goals by demonstrating the benefits of integrating clean cooking energy into national strategies. The findings guide the development of initiatives that enhance energy access and contribute to afforestation projects, aligning with national environmental objectives.

This study contributes to the existing body of knowledge on clean energy use and environmental conservation, providing a foundation for further research. It opens avenues for exploring the long-term impacts of clean cooking energy on environmental sustainability, offering a case study that can be compared with other regions or countries.

Sustainable Development Goals (SDGs): This research directly aligns with several SDGs, particularly Goals 7 (Affordable and Clean Energy), 13 (Climate Action), and 15 (Life on Land). This study provides useful insights into achieving afforestation and environmental conservation at the local Level by analysing the contribution of clean cooking energy.

The study was also expected to provide key insights, emphasising that residents of Moshi adopt clean cooking energy and cultivate a culture of tree planting as part of environmental conservation efforts.

CHAPTER TWO
LITERATURE REVIEW

2.1 Definitions of Key Terms

2.1.1 Clean cooking energy

The World Health Organization (WHO) (2016) defines clean cooking energy as better cook stoves that burn biomass more effectively, as well as fuels like liquefied petroleum gas (LPG) and technologies like biogas, ethanol, and electricity. Liquefied petroleum gas (LPG), electricity, biogas, and better biomass cook stoves are a few examples. Access to clean cooking is crucial for gender equality, environmental sustainability, and health, according to a 2022 International Energy Agency (IEA) research. Over time, the focus has shifted from merely fuel substitution to broader issues such as efficiency, affordability, and environmental impact. In many African countries, including Tanzania, traditional fuels such as firewood and charcoal dominate household energy use (Doggart *et al.,* 2020). However, there is growing recognition of the benefits of transitioning to clean alternatives. In the context of this study, "clean cooking energy" refers to environmentally friendly cooking fuels and technologies that households in Moshi District Council use to promote environmental conservation and lessen indoor air pollution and deforestation. Examples of these technologies include electric cookers, improved charcoal stoves, and liquefied petroleum gas (LPG).

2.1.2 Clean cooking energy adoption

According to the United Nations Sustainable Energy for All (SEforALL) initiative (2020), clean cooking energy adoption is not just about access but about the consistent and sustained use of clean energy solutions. Historically, barriers such as Cost, cultural preferences and lack of awareness have slowed adoption in many developing regions. Adoption patterns vary globally: in urban Kenya and India, subsidies and awareness campaigns have led to increased use of liquefied petroleum gas (LPG), while rural areas still rely heavily on biomass. In Tanzania, adoption of clean cooking energy remains a challenge due to income constraints and limited infrastructure (Alananga *et al.,* 2024). In this study, clean cooking energy adoption refers to the decision and sustained practice of households in Moshi District Council to switch from traditional biomass fuels to cleaner alternatives like liquefied petroleum gas (LPG), electric stoves or improved cook stoves for daily cooking purposes

2.1.3 Afforestation

Afforestation is the process of planting trees in an area that previously had no forest cover. The Food and Agriculture Organisation (FAO) (2015) defines it as the establishment of forests through planting and seeding on land that historically has not contained forests. Globally, afforestation is recognised as a key strategy for combating climate change, preventing desertification, and enhancing biodiversity. In countries like China and India, large-scale afforestation programmes have been implemented to restore ecological balance (Zhu *et al.,* 2023). In Tanzania, afforestation is promoted through Government and community-based initiatives to combat deforestation, improve soil fertility, and support sustainable livelihoods (Owusu *et al.,* 2021). In the context of this study, afforestation refers to households or communities in Moshi District Council actively planting trees on non-forested land to restore natural vegetation, support environmental conservation efforts, and mitigate the impacts of fuelwood harvesting and climate change.

2.1.4 Environmental conservation

According to the United Nations Environment Programme (UNEP) (2019), Environmental conservation is the sustainable management and protection of natural resources and ecosystems to ensure their long-term health and productivity. It involves actions to protect biodiversity, prevent pollution and use resources efficiently. Historically, conservation efforts focused on wildlife protection and national parks but have since evolved to include community-based and household-level practices (Nelson *et al.,* 2021). Globally, countries have adopted conservation strategies as part of climate action and sustainable development. In Tanzania, environmental conservation includes afforestation, the use of clean energy, waste management, and the protection of natural resources. Within the context of this study, environmental conservation refers to household-level actions in Moshi District Council, such as using clean cooking fuels and planting trees, that aim to reduce deforestation, enhance air and soil quality, and promote a healthier, more sustainable environment for current and future generations.

2.1.5 Household

A household is defined by the Tanzania National Bureau of Statistics (NBS) (2022) as a group of people who live together in the same dwelling unit and share meals or living arrangements. The United Nations similarly defines it as all persons who make common provisions for food or other essentials for living (Kamiya & Hertog, 2020). Household characteristics such as income, education level and family size significantly influence environmental practices, including energy choices and resource use. Across countries and cultures, household roles in environmental conservation vary according to gender dynamics, economic activities, and social norms (Lee *et al.,* 2020). In this study, a household is the basic unit of analysis in Moshi District Council, comprising individuals, whether related or not, who live together, cook together, and collectively make decisions regarding energy use, tree planting, and other daily practices that directly affect environmental conservation and natural resource sustainability at the community level.

2.1.6 Tree harvesting practice

According to the World Bank (2021) and FAO (2015), Tree harvesting practice refers to the manner in which individuals or households cut down or use trees for fuel, construction or other domestic purposes. Unsustainable harvesting contributes to deforestation, biodiversity loss and climate change. Energy needs, cultural traditions, economic conditions, and the enforcement of environmental laws influence tree harvesting practices. In many rural African settings, trees are harvested primarily for firewood or charcoal, with insufficient replanting (Seifert, 2020). In Tanzania, tree harvesting is common at the household level, especially where alternative energy sources are limited (Aslam *et al.,* 2021). In this study, tree harvesting practice refers to households in Moshi District Council cutting or collecting trees for daily use, especially for cooking fuel, without proper forest management. It examines whether such practices are sustainable or contribute to environmental degradation, and how adopting clean energy or afforestation alters them.

2.2 Theoretical Framework

2.2.1 Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB), developed by Ajzen (1991), is a widely accepted psychological framework for understanding and predicting human behaviour across contexts. The theory posits that behavioural intention is the most immediate determinant of actual behaviour and is influenced by three key constructs: attitude toward the behaviour, subjective norms, and perceived behavioural control. Attitude refers to an individual's overall evaluation of performing the behaviour, whether it is favourable or unfavourable. Subjective norms involve the perceived social pressures to perform or not perform the behaviour, while perceived behavioural control reflects the individual's perception of the ease or difficulty in carrying out the behaviour, which is closely related to past experiences and anticipated challenges.

In this study, TPB is adopted as the main theoretical framework to assess household behaviours related to tree planting and the adoption of clean cooking energy. The theory is especially useful for examining behavioural changes over time, focusing on how people's attitudes, societal expectations, and perceived control influence their environmental actions. It provides valuable insights into why households may choose to plant trees, such as for biodiversity enhancement, water availability, firewood or timber production or adopt clean energy solutions, depending on both internal motivation and external enabling factors. Studies such as Ibrahim *et al.* (2022) and Staddon *et al.* (2020) have shown that these determinants are multidimensional, encompassing income levels, environmental awareness, and policy-related influences. Furthermore, TPB is relevant to the importance of using modern technologies for tree harvesting, which helps maintain and protect biodiversity, as Fernández and Lamartine (2023) point out.

One of the key strengths of TPB lies in its versatility and structured model, which enable researchers to hypothesise clear relationships among variables and to apply standardised tools for data collection and analysis. The theory has been successfully used in diverse areas such as health behaviour, environmental conservation, and consumer decision-making. However, despite its strengths, TPB has some limitations. It tends to emphasise behavioural intention rather than actual behaviour, and in real-world settings, intentions do not always translate into action due to external constraints or unanticipated circumstances. It may also overlook habitual, emotional, or spontaneous behaviours that significantly influence human action. Ajzen (2020) acknowledges these shortcomings, yet maintains that the TPB remains a valuable framework for examining planned behaviour. In this study, despite its limitations, the TPB is instrumental for analysing the psychological and contextual factors that shape household decisions regarding environmental practices, offering both theoretical and practical contributions to sustainable development, in which people tend to opt for clean cooking energy for better health and environmental conservation.

2.2.2 Resource Dependency Theory

The Resource Dependency Theory (RDT), introduced by Jeffrey Pfeffer and Gerald R. Salancik in 1978, offers a comprehensive framework for understanding organisational behaviour, decision-making, and interdependence in the management of resources. The theory emphasises how access to and control over critical resources influence the behaviour of organisations and individuals within broader systems. In the context of this study, RDT is relevant for explaining the determinants of household-level tree planting behaviour. It suggests that household decisions regarding environmental actions, such as tree planting, are shaped by resource availability and accessibility, individual perceptions, and broader environmental considerations. Factors such as the Cost of accessing tree seedlings, awareness of climate change impacts, and assurance of water availability are critical in influencing whether households choose to engage in tree planting activities (Alkhuzaim *et al.,* 2022).

The relevance of this theory is further underscored by its focus on resource allocation and utilisation, as well as on the role of external stakeholders, including government agencies, NGOs, and local institutions, in shaping household environmental behaviour. RDT also highlights the significance of power dynamics, organisational legitimacy, and inter-organisational alliances, which are often critical in advancing environmental conservation initiatives (Babelytė-Labanauskė, 2022). This theory provides a valuable lens for examining both the drivers and barriers to household engagement in sustainable practices such as tree planting and harvesting.

Despite its strengths, RDT is not without limitations. It tends to focus on macro-level organisational interactions, which can make it challenging to directly translate its principles into individual or household-level behaviour. It also struggles with aggregating individual decisions into a coherent organisational-level analysis (Pfeffer & Salancik, 2021). RDT is applied in this study by providing a theoretical foundation, emphasising the role of resource dependence in shaping household behaviour, thereby contributing to a deeper understanding of how to enhance tree planting and environmental conservation efforts in resource-limited settings.

2.3 Empirical Literature Review

2.3.1 Energy and cooking technologies used in the country

A study by Sepee and Tesfahun (2024) on the role of firewood in rural households found that over 80% of households rely on it, compared with a much smaller share in urban areas. Firewood's dominant role in rural households is explained by accessibility (collected rather than purchased), low or zero direct monetary Cost, and limited market alternatives, factors that also make households price-sensitive but time-rich (i.e., time costs from collection). The time burden, often borne by women and children, reduces the time available for education and income-generating activities and is therefore an important welfare variable to include in evaluations of cook stove interventions. Interventions that reduce collection time (e.g., more efficient stoves or accessible alternative fuels) can have measurable welfare effects beyond fuel savings and should be evaluated for their time-use and educational impacts, as well as for their direct cost savings. The energy and technologies used for cooking in the country include animal dung and crop residues, firewood, charcoal, and kerosene (Sagastume Gutiérrez *et al.,* 2022). Alternative charcoal, bioethanol, Liquefied Petroleum Gas (LPG), natural gas, biogas, electricity, improved cook stoves, and solar stoves. The use of a literature review in this study reflects the absence of using a questionnaire. Therefore, a study using a questionnaire is needed to obtain detailed information on the energy and cooking technologies used in Moshi District Council.

Nzabona *et al.* (2021) asserted that charcoal is the primary fuel of choice in many urban settings because it is sold in small, affordable units and is perceived as cleaner as and more convenient than firewood. Production is highly inefficient: national analyses estimate that roughly 10–12 tonnes of logs are consumed to produce 1 tonne of charcoal, placing strong pressure on forests and contributing to deforestation and greenhouse gas emissions (Sasaki, 2021). Urban demand therefore transmits environmental costs to rural landscapes, forming a clear link between household fuel choice and land-use change. The study highlighted the critical role of charcoal as the primary fuel in many urban settings, as well as the tailored cooking energy systems used by many households. However, the study did not focus on how best cooking technologies used influence environmental conservation at the household level, a gap the current study aimed to fill.

A study by Kumar *et al.* (2024) observed that animal dung and crop residues are commonly used in rural and pastoral communities because they are easily accessible and essentially cost-free. However, their energy density and combustion quality are lower than those of wood or charcoal, and they often produce high particulate emissions unless processed. Their use therefore reduces monetary outlays but still exposes households to harmful emissions, and their collection can compete with soil-health uses. According to Kimemia and Van Niekerk (2024), kerosene has been used for many years as a cooking fuel in some parts of the country. However, it is important to note that using kerosene for cooking poses several challenges, including safety concerns, as it can cause fires or explosions. Since kerosene easily ignites and spreads fire quickly, its use for cooking can pose significant safety risks to users. Empirical evidence and safety reviews highlight kerosene's risks when used for cooking: it poses fire-hazard and explosion risks and emits pollutants that degrade indoor air quality. Both qualitative and quantitative studies associate kerosene use with increased household risk of burns and respiratory illness relative to cleaner fuels. These safety and health dimensions reduce kerosene's attractiveness as a transitional fuel. Therefore, risks associated with kerosene use call for a study to assess clean cooking energy sources that have a positive impact on environmental conservation and human health protection.

Yustas *et al.* (2022) argued that alternative charcoal is produced from various plant residues and agricultural by-products, which are bound together with binders such as clay, starch (including cassava and sweet potato flour), molasses, and/or glue. These residues include paper, sawdust, wood shavings, dry leaves, and rice husks. In addition to generating energy, using these residues helps conserve the environment. The mix used to make alternative charcoal determines its quality and price. Challenges in developing alternative charcoal technology include low public awareness of this type of energy and high initial production costs, including those for production and drying equipment. Some types of alternative charcoal require special stoves, which adds to the user's Cost.

According to Dey *et al.* (2024), cleaner fuels (LPG, natural gas, electricity) are associated with improved air quality outcomes, but their adoption is uneven. Empirical studies from Tanzania and other East African contexts consistently find that household income, education, fuel availability, and fuel cost are the strongest predictors of switching from biomass to LPG or electricity. Supply chain constraints, refill costs, safety perceptions, and cultural cooking practices also limit rapid uptake. National gas discoveries and infrastructure expansion increase the potential for broader uptake, but household-level affordability and reliable distribution remain bottlenecks.

2.3.2 Determinants of tree planting practice and its contribution to environmental conservation at the household level

Kaudo *et al.* (2022) aimed to analyse the factors influencing community tree-planting practices. The study used a mixed-methods approach that included both qualitative research through focus groups and quantitative research via questionnaires administered to residents of the ten locations in Wangchieng ward, Homabay County, in December 2021. A sample of 380 community households was selected, 38 in each location, using a purposive sampling technique, and mixed structured questionnaires were delivered to them. The questionnaires assessed community attitudes and conservation involvement in relation to the socio-economic background, benefits, and costs of planting trees. This study used a questionnaire for data collection but did not apply interviews to gain an in-depth understanding of the study variables. Therefore, the current study was undertaken to conduct key informant interviews to gain broad knowledge of the factors influencing tree planting practices for environmental conservation.

Results of Kaudo *et al.* (2022) showed that most residents of Wangchieng ward have positive attitudes towards tree planting. The data collected from the questionnaires showed that socio-economic factors, such as age, education level, and income, were positively associated with participation in community tree-planting programmes among respondents. A stepwise Binary Logistics conducted ranked six variables as the major factors influencing household tree planting. The findings showed that the importance of trees was ranked first (most influential variable) with an odds ratio of 9.287, and education level ranked sixth with an odds ratio of 1.207. This study concluded that the full model, containing all variables, was statistically significant at χ^2 (10, N = 370) = 98.312, $p < .001$, clearly indicating that the model distinguished between respondents who had planted trees in the last six months and those who had not. Thus, it was recommended that household tree planting can be significantly enhanced by improving knowledge of the importance of trees and their various ecosystem goods and services, making seedlings cheaply available to households, and promoting households to engage in agroforestry on their farms.

Similarly, Kulindwa (2016) analysed factors influencing households' tree-planting practices and the number of trees planted. The Coast and Morogoro regions in eastern Tanzania were selected as the case, and data were gathered from 202 households in 11 villages in these regions where tree-planting programmes have been or are still active. A Heckman model is used to analyse the factors driving tree-planting practice. Results indicated that households obtain wood energy from forest reserves (57%) and from their own planted trees (9.1%). Empirical findings show that the most important factors have significant positive effects on households' tree-planting practices and the extent to which they were implemented. These factors include household land size, household awareness of tree-planting programmes, tree planting for wood energy, and the age of the household head. The right to harvest and transport tree products, households' attitudes towards tree planting, and family size have significant negative effects on households' tree planting practices. This paper is the first comprehensive study to analyse the factors influencing households' tree-planting practices in Tanzania and provides useful insights for other developing countries with similar conditions. Notably, while Kaudo *et al.* (2022) emphasise the role of socio-economic enablers, Kulindwa highlights resource-based factors such as land availability and energy needs, underscoring the complex trade-offs households face when balancing energy consumption and environmental conservation.

Danquah *et al.* (2023) assessed the socio-economic factors influencing homeowners' perceptions of the ecosystem services provided by trees and identified the factors affecting tree planting and retention decisions in three cities in Ghana. Questionnaires were used to collect data from homeowners in three regional capital cities in Ghana*: Kumasi (N* = 205), Sunyani (N = 200), and Cape Coast (N = 200). A Binary Logit Model and MANOVA were applied to the data set of these 605 homeowners. The results of the Binary Logit Model indicated that homeowner age was significant (P = 0.009) and negatively associated with the decision to plant or retain existing trees. Monthly income ($P < 0.001$), housing type (P = 0.042), and ethnicity (P = 0.089) were significant and positively associated with homeowners' tree-planting and retention decisions. This concluded that. Geographical location (city), Gender and marital status significantly influenced homeowners' perceptions of the ecosystem services provided by urban trees. Moreover, the results revealed a negative relationship between age and tree planting, but positive associations with income, dwelling type and ethnicity. This suggested that urban afforestation decisions are more likely to be influenced by economic capacity and housing characteristics than by environmental values alone. Moreover, perceptions of ecological benefits varied by Gender, marital status, and location, indicating that environmental awareness is unevenly distributed across social groups.

Apeh *et al.* (2023) sought to explore the determinants of adopting urban tree planting as a method of reducing climate change in the metropolis of Enugu. The 823 respondents were chosen using a multistage random selection process. Logistic regression and descriptive statistics were employed in analysing the data. The study results indicated that the majority (53%) of the respondents were male, with an average age of 36 years. The majority of households were aware of climate change, as they perceived extreme weather events such as drought, reduced rainfall, and rising temperatures. Moreover, the majority of households experienced declines in agricultural productivity, reductions in farm returns, and increases in unemployment during peak seasons. The mitigation strategy households adopt to address climate change is urban tree planting, which contributes to improved livelihoods.

Furthermore, the study results showed that the price of the tree, access to information on the changing climate, access to water, use and access to trees, and occupation positively influenced households' decisions to adopt urban tree planting. Therefore, this recommends that stakeholders, such as governments, promote the delivery of agricultural extension and advisory services by improving their climate information systems, among other strategies, to boost inclusive adaptation to the effects of climate change. These findings reveal that the intersection of socio-economic status, resource availability, behavioural attitudes, and environmental knowledge shapes household-level tree planting. While income and education positively influence participation, constraints such as limited land access, the Cost of seedlings, and limited awareness of ecological benefits hinder wider adoption.

Nigatu *et al.* (2021) examined the factors influencing the adoption of agroforestry by smallholder farmer households in Tanzania: Case studies from Morogoro and Dodoma. Logistic regression (logit model) was used to analyse household survey data collected from 697 smallholder farmers. Results indicate that only 71 farmers (10.19%) report planting new trees and actively practising agroforestry. Farmers who are part of a project can rent land and have a source of seedlings, and are more likely to adopt agroforestry. When farmers perceive rainfall as changing, their land rights as only moderately secure, and their right to plant trees as dependent on obtaining permission from the landowner or family members, they are less likely to adopt agroforestry. Policy interventions should provide a reliable source of agroforestry inputs, such as seedlings, to ensure that the resource requirements for agroforestry are met.

Maleknia *et al.* (2025) investigated the key determinants of farmers' adoption of agroforestry in forested regions: insights from analysis of psychological factors. This research examined the psychological determinants of agroforestry adoption using a survey of 361 farmers living in forested areas. Grounded in the theory of planned practice, the research approach integrates supplementary variables, such as organisational support and farmers' perceptions of the economic benefits of agroforestry. The results indicate that the fundamental model explains 53% of the variance in farmers' intentions to adopt agroforestry, whereas the augmented model, incorporating additional factors, enhances the explanatory power to 70%. Key factors influencing farmers' intentions encompass attitudes towards agroforestry, perceived behavioural control, and perceived economic advantages. In contrast, subjective norms and organisational support did not have a substantial impact on intention. Based on these insights, it is recommended that programmes focus on improving farmers' favourable opinions, autonomy, and understanding of agroforestry's benefits.

Zaca *et al.* (2023). Factors influencing the uptake of agroforestry practices among rural households: Empirical Evidence from the KwaZulu-Natal Province, South Africa. A sample of 305 families was collected from three communities in the KwaZulu-Natal region: Swayimane, Umbumbulu, and Richmond. Principal component analysis and a Binary Logistic Regression Model were utilised to examine the data. Understanding, attitudes, and perceptions regarding agroforestry were found to positively affect the adoption of agroforestry methods. The findings indicated that age, farming experience, educational attainment, and land area were factors influencing agroforestry adoption. Consequently, the study recommends that politicians, extension officers, and climate change advocates consider the socio-economic attributes, knowledge, attitudes, and perceptions of rural families when formulating agroforestry initiatives. It is advisable to implement training programmes featuring practical demonstrations to enhance understanding of the advantages of agroforestry practices and to motivate rural households to save on-farm trees and bushes.

Kegode *et al.* (2025) assessed the role of exposure in the adoption and intensity of tree-planting practices among smallholder households in Rwanda. The results indicate that exposure augmented the likelihood of adoption by 7% ($p = 0.03$). A greater likelihood of adoption (15%, $p = 0.01$) was observed in households exposed both before and after the baseline period, indicating cumulative effects of exposure over time. Exposure moderately increased tree diversity and abundance in agricultural fields; however, farmers preferred cultivating more exotic species than indigenous ones. A greater likelihood of adoption and increased tree numbers were observed when male household members were involved, and the provision of seedlings increased both tree numbers and species diversity among adopters. This study advocated a more systematic approach to training and information dissemination, emphasising seedling availability and an appropriate policy framework.

Beyene *et al.* (2019). Household-level determinants of agroforestry practice adoption in rural Ethiopia. This research seeks to understand the reasons for the limited adoption of agroforestry technologies by examining household-level factors that may affect their implementation. This research employed the Heckman selection model on household-level data gathered from various districts of rural Ethiopia. The results indicate that the age of the family head, land area, tenure insecurity, and proximity to urban centres significantly influence the likelihood of adoption. The findings indicate that, following the adoption decision, the extent of land allocated to agroforestry technologies is affected by household attributes, including the Gender of the household head, land area, and proximity to urban centres. This study revealed significant methods to promote agroforestry technologies in rural Ethiopia. Our findings may also provide scientific evidence for other countries with predominantly agricultural livelihoods and natural resources, such as forests.

Danquah *et al.* (2023) examined the determinants of homeowners' tree-planting and retention practices in built-up urban areas of Ghana. Data were gathered from householders in three Ghanaian regional capital cities (Kumasi: N = 205; Sunyani: N = 200; Cape Coast: N = 200) via questionnaires. The data set of these 605 homeowners was subjected to a MANOVA and a Binary Logit Model. According to the Binary Logit Model's findings, the homeowner's age was significantly (P 0.009) correlated with whether they chose to plant new trees or keep their current ones. The homeowners' decisions to plant and keep trees were significantly and favourably correlated with their monthly income ($P < 0.001$), dwelling style ($P = 0.042$), and ethnicity (P 0.089). Homeowners' opinions of the ecosystem services offered by urban trees were strongly influenced by their marital status, Gender, and geographic location (city).

2.3.3 Determinants of tree harvesting practice and its contribution to environmental conservation at the household level

Coppinger *et al*. (2023), in a study conducted in rural North-Western Zambia, assessed forest dependence using household interview data collected from 574 households and highlighted the high forest dependence of households (97%) despite growing concerns over unsustainable use. Through the development of a forest use sustainability indicator, the study found that actual forest use behaviour exceeded sustainable limits, largely due to poverty, population pressure, and limited alternative livelihood sources. This demonstrates that high dependency without adequate regulation or alternatives accelerates unsustainable tree harvesting.

Widespread dependence of rural communities on forest products is recognised, however, existing data on forest product use are limited and may not reflect current trends, as dependence patterns change over time. Effective policies should consider the attitudes and behaviours of forest product users and seek to understand the linkages between behaviour and forest use. Forest use data were recorded to inform the development of a forest use sustainability indicator, along with attitudes to forests and forest management, in an area where livelihoods depend on forest resources, against the backdrop of rapid national population growth and deforestation rates.

According to Coppinger *et al*. (2023), while forest dependence among households was high (97% of households used forest products) and attitudes were generally pro-forest conservation, actual forest use (behaviour) showed signs of being unsustainable, as measured by the sustainability indicator used to assess forest use sustainability. By using an indicator approach to measure the sustainability of forest use at the household level, we were able to project future sustainability based on theoretical changes in harvesting practices. Local-level quantifications of sustainability using standardised tools, such as composite indicators, could contribute to greater transparency in the analysis of factors affecting sustainability and to the development of appropriate, inclusive, and situation-specific policies to sustain forest use.

Similarly, Mushi *et al.* (2020) analysed non-timber forest product extraction on the slopes of Mt. Kilimanjaro and found that household characteristics, such as Gender, age, income, and land size, significantly influenced harvesting behaviour. Younger women from larger households with low income and limited cultivated land were more likely to engage in frequent firewood and fodder collection. This underscores how economic vulnerability and gender roles drive forest exploitation at the household level.

Further evidence of socio-cultural and regulatory influences is seen in Al-Okaishi's (2020) study in Yemen's Socotra Island. The research uncovered how traditional reverence for local authority contributed to sustainable forest use. However, increased participation by guest harvesters without local affiliations weakened traditional controls, leading to unsustainable harvesting of dragon's blood tree resin. This shows that while community-based management can support conservation, it can be undermined without external regulatory support and education. Adoption of sustainable alternatives, such as agroforestry, is also linked to tree-harvesting behaviour. Jha *et al.* (2021), using data from Morogoro and Dodoma in Tanzania, observed that households involved in agroforestry programmes were more likely to adopt sustainable practices due to enhanced access to technical knowledge, stakeholder interaction and social networks. This implies that capacity-building initiatives can shift behaviours from extractive to regenerative practices.

In Ethiopia, Massa and Mosa (2021) found that the decision to grow trees for conservation purposes was influenced by factors such as land size, prior experience in tree growing, and income from tree product sales. Interestingly, communal spaces such as funeral grounds retained more native tree species than private farms, suggesting the importance of cultural and communal conservation practices. Strengthening indigenous institutions and facilitating knowledge-sharing were suggested as key strategies to shift household behaviour towards sustainable tree management.

Sheko *et al.* (2023) assessed the importance of socio-economic and institutional factors in the collection of dry forest products: The case of gum and resin in Jawi District. The primary data were collected from 259 randomly selected houses. The results show that a household's participation in dry forest product collection and the amount of money earned from such activities are significantly influenced by age, proximity to the forest, market distance, participation in participatory forest management (PFM), frequency of forest extension, and low wealth status. The market development of resources to increase locals' incomes should be the main focus of policies and measures aimed at improving households' well-being in the nation's dry forest areas.

Girma *et al.* (2024), in the study titled “Correlation of woodfuel production participation among rural households in the dry lands of Ethiopia.” Data were gathered from 1,114 families that produced and did not produce wood fuel through purposefully selected focus groups, key informant interviews, and household surveys. A Binary Logistic Regression Model and descriptive statistics were used to examine the gathered data. The findings showed that households were compelled to engage in woodfuel production mostly due to drought and associated shocks. According to the model results, household participation in woodfuel production is negatively impacted by several statistically significant factors, including age, education, landholding, livestock holding, production asset value, ownership of improved cook stoves, years of residence in the area, distance from the forest, access to forest extension, and institutional membership. The study's conclusions imply that socio-economic, demographic, institutional, and environmental elements associated with families' decisions to engage in woodfuel production must be taken into account for the sustainable management and use of dry land forest resources.

Wale *et al.* (2022) assessed the determinants of rural household livelihood dependence on non-timber forest products. The study discovered a considerable degree of forest dependence in the study area using survey data from 150 families that depend on forests and a logit-transformed Ordinary Least Squares (OLS) model. The empirical results demonstrated that off-farm incomes, employment incomes, forest vouchers obtained from the “Wild lands Project” in exchange for planting trees, household asset values, the timing and dates of visits to the forest for the collection of forest products, and perceived temperature changes all have a significant impact on the contribution of forest resources to rural livelihoods. These results suggest that, for everyone to accept and understand the rules, institutional frameworks for initiatives such as the “Wild lands Project” must be created from the start, with input from all relevant parties. Legislative measures are also required to enable rural inhabitants to diversify their income sources and sustainably support their livelihoods, thereby increasing resilience and lessening the strain on natural forests.

Pelane *et al.* (2023). Rural community dependency on woodland resources: the case of Foley and Makomoto settlements in Central-East Botswana. A systematic questionnaire survey was used to collect data from 183 randomly selected households in three settlements surrounding the Chobe Forest Reserve. Data analysis was done using a Binary Logistic Regression Model. The findings indicated that although other socio-economic characteristics did not significantly affect household reliance on forests, age and education did. As respondents' ages and intellectual attainment increased, their reliance on forests decreased. As a result, younger people were more dependent on forest products than their older counterparts, but dependence decreased with increasing educational attainment. Diversifying youth livelihoods through alternative opportunities and higher education is essential to reducing forest dependency and preserving forests for future generations. This will help to maintain a balance between biodiversity protection and forest dependency.

Biland *et al.* (2021) examined why households depend on forests for income. Analysis of factors influencing households' decision-making behaviours. This study evaluated households' decision-making patterns regarding revenue from the surrounding wooded area, using socio-economic characteristics and survey data from 150 randomly selected households across 21 villages in Pakistan's forest-rich district of Swat. The data were analysed using descriptive statistics and econometric methods, such as logit and Tobit. Off-farm activities accounted for the largest share of respondents' household income (37%), and forest activities for the smallest (16%). The largest source of forest income (66%) is fuelwood, followed by fodder (13%) and medicinal plants (20%). According to this study, households' decision to rely on forest income and their overall income were strongly and negatively correlated with having more physical assets, having more family members who work off the farm, and receiving more income from off-farm sources.

Additionally, it was found that households' overall income was strongly and negatively correlated with their membership in joint forest management committees (JFMCs) and their proximity to the market. Nonetheless, households' reliance on forests was positively and strongly correlated with household size. The study suggests that, especially for large and low-income families, JFMCs should be established to provide off-farm activities and involve locals in forest management.

In tree harvesting, it is important to replant areas where trees have been cut down and to practice selective cutting, which implies choosing specific trees for removal based on their age, size, species, and the health of the surrounding forest, instead of clear-cutting large areas all at once (Aszalós *et al.,* 2022). The Food and Agriculture Organisation of the United Nations (FAO) projects annual worldwide increases of 1.5% for sawn wood, 3.3% for wood-based panels, and 3% for paper for the 2005-2020 period (World Bank, 2021). Afforestation for environmental conservation is a multifaceted approach that benefits local and global ecosystems (McElwee *et al.,* 2021). According to Ghorbani *et al.* (2023), afforestation supports biodiversity, helps combat climate change, improves soil fertility and air quality, and offers socio-economic benefits. This makes it an important strategy for sustainable development and environmental protection (Oláh et *al.,* 2020). Climate change and deforestation are closely interlinked, while tree planting, conversely, acts as a countermeasure by sequestering carbon, thus mitigating climate change effects (Verkerk *et al.,* 2022). In the United States of America, households are increasingly adopting advanced clean cooking technologies, like electric or induction stoves, often coupled with educational programmes that promote renewable energy and sustainability (Antonopoulos *et al.,* 2023). The United Nations Environment Programme (2021) points to the need to recognise that Earth's resources are limited and that human activities can have long-lasting, detrimental effects.

According to Fernández and Lammertink (2023), harvesting practice, particularly the selective cutting of mature trees, plays an essential role in environmental stewardship at the household level. It ensures the health and sustainability of the forest by removing only trees suitable for use, thereby maintaining ecological balance and biodiversity. This approach is essential as it allows forests to regenerate and continue providing ecological services such as carbon sequestration and soil conservation (Di Sacco *et al.,* 2021). Clean energy not only minimises indoor air pollution and improves health outcomes but also contributes significantly to forest conservation by reducing the need for fuelwood. Therefore, integrating clean energy use with sustainable harvesting practices enhances environmental conservation at the household level.

Dagnachew *et al.* (2020) argued that investment in clean cooking oil in East Africa remains underexploited. Observing climate finance, business model innovation, and proactive Government engagement highly contribute toward sustainable investment in clean cooking energy. Despite clean cooking energy adoption strategies and mechanisms, the sector is still hampered by limited financial resources, affordability barriers, weak policy enforcement and limited consumer awareness. The financing decision for clean cooking solutions requires a collaborative approach to unite public funds, donor grants, private investment, and innovative mechanisms such as carbon finance. Governments are urged to set adequate budgets to enable the acquisition, installation, and distribution of clean cooking energy to all households. Given the sector's high investment and capital intensity, the call for donors to facilitate program implementation is a significant milestone. The European Investment Bank (EIB) has provided \$15 million to finance clean cooking energy in Kenya and to support the expansion of electric induction cookers across East Africa (Matsubara, 2024). This investment aims to ensure that clean cooking energy reaches over one million households, thereby reducing carbon dioxide emissions by 12 million tons over five years (Matsubara, 2024).

A study by Elasu *et al.* (2025) conducted in Uganda observed that the Government has implemented government-led initiatives to diversify clean fuel options beyond LPG, such as ethanol and biogas. In its effort, the Government launched the 2024 Uganda Clean Cooking programme, which aims to reach three million households with clean energy by 2030. With this program, key developments include, but are not limited to: government incentives for ethanol fuel production and blending, partnerships with NGOs and donors to expand biogas digesters in rural areas, and consumer awareness campaigns highlighting the health and environmental benefits. On the other hand, the clean cooking program in Uganda is still affected by limited Liquefied Natural Gas distribution infrastructure, specifically in the northern and eastern regions; ethanol supply chain scalability; and financial barriers and a lack of consumer financing options (Elasu *et al.*, 2025). According to Kellomäki (2024), sustainable tree planting and harvesting practices are essential for maintaining forest health and preventing land degradation. Responsible harvesting, such as selective cutting rather than clear-cutting, ensures that only mature or less vital trees are removed, preserving biodiversity and the ecological balance of forests (Kellomäki, 2024).

2.3.4 Cost and benefits of clean cooking energy adoption and its contribution to environmental conservation at the household level

Gill-Wiehl *et al.* (2021) examined the affordability of clean cooking technologies, arguing that traditional affordability measures often overlook the irregular and seasonal income sources common among low-income households. Their study emphasised the need for broader affordability frameworks that incorporate gender disparities, rural-urban divides, and the simultaneous use of multiple fuel types (fuel stacking). Their findings suggest that designing clean energy interventions solely based on income thresholds risks excluding vulnerable populations. Therefore, financing models should be flexible, aligned with real expenditure and saving behaviours and responsive to the diverse household contexts.

Dagnachew *et al.* (2020), through a scenario analysis across Sub-Saharan Africa, projected that, without coordinated policies and financial incentives, over 660 million people will still rely on biomass cook stoves by 2030. The study found that while subsidies for clean cooking technologies may promote adoption, they could also distort markets by crowding out alternative clean solutions. This reveals a policy tension between targeted intervention and fostering competitive, technology-neutral markets. Their findings underscore the importance of systemic policy design that balances affordability, accessibility and innovation in clean cooking energy.

A similar concern is echoed in Oyeniran and Isola (2023), who analysed household cooking fuel choices in Nigeria using data from national surveys and a multinomial regression model. Their results demonstrate that household income, fuel availability, household size and education level significantly influence cooking fuel decisions. Notably, many households still rely on firewood, reflecting both economic constraints and entrenched behavioural norms. The study implies that income growth alone may not guarantee transition to clean energy unless supported by improved access and awareness.

In the Indonesian context, Prasojo and Hartono (2023) highlighted the roles of income and education as major determinants of clean fuel adoption. Their findings indicate that higher household expenditure (a proxy for income) and education levels of household heads are positively correlated with the use of clean cooking fuels. Importantly, the study highlights that price sensitivity and demographic characteristics (age and household size) further moderate energy choices. These findings support the idea that clean energy adoption is not solely a function of economic status but also of information access and social positioning.

Egunjobi (2020), in a study of Oyo State, Nigeria, distinguished the determinants of cooking energy use across rural and urban settings. The findings revealed that, while income, appliance costs, and energy demand are significant in urban households, rural decisions are driven more by social variables such as household size and the availability of cooking infrastructure. This urban-rural disparity suggests that clean energy policies must be geographically contextualised, with rural areas requiring not only financial interventions but also targeted social education and infrastructural support.

Gill-Wiehl *et al.* (2023) in the study titled "Evaluation of the preference for and viability of clean cook stove adoption in rural Tanzania." This study conducted household energy surveys with primary cooks in four villages in Shirati, Tanzania, to determine rural families' preferences for feasible clean fuels. The data analysis includes descriptive statistics and a generalised linear model using the Poisson family with a log link to estimate prevalence ratios, implemented in Microsoft Excel and STATA 16.1. The findings indicated that 83% of families (n = 187) utilised a combination of firewood, charcoal, liquefied petroleum gas (LPG), and/or kerosene, whereas 82% [95% Confidence Interval: 74%, 89%] expressed a preference for using LPG. The study revealed that total LPG spending was lower than daily expenditures on charcoal and firewood. The investigation revealed that all villages had a higher prevalence of storing firewood, charcoal, and LPG than villages farthest from the primary trading hub. Both regions with trading posts exhibited a reduced prevalence of exclusive reliance on firewood. Household preferences must be routinely integrated into clean cooking policy decisions. The study's findings suggest that LPG should not be sought exclusively in urban environments.

According to Aminu *et al.* (2024), the Cost of accessing and using clean cooking energy among small households residing in rural areas impedes the full adoption of the available environmentally friendly cooking energy. Governments have taken many measures to ensure that all marginalised communities are aware and ready to use clean cooking energy as expected. Traditional cooking energy remains a silent killer, whereby over sixty thousand premature deaths occur annually in Africa (Aminu *et al.,* 2024). It has been further reported that frequent use of traditional cooking energy costs the lives of women and children, with the prolonged peril of indoor smoke, which in turn increases the risk of respiratory infections, chronic pulmonary disease and cancer (Aminu *et al.,* 2024).

Aamaas and Grimsby (2024) observed that the emphasis on clean cooking energy has grown significantly in recent years due to increased awareness of environmental degradation and health concerns caused by reliance on biomass fuels in Tanzania, such as firewood and charcoal (Aamaas & Grimsby, 2024). Various governmental and non-governmental organisations have launched campaigns to promote the use of clean, efficient cooking solutions (Grimsby *et al.,* 2024). For example, the National Clean Cooking Strategy (2020–2030), in line with global efforts, Tanzania developed the National Clean Cooking Strategy, which aims to ensure universal access to modern energy solutions by 2030. The strategy focuses on raising awareness and educating the public through various sustainable programmes and campaigns about clean cooking energy.

According to Pratiti *et al.* (2020), the adoption of clean cooking energy in Tanzania is critical for addressing socio-economic and environmental challenges, particularly in reducing deforestation and improving public health. The widespread use of biomass fuels has led to significant deforestation and health issues from indoor air pollution (Pratiti *et al.,* 2020). Various efforts by the government have been made in matters related to clean cooking energy, such as increasing public and institutional awareness of its importance. Furthermore, strengthening the availability of reliable raw materials and infrastructure for clean cooking energy. In addition, reducing the costs of clean energy, equipment, and improved cooking stoves. Moreover, lastly developing, updating, and harmonising policies, laws, regulations, and enabling guidelines to facilitate the use of clean cooking energy (URT, 2024). Additionally, clean cooking energy mitigates environmental and health challenges by reducing dependence on biomass, encouraging tree planting and lowering indoor air pollution (Tomlin, 2021). However, understanding household decisions to adopt clean energy and engage in afforestation requires examining key determinants such as socio-economic status, cultural norms, and awareness.

Additionally, any improvement in stove efficiency has a significant positive impact on the environment and fuel costs. The study concludes that although financial costs are a major factor in the adoption of clean cooking technologies, social and contextual variables are equally important. Therefore, policymakers should emphasise improvements in fuel efficiency and provide targeted financial mechanisms to encourage the adoption of upgraded stoves. The cost-effectiveness of various cooking energy options can be significantly affected by context; therefore, policies should also be customised to local situations.

2.4 Research Gap

The empirical review identifies several key research gaps in the existing literature on the determinants of tree-planting and harvesting practices and on household-level awareness of the impacts of traditional cooking fuels. The reviewed studies have investigated various factors influencing tree-planting practices across different contexts, including China (global context), Ghana (Africa), and Morogoro (Tanzania). This shows that there remains a lack of a comprehensive understanding of the determinants of clean cooking energy adoption and afforestation practices in the Moshi District Council in Tanzania. Furthermore, no study used the Theory of Planned Behavior and Resource Dependence Theory, which meant that a current study was necessary to close methodological and theoretical gaps by evaluating the effects of clean cooking energy and afforestation on environmental conservation at the household level using Planned Behavior and Resource Dependence Theories in the context of Tanzania's Moshi District Council.

2.5 Conceptual Framework

A conceptual framework is a structured representation that outlines the key concepts, variables, and their presumed relationships in a study (Tamene, 2016). It serves as a blueprint for the research by defining the main variables, both independent and dependent, and showing how they are connected based on theories, previous studies, or logical reasoning. The framework guides the research design, data collection, and analysis by clarifying what is being studied, why it is important, and how the different components fit together. In essence, it acts as a map that directs the study toward achieving its objectives. In a study on the adoption of clean cooking energy, the conceptual framework illustrates the determinants of tree-planting and tree-harvesting practices. The costs and Benefits of adopting clean cooking energy influence adoption decisions.

The Resource Dependency Theory (RDT) and the Theory of Planned Behavior (TPB) serve as the foundation for this study's conceptual framework. TPB describes how family behaviors related to planting, harvesting, and using clean cooking energy are influenced by attitudes, subjective norms, and perceived behavioral control. RDT enhances this by highlighting how families depend on natural resources, which influences conservation choices. The framework illustrates the link between the dependent variable environmental conservation and the independent variables—determinants of tree planting and harvesting practices and the cost-benefit analysis of clean cooking energy adoption. For instance, variables such as age, education, income, and housing type affect behavioural intentions and actual conservation practices (Ajzen, 1991). Similarly, forest resource dependency and perceived benefits of clean cooking technologies drive adoption behaviour (Pakravan & MacCarty, 2020). The literature supports these links, as studies show that education influences tree planting (Ibrahim *et al.,* 2022) and that perceived health and time-saving benefits enhance clean energy adoption (Petrokofsky *et al.,* 2021). Thus, the framework integrates behavioural and resource-based perspectives to explain environmental conservation at the household level. The pictorial presentation of the conceptual framework is shown in Figure 1.

Independent Variables **Dependent Variables**

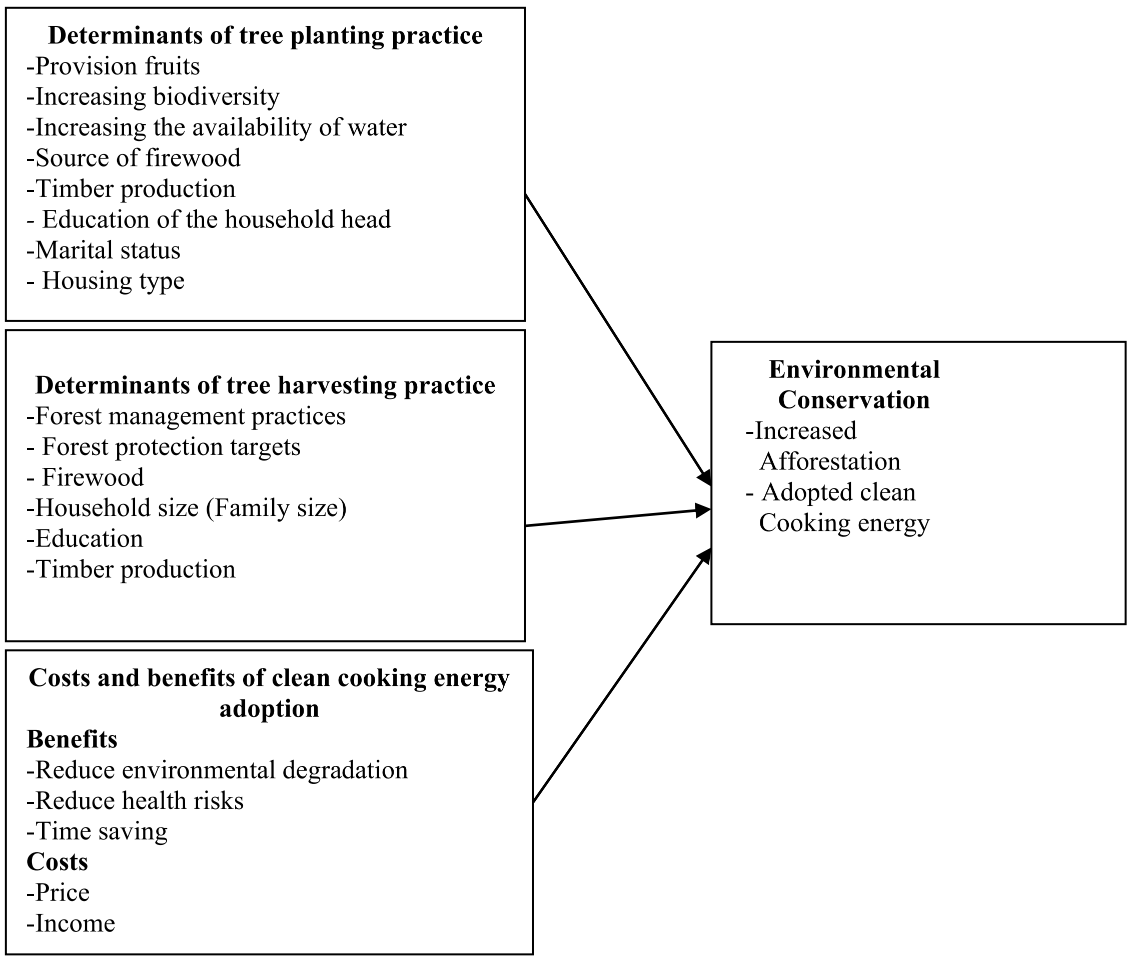

Figure 1: Conceptual Framework

Source: Researcher's own construct

CHAPTER THREE
METHODOLOGY

3.1 Research Design

The study used a cross-sectional research design. This research design was employed to facilitate data collection from the target population at a specific point in time. This design was appropriate for capturing a snapshot of the current situation regarding the use of clean cooking energy and household-level afforestation practices in Moshi District Council. The choice of this design was guided by its cost-effectiveness and time-efficiency (Wang & Cheng, 2020). Data collected through this approach addressed the study's research questions, as supported by Maier *et al.* (2023) and Kropko and Kubinec (2020).

The cross-sectional research methodology, which allows for data collection from families at a specific moment in time, is in line with the goals of the study. This design made it possible to determine the factors that influence tree-planting and harvesting practices and to assess the advantages and disadvantages of using clean cooking energy at the Moshi District Council home level.

3.2 Geographical Coverage

The Moshi District Council in Tanzania was the site of this investigation. Moshi District Council has 535,803 residents overall, living in 145,669 homes with an average household size of 3.7 people, according to the 2022 Tanzania Population and Housing Census (National Bureau of Statistics [NBS], 2022). 96% of the rural population in this area uses firewood as their primary energy source, making it the most popular cooking fuel (Mosses et al., 2023). It is located between latitudes 2° to 30' to 50° south of the Equator and longitudes 37° to 38° east.

The Moshi District Council is administratively divided into 32 wards: Arusha Chini, Kahe, Kahe Mashariki, Kibosho Kati, Kibosho Magharibi, Kibosho Mashariki, Kilema Kaskazini, Kilema Kati, Kilema Kusini, Kimochi, Kindi, Kirima, Kirua Vunjo Kusini, Kirua Vunjo Magharibi, Kirua Vunjo Mashariki, Mamba Kaskazini, Mamba Kusini, Marangu Magharibi, Marangu Mashariki, Mabogini, Makuyuni, Njiapanda, Mbokomu, Mwika Kaskazini, Mwika Kusini, Okoani, Old Moshi Magharibi, Old Moshi Mashariki, Uru Mashariki, Uru Shimbwe, Uru Kusini and Uru Kaskazini. The

Moshi District Council was chosen because the district's excessive reliance on traditional biomass for cooking is causing significant deforestation (Mushi et al., 2020). In 2020, Moshi District Council's natural forest covered 32 kha, or more over 23% of the total land area. It lost 25 hectares of natural forest in 2024, which is equal to 9.7 kt of CO2 emissions. Between 2001 and 2024, Moshi District Council lost 150 kt of CO2 emissions and 250 ha of tree cover, or 0.73% of the tree cover area in 2000. Of the tree cover loss, 50% happened in regions where deforestation was the primary cause (Global Forest Watch, 2025). A considerable portion of families use charcoal and firewood for cooking, which directly causes deforestation (Bär et al., 2021).

3.3 Population, Sample and Sampling Techniques

3.3.1 Study population

The target population refers to the entire group of individuals, objects, or elements that possess the characteristics of interest to the researcher and from which the study seeks to conclude (Casteel & Bridier, 2021). It encompasses all potential respondents or units that fit the defined criteria and about whom the researcher intends to make generalisations. For the present study, the target population consisted of 145,669 households residing within Moshi District Council, who are directly involved in or affected by household cooking energy practices. In addition, it included key stakeholders such as officials from the Moshi District Council and the Tanzania Forest Services Agency (TFS), who are instrumental in formulating, implementing, and monitoring policies related to environmental conservation, forestry management, and sustainable energy use. By including both household respondents and institutional stakeholders, the study ensured a comprehensive understanding of the dynamics of clean cooking energy adoption from the perspectives of end users, policymakers, and regulatory authorities.

3.3.2 Sample size

According to Lakens (2022), sample size refers to the number of participants or observations included in a study to represent a larger population. It is crucial for ensuring the accuracy, reliability, and generalizability of the research findings. A well-chosen sample size enhances the validity of the study's results and reduces the likelihood of bias.

Sample size was determined using Cochran's (1977) method, with ±5% precision and a 95% confidence level. When the population is 535,803, the sample size should be 381 with ±5 % precision at a 95% confidence level. Consequently, 381 Moshi District Council homes made up the study's sample size.

$$\boldsymbol{n} = \frac{\boldsymbol{N}.\boldsymbol{Z}^2 \times \boldsymbol{p} \times (\mathbf{1}-\boldsymbol{p})}{(\boldsymbol{N}-\mathbf{1}) \times \boldsymbol{e}^2 + \boldsymbol{Z}^2 \times \boldsymbol{P}(\mathbf{1}-\boldsymbol{P})} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where,

n = required sample size, N Total population size (535 803 in this case), Z = score corresponding to the desired confidence level (in this case, 95% confidence level, Z is approximately 1.96), P = Proportional value (0.7), e = Margin of error (desired level of precision) = 5%= 0.05. Therefore, the sample comprised 381 household heads from ten Wards in Moshi District Council, namely Arusha Chini (39), Kahe (38), Kahe Mashariki (38), Kibosho Mashariki (38), Kirua Vunjo Mashariki (38), Marangu Mashariki (38), Mabogini (38), Njiapanda (38), Mwika Kusini (38), and Uru Mashariki (38).

3.3.3 Sampling techniques

A sampling technique is the specific method or process a researcher uses to select a subset of individuals, objects, or elements from a larger target population for inclusion in a study (Etikan & Bala, 2017). It determines how participants are selected to ensure the selected sample accurately represents the population, thereby allowing valid generalisations from the findings. Sampling techniques are generally categorised into probability sampling, in which each member of the population has a known and equal chance of being selected, and non-probability sampling, in which selection is based on the researcher's judgment, convenience, or other non-random criteria. The choice of a sampling technique depends on factors such as the research objectives, population size, available resources, and the desired level of accuracy. A well-chosen sampling technique increases the reliability and validity of research results while minimising bias and ensuring that the collected data reflect the true characteristics of the population.

To guarantee the representativeness and applicability of the chosen respondents, this study used both basic random sample and purposive selection approaches.

Households from particular Moshi District Council wards were chosen by simple random selection. Household heads were approached by the researcher at their residences and requested to take part in the study.

Secondly, the study employed purposive sampling to select key informants from relevant institutions. Specifically, officers from the Moshi District Council and the Tanzania Forest Services Agency (TFS) were selected for their expertise in clean cooking energy initiatives and afforestation programmes. These individuals were chosen for their deep knowledge, professional roles, and direct involvement in implementing and monitoring environmental conservation efforts in the district. Their information was essential in understanding policy, programme implementation and institutional challenges related to environmental conservation at the household level. Together, these two techniques ensured that both community-level and institutional-level perspectives were comprehensively captured in the study.

3.3.4 Sampling frame

According to Meyer and Mayrhofer (2022), a sampling frame is a complete list or database of all the elements (individuals, households, organisations, etc.) in the population from which a sample was drawn for a research study. It serves as the foundation for selecting participants and ensures that each member of the population has a known and non-zero chance of being included in the sample. In this study, in addition to 381 respondents, 2 officers from Moshi District Council and 2 officers from Tanzania Forest Services (TFS) were selected because they hold key positions directly responsible for implementing and overseeing clean cooking energy and afforestation initiatives in the district. These officers were selected because they possess specialised knowledge, making them the most appropriate informants for capturing accurate, in-depth information at the policy and administrative levels.

Table 1: Sampling frame

S/N	Details	Number of Respondents
1	Heads of the household respondents	381
2	Officers from the Moshi district council	2
3	Officers from the Tanzania Forest Services (TFS)	2
	Total Respondents	**385**

3.4 Types and Sources of Data

3.4.1 Types of data

This study examined the effects of afforestation and clean cooking energy on environmental conservation at the home level using both qualitative and quantitative data. Qualitative data is non-numerical in nature which is collected through methods of survey and one-to-one interviews included provision of fruits trees, increasing biodiversity, increasing the availability of water, source of firewood, timber production, education of the household head, marital status, housing type, forest management practices, forest protection targets, firewood, education, reduce environmental degradation and reduce health risks where they were collected in form of explanation. Quantitative data is data whose values are measured numerically, including age of respondents, family income, household size, and time savings, which were collected numerically.

3.4.2 Sources of data

Data were collected from primary and secondary sources, including questionnaires, checklists, and a documentary review guide. Primary information included provision of fruits trees, increasing biodiversity, increasing the availability of water, source of firewood, timber production, education of the household head, marital status, housing type, forest management practices, forest protection targets, firewood, education, reduce environmental degradation, reduce health risks, age of the respondents, family income, household size, and time saving. A questionnaire and checklist were used to gather these, and personnel from the Tanzania Forest Services Agency (TFS) and Moshi District Council participated in Key Informant Interviews (KIIs). These tools were chosen to capture both measurable household-level data and expert perspectives. Secondary data, such as household histories of clean cooking use and trends in afforestation and deforestation rates, were gathered using a documentary review guide from government reports, academic publications, statistical databases, organisational archives, online repositories, and previous research studies. The primary advantage of secondary data is that it is generally less costly and quicker to obtain compared to primary data collection. Furthermore, it was useful for providing background information, supporting literature reviews, and identifying trends over time.

3.5 Data Collection Methods

Key informant interviews, a survey questionnaire, and a documentary review were among the data gathering techniques used in this study, as detailed in the subsections.

3.5.1 Survey

A survey is a systematic method of data collection employed to obtain information from a predefined population or sample (Hadeler *et al.,* 2021). Surveys typically consist of a structured set of questions presented in a standardised format to ensure consistent and comparable responses.

To address the research objectives concerning tree planting, harvesting practices, and the costs and benefits of adopting clean cooking energy practices, a structured questionnaire was employed. This tool was designed to gather detailed data across various dimensions relevant to the study, with questions tailored to each specific objective. The questionnaire used closed-ended Likert-scale questions for quantitative analysis (Baburajan *et al.,* 2020). The questionnaire was adapted to the household respondents.

3.5.2 Key informant interview

This study conducted 4 interviews with 2 Moshi District Council officers and 2 TFS officers to assess clean cooking energy and afforestation in relation to environmental conservation at the household level. Key informant interviews (KIIs) offered the opportunity to explore unforeseen ideas and concepts not initially included in the study, thereby enabling flexibility in the research process (Akhter, 2022). In addition, this approach is more cost-effective and simpler to implement. The interviews employed open-ended questions.

3.5.3 Documentary review

This method was employed to gather secondary information that could not be obtained using the other methods. The documentary review was conducted using the documentary review guide. The reviewed documents included government reports on clean cooking energy, academic publications, statistical databases, organisational archives, online repositories, and previous research studies. The obtained information included the number of populations in the study area, household histories of using clean cooking, and trends in afforestation and deforestation rates in Tanzania.

3.6 Data Analysis Methods

Data analysis is the systematic process of inspecting, organising, transforming, and interpreting data to discover useful information, draw conclusions, and support decision-making (Wickham, 2016). It is a critical component of empirical research and is widely used across disciplines such as statistics, economics, social sciences, computer science, and business analytics. The process typically involves several stages, including data cleaning (removing errors or inconsistencies), data exploration (identifying patterns and trends), and applying statistical or computational techniques to test hypotheses or uncover relationships within the data. Methods of data analysis can be quantitative, focusing on numerical data and statistical procedures, or qualitative, emphasising non-numerical data such as text, images, or interview transcripts, often analysed through coding and thematic exploration.

3.6.1 Quantitative data

Quantitative data refers to information that is measured and expressed numerically, allowing it to be analysed using statistical, mathematical, or computational techniques (Cooksey, 2020). This type of data concerns quantities rather than qualities, focusing on measurable characteristics such as counts, frequencies, percentages, and numerical scores. Quantitative data is typically collected through structured tools such as surveys with closed-ended questions, experiments, standardised tests, or observational checklists, where outcomes can be counted or measured. Its main strength lies in its ability to produce objective, comparable, and generalizable results, making it suitable for identifying patterns, testing hypotheses, and establishing relationships between variables (Creswell & Creswell, 2017). In this study, quantitative data include Monthly Household Income, Household Size, Amount spent on installing clean cooking energy, Amount spent monthly on clean cooking energy, and Amount saved by the household annually when adopting clean cooking energy. Such numerical evidence enables the researcher to make precise comparisons, calculate cost–benefit ratios, and statistically assess the impacts of adopting clean cooking energy.

Determinants of tree planting practice at the household level

This study employed a Binary Logistic Regression Model to analyse the relationship between the types of planted trees (the dichotomous dependent variable) and the independent variables. Dependent variable were (1 = Planting trees, 0 = Not planting trees) and the independent variables were determinants of planting trees which were measured by the number of fruits tree planted, (Ibrahim *et al.,* 2022), number of indigenous trees planted (Kulindwa, 2016), household heads, monthly income measured by the income generation by respondents in monthly basis, for example, less than 100 000, 100 000 – 500 000, 500 000 and above (Gebreegziabher *et al*., 2020), number of water sources protected and number of household use firewood as cooking energy (Mosa *et al.,* 2020). The Binary Logistic Regression Model was used to estimate the probability that planting trees, or not planting trees, influences household heads' decisions to plant trees (Danquah *et al.,* 2023). The model will be as shown below:

$$y = log\left(\frac{P}{1-P}\right) = \beta_0 + \sum_{i=1}^{n8} \beta_i x_i + \varepsilon \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where:

X_1 = Provision of fruit trees, X_2= Increasing biodiversity, X_3= Increasing the availability of water, X_4 = Source of firewood, X_5 = Timber production, X_6= Education, X_7= Marital status, X_8= Housing type

P (tree planting=1) is the probability that a household engages in tree planting.

β_0 is the intercept of the model.

β_1: These are the coefficients for each independent variable. Each coefficient represents the change in the log-odds of tree planting for a one-unit change in the corresponding independent variable, holding all other variables constant.

X_1 is the independent variable (Determinants of tree planting practice)

Determinants of tree harvesting practice at the household level

Binary Logistic Regression Models were used to explore tree harvesting practices as the dependent variable and various determinants as independent variables. The dependent variable measuring tree harvesting practice included (1 = number of trees harvested and 0 = no trees harvested by household). Moreover, the independent variables such as forest management practices (Banaś & Utnik-Banaś, 2022), forest protection targets, use of firewood, education, household size and timber production were explored as determinants of tree harvesting practice and measured by the number of jobs created and the level of deforestation (Ackerman, 2021). The model was shown as below: -

$$y = log\left(\frac{P}{1-P}\right) = \beta_0 + \sum_{i=1}^{n6} \beta_i x_i + \varepsilon \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (2)$$

Where:

X_1= Forest management practices, X_2 = Forest protection target, X_3 = Firewood, X_4= Education, X_5 = Household size, X_6 = Timber production

P (tree harvesting =1) is the probability that a household engages in tree harvesting.

β_0 is the intercept of the model.

β_1: These are the coefficients for each independent variable. Each coefficient represents the change in the log-odds of tree harvesting for a one-unit change in the corresponding independent variable, holding all other variables constant.

X_1 is the independent variable (Determinants of tree harvesting practice)

Cost and benefit analysis of clean cooking energy adoption practice

The Benefit-Cost Ratio (BCR) was used in the Benefit-Cost Analysis (BCA) method to analyze this goal. Mosa et al. (2020) state that the adoption of clean cooking energy as a sustainable environmental conservation technique is justified if the computed BCR is greater than 1, indicating that benefits exceed costs. Conversely, if BCR < 1, the costs exceed benefits, highlighting barriers or inefficiencies in the adoption process.

The BCR formula was used as:

$$BCR = \frac{\sum_{t-1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t-1}^{n} \frac{C_t}{(1+i)^t}} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . (3)$$

As per the indicated formula, the variables are defined as;

Where:

Bt= Discounted stream of benefits

Ct= Discounted stream of costs

n = number of years

i = Discount rate

t = time in years

Benefits (Bt):

Reduced Environmental Degradation

This variable is included to capture the ecological benefit derived from reduced dependence on firewood and charcoal. Households using clean energy reduce deforestation and CO_2 emissions. Expected Sign: Positive, higher clean energy use should correlate with lower degradation and thus higher benefits.

Reduced Health Risks

The rationale is that clean cooking energy reduces exposure to harmful indoor smoke, decreasing respiratory illnesses. Respondents were asked if they experienced recent health effects from traditional cooking. Expected Sign: Positive, fewer health issues translate into direct health cost savings and improved quality of life.

Time Saving

Clean energy options such as gas or electric stoves are more efficient than collecting firewood or using traditional stoves. Saved time can be redirected to productive activities. Expected Sign: Positive time efficiency contributes to increased productivity and overall well-being.

Costs (Ct):

Price of Clean Cooking Energy

Represents the financial Cost of purchasing and delivering clean energy per household per month. Expected Sign: Negative. Higher prices increase costs, possibly discouraging adoption.

Household Income

Income determines affordability and willingness to adopt clean technologies. Households with higher incomes are more likely to adopt clean cooking energy. Expected Sign: Negative on the cost side, but positive for influencing adoption practice; higher income reduces the weight of the Cost.

Including these variables provides a realistic estimate of the net economic impact of household-level clean energy adoption. The model aims to quantify tangible and intangible benefits and align them with direct financial and opportunity costs. This framework is expected to offer policy-relevant insights on economic efficiency and sustainability of clean cooking interventions in Moshi District Council.

3.6.2 Qualitative data

The qualitative data were collected through semi-structured interviews and were analysed using content analysis. This process involved several stages to ensure a systematic and rigorous interpretation of participant responses. All interview responses were transcribed verbatim to maintain accuracy and preserve the meaning of participants' words. After transcription, the data were read repeatedly to become familiar with them and identify initial patterns. These patterns were then grouped into meaningful units or codes based on recurring ideas, phrases, or concepts.

Using a thematic content analysis approach, similar codes were clustered into broader themes and sub-themes that reflected the key issues emerging from the data. An inductive strategy was employed: some themes emerged directly from the participants' responses (inductive). Coding was done manually to allow for careful reflection and comparison across participants. To enhance the credibility of the findings, direct quotations from participants were used to support each theme, ensuring respondents' voices were accurately represented. Additionally, data were triangulated with quantitative findings to offer a comprehensive interpretation of the results.

3.7 Measurement of Study Variables

This section provided information on how variables were measured, focusing on the study variables of tree planting practices and afforestation in relation to environmental conservation.

Table 2: Operational definition of variables and their measurement

Variables	Definition	Measurement	Instrument	Expected sign
Provides fruits	The process by which trees produce fruits serves as a reproductive mechanism that also provides food for various species, including humans.	The number of fruit trees planted.	Questionnaire, and interview guide	+
Increasing Biodiversity	Enhancing species diversity within an ecosystem increases ecological resilience and stability.	Number of indigenous trees planted	Questionnaire and interview guide	+
Increasing the availability of water	Water is a major component of tree planting and development.	Number of water sources protected	Questionnaire and interview guide, documentary review	+
Timber production	The use of electronics in performing procurement functions	Number of indigenous trees planted	Questionnaire and interview guide	+

3.8 Data Validity and Reliability

Reliability refers to the degree to which a research instrument, measurement, or procedure produces consistent and stable results over repeated applications under similar conditions. In other words, it indicates the extent to which the results are free from random errors and can be replicated if the study is repeated with the same methods and participants (Taherdoost, 2016). A reliable instrument ensures that variations in the findings are due to actual differences in the variables being measured, rather than inconsistencies in the measurement process.

To ensure data validity and reliability, all relevant data were collected from the target population; the study tested the data collection tool; some questions were omitted; and the concepts intended to be captured in the questions were refined through consultation with other experts. SPSS was used to harmonise missing values in the questionnaire, as adopted by Sambuo & Msaki (2021). By measuring internal consistency using Cronbach's alpha coefficient on all Likert-type scale questions, this study assured dependability; questions with excellent consistency (> 0.6) were approved. Ten respondents participated in pilot research. The sample size should be more than the number of questionnaire items, as Fife-Schaw (2020) makes abundantly evident.

The instrument was piloted before data collection to ensure validity and reliability. To ensure constant, stable data collection and measurement, the data collection tool must be legitimate and reliable. This piloting process evaluated and improved instrument clarity, reliability, and internal validity in a subset of the targeted population. Additionally, the piloting stage looks for and fixes any logical errors that would prevent responders from fully understanding the questions. Participants were invited to fill out the study questionnaire, which was given to twelve respondents as part of the piloting procedure.

Twelve houses participated in pilot research. The pilot study made it possible to estimate the study's duration and assess the research instruments' internal consistency dependability. Connelly's (2008) advice that the pilot study sample size be 10% of the research's total sample size was followed in selecting the 12 participants.

The internal consistency of the questionnaire was evaluated using Cronbach's alpha. As recommended by Creswell (2016), a value greater than 0.6 was attained; if not, the instrument would have been modified. The reliability test results are shown in the table below. The results showed a significant average Cronbach's alpha value of 0.8, which was higher than the recommended minimal threshold of 0.6 and suggested that the questionnaire's reliability was acceptable.

Table 3: Reliability test

Variables	Cronbach's Alpha	N of items
Determinants of tree planting practice	0.85	11
Determinants of tree harvesting practice	0.89	11
Costs and benefits of clean cooking energy adoption	0.63	11
Environmental conservation	0.80	7

Validity refers to the extent to which a research instrument or method accurately measures what it is intended to measure. It determines whether the results of a study genuinely reflect the concept or phenomenon being investigated, rather than being influenced by extraneous factors (Heale & Twycross, 2015). A valid tool captures the "truth" of the subject matter, ensuring that the conclusions drawn are accurate and meaningful. High validity increases the accuracy, usefulness, and credibility of the findings, making them more applicable for policy-making or practical interventions.

The survey questionnaire underwent a content validity test through expert review to ensure that the instrument has sufficient items to measure the subject under study. Items that were found not to measure the required subject were omitted. Content validity was then tested using a content validity index (CVI), which was determined by dividing the number of valid questions (35) by the number of total questions (40), leading to a CVI of 0.892, which was above the 0.5 threshold set by Ammari (2022), such that a CVI value greater than 0.5 was considered reliable.

$$\text{CVI} = \frac{Number\ of\ valid\ questions}{Total\ number\ of\ questions} = \frac{35}{40} = 0.875$$

3.9 Diagnostic Test

A diagnostic test is a tool, procedure, or method used to determine the presence, absence, or nature of a specific condition, problem, or characteristic in a subject or system (Leeflang & Allerberger, 2019). It involves collecting and analysing information to make an informed judgment or decision about the state of the subject being examined. In research, diagnostic tests are often used to assess accuracy, efficiency, or performance by comparing results to a known standard or benchmark.

To ensure that the assumptions of the classical linear regression model (CLRM) were met, a regression analysis was conducted prior to initiating the process. When the assumptions of linear regression are violated, the estimation of these equations risks yielding biased, inefficient, and inconsistent parameter estimations (Regenwetter & Cavagnaro, 2019). This study assessed multicollinearity.

Multicollinearity refers to a situation in which there is a significant correlation between the independent and dependent variables. In the absence of consideration for complete multicollinearity, the regression coefficients become indeterminate, and the standard errors approach infinity. Conversely, imperfect multicollinearity results in elevated standard errors (Bayo *et al.,* 2021). The precision and accuracy of rejecting or accepting a hypothesis are affected by significant standard errors. The strength of multicollinearity in estimate is the issue, not its existence. The variance inflation factor (VIF) was used to measure multicollinearity; a VIF of 10 or above indicated its presence. The table below shows the outcomes.

The aforementioned table's results demonstrate that all of the independent variables—tree planting, tree harvesting, and cost and benefits—had tolerance values more than 0.8 and VIF values less than 10, suggesting the absence of multicollinearity.

Table 4: Multicollinearity test

Variable	Collinearity Statistics	
	Tolerance	VIF
Determinants of tree planting practice	0.941	1.062
Determinants of tree harvesting practice	0.879	1.138
Costs and benefits of adopting clean cooking energy	0.922	1.084

3.10 Ethical Considerations

Ethical considerations are the moral principles and professional standards that guide researchers in conducting studies responsibly, respectfully, and with integrity (Ali *et al.,* 2025). They form the foundation for protecting the rights, dignity, safety, and well-being of all participants involved in the research process. These considerations help ensure that the study not only produces valid and credible results but also upholds human values, fosters Trust, and avoids any form of exploitation or harm. In practice, ethical considerations encompass a range of responsibilities. First, researchers must obtain informed consent, meaning participants are given clear, complete, and understandable information about the purpose, procedures, risks, and benefits of the study before agreeing to take part. Participation should always be voluntary, with individuals free to withdraw at any stage without any negative consequences. Maintaining confidentiality and anonymity is essential, ensuring that personal data is protected and that participants cannot be identified from published results.

During the study method, ethical norms and standards were scrupulously respected. For example, a research letter was received from Moshi Co-operative University and thereafter submitted to the Moshi District Council office in accordance with the standards and values of MoCU. A research permission was obtained and filed to the local authorities in the study region prior to data collection. Secrecy, privacy, honesty, sensitivity, and participant anonymity were all given top priority in the study, which respected people's freedom to decide whether or not to take part in the study. People were given numbers rather than names in order to preserve secrecy. Respondents were particularly questioned about their willingness to express their ideas prior to data collection, with a focus on maintaining participant confidentiality. The information gathered was only used for scholarly study.

CHAPTER FOUR
FINDINGS AND DISCUSSION

4.1 Chapter Overview

Data analysis, conclusions, and discussion are presented in this chapter. This comprises the demographic data of the respondents as well as a detailed analysis that links the data among respondents. The research's primary goal, to examine the effects of afforestation and clean cooking energy on environmental conservation at the home level in Tanzania using a case study of Moshi District Council, serves as the foundation for the discussion of the results.

Specifically, this study aimed at examining the determinants of tree planting practice and its contribution to environmental conservation at the household level, exploring the determinants of tree harvesting practice and its contribution to environmental conservation at household level and determining costs and benefits of clean cooking energy adoption (particularly the use of gas) and its contribution to environmental conservation at household level in Moshi District Council.

4.2 Demographic Information of Respondents

This segment includes information on respondents' gender, marital status, and level of education, household size, Occupation, monthly household income, and age. As argued by Khoa *et al.* (2023), demographic information is important in a research report because it helps readers understand the background and characteristics of the study participants. Including demographic data adds transparency and allows other researchers to replicate the study or compare its results with those of similar studies.

Table 5: Demographic information of respondents

Variables	Category	Frequency	Per cent (%)
Gender	Male	240	63
	Female	141	37
	Total	**381**	**100**
Marital status of respondents	Single	200	52.5
	Married	181	47.5
	Total	**381**	**100**
Level of education	No formal education	80	21
	Primary education	77	20.2
	Secondary education	181	47.5
	Bachelor degree	43	11.3
	Total	**381**	**100**
Household size	2 members	197	51.7
	3 members	4	1
	5 members	149	39.1
	8 members	31	8.1
	Total	**381**	**100**
Occupation	Agriculture	112	29.4
	Business	112	29.4
	Government employee	58	15.2
	Self-employed	99	26
	Total	**381**	**100**
Monthly household income	341 500	158	41.5
	541 000	82	21.5
	675 000	57	15
	875 000	40	10.5
	1 075 000	44	11.5
	Total	**381**	**100.0**
Age of respondents	18-35 years old	22	5.8
	36-45 years old	198	51.9
	46-55 years old	145	38.1
	55 years and above	16	4.2
	Total	**381**	**100**

4.3 Gender of respondents

The results indicate that of the 381 respondents, 37% were female (n=141) and 63% were male (n=240). This gender disparity implies that males make the majority of household choices in the research region or are more likely to represent households in community-based surveys. Given that household energy decisions and land-use practices often rest with the head of the household, the high proportion of male respondents suggests that men may have greater influence over whether a household adopts clean cooking energy, particularly gas, or participates in afforestation. Nevertheless, this also raises a concern: excluding or under-representing women in decision-making could limit the effectiveness of environmental programmes, especially considering that women are the primary users of cooking energy.

4.3.1 Marital status of respondents

In this study, 52.5% of respondents were single (n = 200), while 47.5% were married (n = 181), a near-equal distribution that provides a sound basis for analysing how marital status and family structure may influence energy and environmental practice. The balanced representation allows exploration of how decision-making dynamics differ between the two groups. Married couples may display more stable, long-term planning practices, potentially favouring investments in sustainable technologies, such as clean cooking stoves, or in tree-planting actions aligned with shared household goals and future-oriented strategies. Additionally, married households often benefit from pooled resources and joint decision-making, which may facilitate access to installation costs and ongoing maintenance.

Conversely, single households enjoy greater flexibility in decision-making about adoption. Without familial obligations such as childcare or spousal agreement, single individuals might be more nimble, particularly if the clean technologies are affordable and accessible. They may face financial constraints if they lack shared income, making initial investments in improved cook stoves or biogas systems more challenging, especially without subsidies or targeted financing. Similarly, Bartiaux (2022) found that married households, who are often financially better off, are more likely to invest in energy-efficient home improvements, suggesting that marital status, as part of the family life cycle, impacts household energy practices.

4.3.2 Level of education of respondents

The results reveal that 47.5% of respondents had attained secondary education, followed by no formal education (21%), primary education (20.2%), and a bachelor's degree (11.3%). This distribution indicates that while nearly half of the population has a moderate level of education, a significant portion has a limited or no formal education. Education is a key driver of environmental awareness, shaping attitudes and the ability to understand the complex linkages between resource use, energy consumption, and environmental sustainability (Vladova, 2023). Respondents with secondary and higher education are more likely to comprehend the long-term economic, health, and ecological benefits of adopting clean energy and engaging in afforestation initiatives. They are also more likely to critically evaluate environmental policies, embrace innovations, and act as local advocates for change.

The 21% of respondents with no formal education represent a substantial demographic that face challenges in accessing environmental information or understanding the rationale behind conservation interventions. In such cases, traditional practices, socio-cultural norms, or misconceptions about modern energy technologies may prevail, potentially slowing adoption rates. Similarly, those with only primary education may possess basic literacy yet lack the technical understanding required to fully appreciate the benefits of sustainable practices. This variation in educational attainment suggests that environmental programmes in the area must adopt differentiated communication strategies leveraging visual demonstrations, community engagement, and practical examples for less educated groups.

4.3.3 Household size

Most respondents reported having 2 household members (51.7%), while others reported 5 members (39.1%), 8 members (8.1%), and 3 members (1%). Household size plays a significant role in shaping both energy demand and environmental strain. Smaller households typically consume less firewood or charcoal, thereby reducing biomass extraction and lowering household exposure to indoor air pollution. Such households can more easily transition to gas stoves, as the required investment in equipment and fuel is lower than for larger families. This aligns with findings by Bersisa *et al.* (2021), who reported that smaller households in Ethiopia had higher adoption rates of improved cook stoves due to reduced cost barriers and greater ease of behavioural change.

Equally, larger households, which are more common in traditional and rural settings, tend to consume significantly more biomass energy, thereby exerting greater pressure on forest resources and increasing greenhouse gas emissions. Owusu-Amankwah *et al.* (2023) found that, households with more than six members used almost double the amount of firewood compared to smaller households, primarily due to higher cooking frequency and larger meal portions. This greater consumption contributes to deforestation and intensifies indoor air pollution levels, disproportionately affecting women and children who spend more time near cooking areas. Additionally, Stritzke *et al.* (2023) observed that, larger households face greater financial challenges in transitioning to clean cooking technologies, especially if initial investment costs are high, making targeted subsidies or financing schemes critical for adoption.

4.3.4 Occupation of respondents

The study revealed that respondents were equally distributed between agriculture (29.4%) and business (29.4%), followed by self-employed individuals (26%) and government employees (15.2%). These occupational differences are significant in understanding household energy choices and environmental practices. According to Gayen *et al.* (2024), Occupation shapes income levels, access to information, and priority-setting in adopting sustainable energy technologies. Agricultural households, for example, are often directly dependent on natural resources such as forests and farmland. This close interaction with land and biomass resources makes them highly relevant in afforestation and environmental conservation efforts. Nonetheless, their adoption of clean cooking energy technologies can be constrained by seasonal income fluctuations, limited capital investment, and inadequate access to infrastructure.

Business owners and self-employed individuals, on the other hand, possess greater financial stability, enabling them to adopt clean energy solutions more readily. Their decision-making is often guided by efficiency, cost savings, and productivity gains, making them likely candidates for early adoption of modern energy technologies. In contrast, government employees, who typically have higher education levels and more consistent incomes, play a crucial role as community change agents. Their access to formal training, broader exposure to sustainability initiatives, and capacity to influence others make them strategically important in promoting behavioural change toward environmental conservation.

4.3.5 Monthly household income

The majority of households (41.5%) reported a monthly income of 341 500 TZS, with smaller proportions earning 541 000 TZS (21.5%), 675 000 TZS (15%), 875 000 TZS (10.5%), and 1 075 000 TZS (11.5%). The findings indicate that the majority of households (41.5%) reported a monthly income of 341 500 TZS, while smaller proportions reported incomes of 541 000 TZS (21.5%), 675 000 TZS (15%), 875 000 TZS (10.5%), and 1 075 000 TZS (11.5%). Income level is a critical determinant in the adoption of clean cooking energy and environmental conservation practices. Households with lower incomes, such as those earning 341,500 TZS, may prioritise immediate, cost-effective energy sources, often traditional biomass fuels such as firewood and charcoal, over cleaner alternatives. These choices are largely influenced by affordability, accessibility, and the lack of initial capital to invest in cleaner technologies like liquefied petroleum gas (LPG) stoves or improved biomass cookers.

Conversely, households in higher income brackets have greater financial flexibility to invest in energy-efficient technologies and may also possess greater awareness of their environmental and health benefits. Though, higher income does not automatically translate to cleaner energy adoption; cultural cooking preferences, fuel availability, and perceived convenience still influence decision-making. In some cases, even well-off households may continue using biomass for taste, tradition, or social norms, even though they can afford cleaner options.

The observed income distribution suggests that interventions to promote clean cooking technologies should be tailored to affordability levels, through subsidies, microfinance, or pay-as-you-go models for lower-income households. Simultaneously, awareness campaigns targeting all income levels are essential to address non-financial barriers. Ultimately, household income, when combined with education, cultural practices, and accessibility, significantly shapes the trajectory toward sustainable energy adoption and environmental conservation. This is being evidenced through the findings below,

> *"...Due to limited income, my household is only able to afford a single 6kg gas cylinder per month, which is strategically used for cooking light meals such as tea or rice. For heavier meals like beans or makande (a traditional dish made from maise and beans), which require prolonged cooking times, they resort to cheaper, traditional fuels like firewood or charcoal to avoid depleting their gas supply prematurely and exceeding their household budget...*" (KII 3 Moshi DC, November 2024).

Furthermore, the other respondent indicated the following,

> *"...While we are aware of the health and time-saving benefits of clean energy, our financial limitations prevent us from purchasing electric cooking appliances, which are significantly more expensive than traditional stoves or open fires. Even when these appliances are available in local markets, the initial investment cost remains a barrier for many households whose incomes barely cover basic needs..."* (KII 4, Moshi DC, November 2024).

As White *et al*. (2022) found, increased income generally promotes positive environmental behaviours, such as afforestation. In many rural settings, lower-income households tend to rely more heavily on natural resources, including trees, for daily needs such as firewood, construction materials, shade, or supplementary income. These households often integrate trees into their land use systems as a coping strategy for economic insecurity. Conversely, higher-income households may shift away from labour-intensive or subsistence-based activities, such as tree planting, toward more immediate and financially rewarding ventures. They also reside in urban or peri-urban areas where land access or interest in long-term natural resource investments is lower. Using an interview guide with key respondents, it was found that household income is a key determinant of their ability to adopt and consistently use clean cooking energy technologies.

4.3.6 Age of respondents

The findings showed that 5.8% of respondents were aged 18-35 years old, 51.9% were aged 36-45 years old, 38.1% were aged 46-55 years old, and 4.2% were aged 55 years and above. This indicates that the majority of respondents were mature adults aged 36-45 years (51.9%), followed by senior adults aged 46-55 years (38.1%). The predominance of mature adults and senior adults suggests that clean cooking energy facilitates afforestation in the study area, thereby positively impacting environmental conservation at the household level, given their considerable life experience and deep understanding of conservation strategies. However, age diversity can enhance environmental conservation by balancing modern clean cooking energy with traditional knowledge in conservation strategies. Participants revealed that age plays a significant role in shaping household tree-planting behaviours. It was observed that elderly individuals, especially household heads, are often the key motivators behind tree planting activities. The following findings evidence this.

> *"...Older members of the community play a central role in influencing younger generations to engage in tree planting activities. In our household, for example, it is the elders who consistently remind and guide the youth to plant trees, emphasising the long-term benefits for the environment and future generations. They have lived through periods when the environment was more stable and productive, and they often refer to those times to highlight the urgency of restoring tree cover...."* (KII 2, Moshi DC, November 2024).

Furthermore, the other respondent indicated the following,

> *"...In many homes, it is the house owners who are typically older who initiate tree planting around the compound. For them, planting trees is not only about conservation but also about beautifying the environment and taking responsibility for future ecological well-being..."* (KII 1, Moshi DC, November 2024).

The current finding aligns with that of Mhagama and Heriel (2023), who found that the age of the head of household is among the key determinants of households' clean energy use choices for cooking in Tanzania's mainland. Additionally, the age of the household head was a significant predictor of the household's primary source of clean cooking energy. This indicated that the household head's age significantly impacted the determination of the primary source of clean cooking energy. As the age of household heads increases, the odds of using firewood for cooking increase. Similar findings were reported by Debebe *et al.* (2023), who found that as household heads' age increases, the odds of using charcoal decrease.

4.4 Tree Planting Practice and Its Contribution to Environmental Conservation

This study's primary goal was to evaluate the factors that influence Moshi District Council households' tree-planting practices. This goal was evaluated using a Binary Logistic Regression Model. When the dependent variable is dichotomous and the goal is to investigate the link between one or more independent factors and the probability of an event occurring, a binary logistic regression model is frequently utilized. In this study, the model estimates the probability that a household plants trees based on several independent variables, including the provision of fruit trees, biodiversity, water availability, firewood, timber production, education, marital status, and housing type.

Table 6: Binary Regression results on determinants of tree planting practice at the household level in Moshi District Council

Determinants	Coefficient	Std. Err.	T	P>|t|	[95% Conf.	Interval]
Provision of fruits trees	0.2017	0.0582	0.35	0.029*	0.9424	0.1346
Biodiversity	0.2600	0.0645	4.03	0.000**	0.1329	0.3865
Water availability	0.0003	0.0299	0.01	0.999	-0.585	0.0592
Firewood	-0.0088	0.0176	-0.50	0.619	-0.4341	0.0259
Timber production	0.0237	0.0166	1.43	0.001*	-0.0090	0.0564
Education	0.0898	0.0195	4.59	0.000**	0.1290	0.0535
Marital status	0.0626	0.0451	2.39	0.017*	0.1513	0.0262
Housing type	-0.0132	0.0398	0.33	0.739	-0.0649	0.0915
_cons	1.3037	0.2579	5.06	0.000	0.7966	1.8108

Log likelihood value = 28 22, Likelihood ratio statistics $X^2_1 = 92.21$, $R^2 = 56.28\%$, % of correct prediction = 68.4%, Number of observation (N) =381, **statistically significant at $P < 0.01$, *statistically significant at $P < 0.05$.

The regression analysis indicated a positive, statistically significant relationship between fruit tree provision and tree planting practice ($\beta = 0.2017$, $p < 0.05$). The provision of fruit trees has statistically significant influence on household choices about planting fruits trees. This outcome indicates that households are more incentivised by the long-term advantages of fruit growing, including higher yields and pressing livelihood requirements. Many households prefer growing fruits tree species that provide long-term benefits which in turn helps conserving environment. The findings of this study align with Kulindwa's (2016) observations, which indicated that Tanzanian rural families prioritise long-term environmental or nutritional advantages when deciding to plant trees.

The regression results show a statistically significant, positive relationship between biodiversity and tree-planting practice ($\beta = 0.260$, $p < 0.05$). This indicates that households that value biodiversity are significantly more likely to engage in tree planting activities. This result highlights the crucial role of environmental consciousness in influencing household-level afforestation efforts. When households understand the ecological importance of trees, such as their role in preserving diverse plant and animal species, stabilising ecosystems, and improving climate resilience, they are more inclined to plant and conserve them.

The results are connected to the Theory of Planned Behavior in order to comprehend and forecast human behaviors, such as perceived social pressure to plant trees. Perceived behavioral control, on the other hand, reflects an individual's assessment of how simple it is to plant trees, which is closely linked to prior experiences with environmental challenges. This Theory provides a framework for assessing household behaviours related to tree planting and the adoption of clean cooking energy, particularly gas stoves. It provides valuable insights into why households may choose to plant fruit trees, and into biodiversity enhancement, depending on both internal motivations, including health benefits, and external enabling factors, such as the provision of fruit trees for both health and environmental conservation.

Results of this study resemble those of Brancalion and Holl (2020), who emphasised that biodiversity awareness among rural communities significantly increases the likelihood of engaging in tree planting, particularly when the benefits of diverse ecosystems, such as improved soil health, pest control, and resilience to climate change, are well understood. Additionally, Sharma *et al.* (2020) found that farmers who were aware of the role of native tree species in maintaining local biodiversity were more likely to adopt tree-planting practices on their agricultural land. Their research further suggested that integrating biodiversity education into community outreach programmes had a measurable impact on reforestation rates.

The finding that timber production has a positive and statistically significant association with tree planting practice ($\beta = 0.0237$, $p < 0.05$) suggests that, while households may be aware of the economic benefits of timber, these benefits can also translate into significant tree planting practice. Many households prefer long-term investment for their family's future; therefore, timber species often appeal to households that typically prioritise long-term gains and view land tenure as an appreciated asset. Increasing land values in the future increases households' willingness or ability to commit to long-term forestry investments.

This result contradicts the findings of Kansanga *et al.* (2021), who argue that long-term land-use decisions, such as timber production, require not only economic incentives but also institutional and technical support, especially in smallholder settings. Similarly, Amare & Darr (2020) emphasise that agroforestry adoption is limited by the time lag between investments and returns unless external support mechanisms are in place. Consequently, farmers are more inclined to cultivate trees that yield construction materials and fuelwood for their immediate needs rather than those that will bear fruit in the future (Melvani *et al.,* 2022).

Education was found to have a strong, positive, and statistically significant effect on tree planting practice ($\beta = 0.0898$, $p < 0.05$). This indicates that as educational attainment increases, the likelihood of engaging in tree planting practice increases. This result reflects a shift in priorities among more educated individuals, who may focus on off-farm employment or urban livelihoods, thereby reducing their direct involvement in activities such as tree planting. Additionally, higher levels of education may be associated with lifestyles that are less reliant on land-based resources or more detached from traditional agricultural practices. This finding contrasts with studies such as Robinson (2016), who found that education generally enhances environmental awareness and participation in sustainable practices. Furthermore, formal education may decrease time and interest in planting trees in some rural environments, especially if people move to cities or take up other sources of income.

The habit of planting trees was positively correlated with marital status; this correlation was statistically significant ($\beta = 0.0626$, $p < 0.05$). This implies that whether or not families plant trees is significantly influenced by marital status. Married households share common priorities, including childcare, financial planning, and managing household resources, which increase their focus on long-term environmental investments, such as tree planting, for future family gain. This finding contradicts that of Zande and Mzuza (2022), who found that the presence of additional dependents, such as children, reduces the household's ability to invest in long-term strategies, such as tree planting. These findings suggest that, rather than marital status itself, it is the broader context of household dynamics, including the number of dependents and family financial constraints, that could indirectly shape decisions related to land and tree management.

4.5 Determinants of Tree Harvesting Practice and Its Contribution to Environmental Conservation

The second objective of this study was to examine the determinants of tree harvesting practice and its contribution to environmental conservation at the household level in Moshi District Council. A Binary Logistic Regression Model was used to assess determinants of tree harvesting practice at the household level in Moshi District Council. In this study, the model estimates the probability that a household harvests a tree based on several independent variables, including forest management practices, forest protection targets, firewood availability, education, household size, and timber production.

Table 7: Determinants of tree harvesting practice

Determinants	Coefficient	Std. Err.	T	P>|t|	[95% Conf.	Interval]
Forest mgt practices	0.9042	0.0574	0.000**	0.116	0.2033	0.0225
Forest protection targets	0.0770	0.0489	0.047*	0.117	0.1731	0.0193
Firewood	0.0086	0.0155	-0.440	0.660	0.0372	0.2361
Education	0.0852	0.0198	0.029*	0.000	0.0462	0.1242
Household size	0.0920	0.0113	0.001*	0.859	0.0241	0.0201
Timber production	0.0809	0.0143	0.000**	0.950	0.0291	0.0273
_cons	1.1730	0.1316	8.91	0.859	.9142	1.4319

Log likelihood value = 36.48, Likelihood ratio statistics $X^2_1 = 84.16$, $R^2 = 58.63\%$, % of correct prediction = 62.6%, Number of observation (N) =381, **statistically significant at $P < 0.01$, *statistically significant at $P < 0.05$.

Forest management practices are positively and statistically significantly associated with tree harvesting among households in Moshi District Council ($\beta = 0.9042$, $p < 0.05$). This implies that, theoretically, forest management could influence household decisions and have a meaningful impact on tree harvesting practices. This may be because many forest management initiatives in the area are effectively implemented due to strong community engagement, suggesting that current forest management practices in Moshi District Council may involve a participatory approach to tree harvesting that positively influences environmental conservation.

As Luswaga and Nuppenau (2020) noted, the success of forest management in Tanzania depends heavily on local participation and perceived community benefits. Without this, management efforts are unlikely to shape harvesting decisions. Yami and Mekuria (2022) argued that participatory models are more effective than top-down approaches. Therefore, unless forest management becomes more inclusive and locally driven, it will continue to have limited influence on household-level tree harvesting.

The regression result for forest protection targets reveals a positive coefficient of 0.0770 ($p < 0.05$), indicating a strong, statistically significant relationship with household tree-harvesting practice. This finding implies that forest protection targets influence household tree-harvesting practices in Moshi District Council. While forest protection goals may exist on paper or in broader community programmes, they may be effectively communicated, enforced, or incentivised at the household level. Without concrete benefits, practical enforcement measures, or local engagement strategies, such targets are likely to be perceived as abstract or irrelevant by the communities they are intended to influence.

The current finding is consistent with that of Bakehe and Hassan (2023), who found that forest protection leads to a decline in the use of traditional biomass fuels, thereby reducing pressure on forest resources. In this context, households may prioritise clean cooking energy and health benefits over traditional practices, especially when affordable clean energy solutions are accessible. Contrary to this, Swallehe (2022) notes that although Tanzania has comprehensive forest policies, their implementation remains inconsistent and weak at the household level, where much of the resource pressure occurs. Furthermore, the ineffectiveness of protection targets in shaping household practice reflects a broader challenge in environmental governance policy: a lack of participation. As indicated, several researchers have indicated that households are more likely to comply with forest conservation efforts when they are actively involved in decision-making (Biland *et al.,* 2021), offered alternative livelihoods (Charnley, 2023) and lastly when they are provided with direct incentives such as subsidies for clean cooking energy (Singh *et al.,* 2021).

The regression results show that education has a positive, statistically significant relationship with tree harvesting practice, with a coefficient of 0.0852 and $p < 0.05$. This strong association suggests that education plays a critical role in shaping households' interactions with forest resources. Rather than acting as a deterrent to tree harvesting, higher levels of education empower individuals to engage with forest ecosystems in more informed and economically strategic ways. This aligns with Börner *et al.* (2020), who argue that education is positively correlated with more responsible, regulated forest use, emphasising its potential as a tool for both conservation and livelihood improvement.

The regression analysis indicates a statistically significant relationship between household size and tree harvesting practice, with a coefficient of 0.0920 and a $p < 0.05$. This result suggests that household size has a meaningful effect on tree-harvesting decisions in Moshi District Council. It is often assumed that larger households exert greater pressure on forest resources due to increased demand for cooking fuel, construction materials, or income from forest products, leading to higher tree harvesting rates as household size increases. One possible explanation is that households, regardless of size, have access to alternative sources of energy or building materials, or are influenced more by cultural, economic, or regulatory factors than by household size. Mantey and Teye (2021) found a positive association between household size and forest dependence in rural areas, suggesting that this relationship may be due to differences in resource availability, household coping mechanisms, or forest access regulations.

The regression output shows that timber production has a statistically significant relationship with tree harvesting practice, with a coefficient of 0.0809 and a $p < 0.05$. This suggests that timber production is a reliable predictor of household tree-harvesting practices in Moshi District Council. It is commonly assumed that the pursuit of timber for construction, commercial purposes, or household use would significantly influence harvesting practices. This indicates that timber production activities are more influenced by factors such as cultural practices, land ownership, and institutional controls than by tree-harvesting decisions. This is contradicted by the findings of Blerk *et al.* (2021), who emphasise the role of timber extraction in driving forest degradation in many forest-adjacent communities. The findings from this study suggest that timber production, on its own, does not have a significant effect on household tree-harvesting practices in Moshi District Council.

4.6 Cost and Benefits of Clean Cooking Energy Adoption and Its Contribution to Environmental Conservation

This study's third objective was to identify the advantages and disadvantages of clean cooking energy adoption at the Moshi District Council home level. To accomplish this goal, both qualitative and quantitative methodologies were used. This goal was to evaluate the financial and non-financial costs and advantages of using clean cooking energy, such as the initial outlay, fuel savings, time savings, health benefits, and environmental preservation. Finding the benefits and drawbacks of clean cooking energy adoption at the Moshi District Council household level was the third goal of this study. Both qualitative and quantitative approaches were employed to achieve this objective. This objective was to assess the financial and non-financial costs and benefits of adopting clean cooking energy, including the initial investment, fuel and time savings, health benefits, and environmental preservation.

Table 8: Costs of adopting clean cooking energy

Variable costs	Costs (TZS)
Amount spent on installing clean cooking energy	156 496.06
Amount spent monthly on clean cooking energy	36 581.60
Total variable costs	193 077.66
Net revenue	21 922.34

Regarding the amount spent on installing clean cooking energy, the data reveal that 69% of households spent less than 125,000 TZS, 6% spent 375,007 TZS, 24.7% spent 187,500 TZS, and the remaining spent 500,000 TZS. This suggests that the upfront cost of adopting clean cooking technologies is a major barrier, especially for rural or economically vulnerable populations. This is because most households at the beginning of adopting clean cooking energy incur costs of an average of 156,496.06

TZS, and an average amount of 36,581.60 TZS spent monthly on clean cooking energy, which both make a total cost amount of 193,077.66 TZS, a huge amount compared to the household income level. The low willingness or ability to pay for higher installation costs limits the spread of more efficient or durable clean cooking systems. If installation remains out of reach for the majority, clean cooking interventions risk being concentrated among relatively better-off populations, thereby exacerbating energy inequality.

The importance of reducing upfront installation costs is well-documented in clean energy literature as Schilmann *et al.* (2021) found that the adoption rate of improved cook stoves in Mexico significantly increased when subsidies were introduced for installation. In Tanzania, Alananga (2024) showed that high initial costs deterred rural households from switching to cleaner alternatives, even when they were aware of the health benefits. Moreover, Fernandez-Vallado (2025) highlighted that financial mechanisms such as microcredit and pay-as-you-go systems could be transformative in promoting the adoption of clean energy, especially for marginalised groups. These findings strongly support the argument that without affordable financing or targeted subsidies, high installation costs will remain a persistent barrier to clean cooking energy access.

The findings on the amount spent monthly on clean cooking energy showed that the largest proportion of households, 45.7% spent about 25,000 TZS monthly on clean cooking energy, 30.2% spent 37 500 TZS, and 23.6% spent about 62,500 TZS, while the remaining 0.5% spent 75,000 TZS monthly on clean cooking energy. This means that households in the study area spent an average of 36,581.60 TZS per month, as indicated in Table 9. This implies that although clean cooking energy is moderately affordable for many households, ongoing fuel costs remain a significant recurring expense, particularly for low-income households. The minimal proportion of households (0.5%) spending over 75,000 TZS suggests that premium clean energy solutions are not widely adopted, possibly due to cost constraints. This means many households tend to look for alternative cooking fuels, including charcoal and firewood, by cutting down trees, which leads to environmental degradation and endangers efforts to conserve the environment sustainably.

Additionally, sustained use of clean energy is closely tied to household income, and for broader adoption, subsidised fuel pricing or income-based support programmes may be essential. Without such interventions, households may revert to traditional biomass options, undermining both health and environmental progress. The current findings are consistent with those of Nzengya *et al.* (2021), who found that fuel affordability is a primary factor in determining whether households continue using improved cook stoves or revert to traditional biomass. Similarly, Nabukwangwa *et al.* (2023) report that, even when clean cooking technologies are introduced, high and inconsistent fuel prices reduce long-term use among low-income households in Sub-Saharan Africa.

Based on discounted variable costs and benefits, a Benefit-Cost Ratio (BCR) analysis of clean cooking energy adoption was conducted. This included amount spent on installing clean cooking energy, amount spent monthly on clean cooking energy, total discounted variable costs and total discounted benefit as presented in Table 9.

Table 9: Benefit-cost ratio analysis of clean cooking energy

Discounted variable costs and benefits	Costs (TZS)
Amount spent on installing clean cooking Energy. Amount spent	142 269.15
monthly on clean cooking energy	33 256.00
Total discounted variable costs	175 525.15
Total discounted benefit	195 454.55
BCR	**1.1**

The findings on clean cooking energy adoption in Moshi District Council revealed a total discounted cost of 175 525.15 TZS per household for installing and using clean cooking energy**,** and a corresponding benefit of 215 000 TZS, yielding a BCR of 1.1. This indicates that clean cooking energy has significant benefits compared to its costs, implying that using clean cooking energy saves money, time spent going and returning, and time spent gathering firewood, and reduces health risks associated with medical expenses. This suggests that the immediate financial gain outweighs the costs, and that clean cooking energy remains potentially worthwhile when considering long-term social, environmental, and health benefits, including reduced indoor air pollution, lower fuelwood demand, and improved household well-being, which are not fully captured in the monetary calculation.

Moreover, the respondents were asked how much time they save on cooking-related activities each day after adopting clean cooking energy. The findings showed that several benefits are expected to arise from the adoption of clean cooking energy among households in Moshi District Council. These benefits include reduced environmental degradation, reduced health risks and time saving. The findings reveal that the majority of households benefit significantly from time savings after adopting clean cooking energy. Specifically, 34.9% of respondents reported saving 2 hours and 30 minutes daily, while 28.1% saved 1 hour and 30 minutes.

Additionally, 25.7% saved 45 minutes, and 11.3% saved 15 minutes. This shows that over 88% of the surveyed households gained at least 45 minutes of extra time each day due to more efficient cooking. As one of the key informants said:

> *"...Using clean energy sources such as gas stoves, solar cookers, or electric stoves drastically reduces the time spent cooking, as these technologies heat up quickly and require less monitoring than traditional biomass fuels like firewood or charcoal. The quick ignition and consistent heat of these stoves enable users to prepare meals more efficiently, especially during peak hours such as early mornings and evenings..."* (KII 1, Moshi DC, November 2024).

Another participant pointed out that:

> *"...Traditional fuels require significant time to collect (especially firewood), which is eliminated by adopting clean energy solutions. This saves women and children, who are often responsible for fuel collection, several hours per week, reducing physical strain and creating time for education, rest, or economic pursuits..."* (KII 2, Moshi DC, November 2024).

This finding implies that time savings enable household members, especially women, who often bear the cooking burden, to reallocate their time toward more productive or leisure activities. This includes engaging in small-scale economic activities, supervising children's education, or participating in community initiatives. Clean energy solutions not only improve cooking efficiency but also contribute to time poverty reduction, a core barrier to development among rural and peri-urban households. The findings of this study align with those of Tornel-Vázquez *et al.* (2024), who highlighted that adopting clean cooking energy helps women in low-income countries recover up to 3 hours daily, thereby directly boosting household economic participation and quality of life. Similarly, Afridi *et al.* (2023) found that users of clean stoves in Indian villages reported improved time management and productivity.

Regarding reductions in household health issues from indoor air pollution, the findings showed that a significant majority (86.4%) of respondents experienced a notable improvement in household health after switching to clean cooking energy. Another 11.8% reported slight improvements, while only 1.6% saw no change and 0.3% reported worsening health. The findings of this study imply that traditional cooking methods using biomass fuels emit high levels of indoor air pollutants, such as carbon monoxide, which are linked to respiratory diseases, eye irritation, and other chronic health problems. The substantial reduction in health issues validates the role of clean cooking energy as a preventive public health intervention. According to the (WHO, 2021), indoor air pollution from cooking fuels causes over 4 million premature deaths annually, mostly in low-income countries. Additionally, Maji *et al.* (2021) found that switching to clean stoves reduced respiratory illnesses among women and children by over 50%.

Regarding the reduction in environmental degradation, respondents showed near-universal agreement on the environmental benefits of clean cooking energy. An overwhelming 99.7% of households stated that adopting clean cooking methods has helped reduce environmental degradation, while only 0.3% disagreed. These results imply that adopting clean cooking energy has a strong effect on environmental conservation, particularly by reducing reliance on firewood and charcoal. This reduction in biomass use directly contributes to lowering deforestation rates and promoting ecological balance. The near-unanimous support also suggests that environmental messaging around clean energy is effective and resonates with communities. The findings of this study align with those of Bakehe & Hassan (2023), who noted that clean cooking technologies could reduce forest degradation by up to 30% in regions heavily reliant on wood fuels. Similarly, Daka (2023) reported that widespread adoption of clean cooking can significantly slow deforestation and reduce carbon emissions.

To explain the behavioural aspect of adoption, the Theory of Planned Behaviour (Ajzen, 1991) is more applicable, as it suggests that individual decisions, such as adopting clean cooking energy, are shaped by three key factors: attitude toward the behaviour, subjective norms, and perceived behavioural control. Households adopt clean energy not only for financial reasons but also for perceived health benefits, social encouragement (e.g., community leaders or neighbours already using clean energy), and confidence in their ability to sustain its use. The fact that many households observed improvements in health and environmental quality likely reinforces a positive attitude and intention toward continued use, even when the monetary return is minimal.

Supporting this argument, Mbaru *et al.* (2021) observed that initiatives addressing household well-being and environmental sustainability are more likely to succeed when they incorporate both tangible and intangible benefits. Similarly, Nchanji *et al.* (2023) highlighted that access to sustainable technology in rural Burundi improved not only economic conditions but also social behaviours toward resource use.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the findings, the conclusion, the recommendations, and the areas for further research. The objective of this chapter is to empower researchers to tackle specific challenges and provide information for future studies analysing the Impact of clean cooking energy and afforestation on environmental conservation at the household level in Tanzania.

5.2 Summary of the Key Findings

This research's main objective was to evaluate the effects of afforestation and clean cooking energy on environmental preservation at the home level in Tanzania using Moshi District Council as a case study. The specific goals of this study were to determine the costs and benefits of adopting clean cooking energy and its contribution to environmental conservation at the household level in Moshi District Council, as well as to investigate the determinants of tree planting practice and its contribution to environmental conservation, as well as the determinants of tree harvesting practice and its contribution to environmental conservation at the household level.

The examined results of the study are presented in accordance with the specified objectives in this chapter. It also provides stakeholders and policymakers with suggestions on clean cooking energy and afforestation for environmental conservation at the household level in Tanzania.

The results indicate that of the 381 respondents, 37% were female (n=141) and 63% were male (n=240). In terms of marital status, 47.5% of respondents were married (n=181), whilst 52.5% of respondents were single (n=200). Secondary education was obtained by 47.5% of respondents, followed by no formal education (21%), elementary education (20.2%), and a bachelor's degree (11.3%). This shows that a significant proportion of the population has at least a basic or moderate level of formal education. Most respondents reported having 2 household members (51.7%), followed by 5 (39.1%), 8 (8.1%), and 3 (1%). Respondents were equally distributed between agriculture (29.4%) and business (29.4%), followed by self-employed individuals (26%), and government employees (15.2%). The majority of households

(41.5%) reported a monthly income of 341 500 TZS, with smaller proportions earning 541 000 TZS (21.5%), 675 000 TZS (15%), 875 000 TZS (10.5%), and 1 075 000 TZS (11.5%).

The first objective of this study was to assess the determinants of household-level tree-planting practices in Moshi District Council. A Binary Logistic Regression Model was used to assess this objective. The regression analysis indicated a positive, statistically significant relationship between fruit tree provision and tree planting practice ($\beta = 0.2017$, $p < 0.05$). The regression results show a statistically significant, positive relationship between biodiversity and tree-planting practice ($\beta = 0.2600$, $p < 0.05$). The findings showed that timber production has a positive and statistically significant association with tree planting ($\beta = 0.0237$, $p < 0.05$). Education was found to have a strong, positive and statistically significant effect on tree planting practice ($\beta = 0.0898$, $p < 0.05$). Marital status was positively associated with tree planting, and the relationship was statistically significant ($\beta = 0.0626$, $p < 0.05$).

The second objective of this study was to explore the determinants of household-level tree harvesting practices in Moshi District Council. Forest management practices were positively and statistically significantly associated with tree harvesting among households in Moshi District Council ($\beta = 0.9042$, $p < 0.05$). The regression results for forest protection targets reveal a positive coefficient of 0.0770 ($p < 0.05$). The regression results show that education has a positive, statistically significant relationship with tree harvesting practice, with a coefficient of 0.0852 and $p < 0.05$. The regression analysis indicates a statistically significant relationship between household size and tree harvesting practice, with a coefficient of 0.0920 and a $p < 0.05$. The regression output shows that timber production has a statistically significant relationship with tree harvesting practice, with a coefficient of 0.0809 and a $p < 0.05$.

This study's final goal was to identify the advantages and disadvantages of implementing clean cooking energy techniques at the Moshi District Council home level. A total projected cost of 193,077.66 TZS per family and a comparable benefit of 215,000 TZS were found in an evaluation, resulting in a BCR of 1.1.

5.3 Conclusion

Firstly, the results highlight the crucial role of environmental consciousness in influencing household-level afforestation efforts. When households understand the ecological importance of trees, such as their role in preserving diverse plant and animal species, stabilising ecosystems, and improving climate resilience, they are more inclined to plant and conserve them. Many households prefer long-term investment for the family's future; therefore, timber species often appeal to households that typically prioritise long-term gains and view land tenure as an appreciated asset. Increasing land values in the future increases households' willingness or ability to commit to long-term forestry investments.

Secondly, regarding tree harvesting practices, forest management can influence household decisions and has a meaningful impact on them. This may be because many forest management initiatives in the area are effectively implemented due to strong community engagement, suggesting that current forest management practices in Moshi District Council may, through a participatory approach to tree planting, influence environmental conservation. On the other hand, larger households exert greater pressure on forest resources due to increased demand for cooking fuel, construction materials, or income from forest products.

Lastly, the cost-benefit analysis for clean cooking energy adoption showed a BCR of 1.1, indicating that the benefits outweigh the costs. This means that using clean cooking energy saves money, time spent going and returning, and time spent gathering firewood, and reduces health risks that could lead to medical expenses. This concludes that the immediate financial gain outweighs the costs, and that clean cooking energy remains worthwhile when considering long-term social, environmental, and health benefits. This includes reduced indoor air pollution, lower fuelwood demand, and improved household well-being, which are not fully captured in the monetary calculation. Moreover, households benefit significantly from time savings after adopting clean cooking energy, as traditional cooking methods using biomass fuels emit high levels of indoor air pollutants, such as carbon monoxide, which are linked to respiratory diseases, eye irritation, and other chronic health problems.

5.4 Recommendations

Based on the results, the following suggestions are made to enhance Tanzanian households' access to clean cooking energy and promote environmental preservation through afforestation.

Given the strong influence of education on both tree planting and harvesting practice, LGAs should integrate environmental education into local development agendas. This could be achieved by incorporating environmental content into primary and secondary school curricula, as well as by organising community seminars, workshops, and public sensitisation forums in collaboration with local leaders. Special attention should be given to educating youth and rural populations, who are most likely to engage in unsustainable harvesting.

LGAs should collaborate with the Ministry of Energy to offer subsidies or tax exemptions on clean cooking equipment such as improved cook stoves. Introducing community-based revolving funds or payment plans can also make these technologies more accessible to low-income households.

NGOs should take the lead in raising awareness of the environmental and economic consequences of poor tree harvesting practices. These campaigns can include door-to-door education, radio programmes, and participatory theatre that communicates messages in local languages. Involving respected community figures can enhance credibility and local buy-in.

NGOs and environmental organisations should strengthen community reforestation by partnering with schools, women's groups, and youth clubs. Providing seedlings, tools, and technical knowledge on proper tree spacing, species selection, and post-planting care can improve survival rates and environmental Impact.

International donors and development partners should prioritise clean energy interventions in their development portfolios. By funding projects that provide affordable, context-appropriate technologies, they can reduce households' reliance on firewood and charcoal. Projects should include technical training, user support, and follow-up services to improve sustainability.

Community leaders, including village elders and religious leaders, should actively promote sustainable practices during public gatherings, religious services, and local celebrations. Their involvement can shift community norms and encourage hesitant households to adopt environmentally friendly practices.

Households that are already engaging in tree planting or using clean cooking energy should be encouraged to share their experiences through village forums or peer-learning sessions. By showcasing both the challenges and benefits they have encountered, they can serve as role models for others in the community, thereby accelerating broader behavioural change.

5.5 Areas for Further Studies

Future studies should adopt a longitudinal approach to assess the long-term socio-economic and health impacts of clean cooking energy adoption. Such studies would help capture delayed benefits, such as reduced healthcare costs, improved respiratory health, and long-term environmental outcomes, such as forest regeneration.

While this study examined socio-economic factors, future research should investigate the cultural and behavioural dimensions that influence tree-planting and harvesting decisions. Understanding local traditions, beliefs, and values around land use and tree management could provide more context-specific policy interventions.

This study did not conduct a gender-disaggregated analysis. Future studies could explore how gender roles and responsibilities affect tree planting, harvesting, and the adoption of clean energy technologies. This would help in designing inclusive policies and interventions that empower both men and women.

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APPENDICES

Appendix 1: Planting Behaviour

Tree planting behaviour

Variable Name	Definition of Variable	Measurement of variables	Authors	Expected Sign
Provides fruits	The process by which trees produce fruits serves as a reproductive mechanism that also provides food for various species, including humans.	The number of fruit trees planted.	Swedish University of Agricultural Sciences, SLU Faculty of Natural Resources and Agricultural Sciences (NJ) (2020)	+
Increasing Biodiversity	Enhancing species diversity within an ecosystem increases ecological resilience and stability.	Number of indigenous trees planted	Swedish University of Agricultural Sciences, SLU Faculty of Natural Resources and Agricultural Sciences (NJ), (2020)	+
Income generation	Creating financial earnings through various activities or investments, supporting economic stability	household heads' monthly income	Swedish University of Agricultural Sciences, SLU Faculty of Natural Resources and Agricultural Sciences (NJ), Chiou, C., *et el* 2021	+
Increasing the availability of water	Water is a major component of tree planting and development.	Number of water sources protected	Kaudo, B. O., *at el* (2022).	+/-
Source of firewood	The provision of wood used for burning, typically sourced from trees, to generate heat or for cooking purposes.	Number of households that use firewood as cooking energy.	Kaudo, B. O., *at el* (2022). Kulindwa, Y. J. (2016).	+/-
Timber production	The process of cultivating, harvesting, and processing trees to produce wood for construction, furniture, and other uses.	Number of trees planted per year for timber production	Swedish University of Agricultural Sciences, SLU Faculty of Natural Resources and Agricultural Sciences (NJ) (2022). Staddon *et al* (2020). Kulindwa, Y. J. (2016).	+

Age	Age refers to the number of years a person has lived from birth to the present time.	Years of respondents	Osterman et al., (2022).	+
Education	Education refers to the level of formal schooling or training that an individual has completed.	Level of education attained by respondents	Fafunwa & Aisiku (2022).	+
Marital status	Marital status refers to the legally defined marital state of an individual. It indicates whether a person is single, married, divorced, widowed, or separated.	Marital status (single, married, divorced, widowed, or separated	Leung et al., (2022).	+
Housing type	Housing type refers to the kind of dwelling in which an individual or household resides. It includes various forms such as detached houses, apartments, and temporary shelters.	Detached houses, apartments, and temporary shelters.	Debrunner & Gerber, (2021).	+

Tree harvesting behaviour

Variable Name	Definition of Variable	Measurement of variables	Authors	Expected Sign
Increase income	Managing and utilising forest resources sustainably to generate financial returns from timber, firewood, and other forest products.	Number of jobs created	Banaś, J., & Utnik-Banaś, K. (2022).	+/-
Forest management	improve forest growth	Level of deforestation	Barrette, J., *et al* (2023), Sampo Soimakallio and Hannes Böttcher	
Source of charcoal	The materials, typically wood or other organic matter, are heated in the absence of oxygen to produce charcoal.	Number of harvested trees for charcoal	P Staddon, J. U *et al* (2020)	+/-
Forest protection targets	Specific goals and measures aimed at preserving forest ecosystems to maintain biodiversity, mitigate climate change, and sustain ecological functions.	Actual tree harvesting ages	Law, B. E., *et al* (2021). Tedesco, A. M., *et al* (2023).	+/-
use of wood products	Using timber and other wood-derived materials for construction, furniture and energy	Number of trees harvested for wood	Kottek P, *et al* 2023	+/-
Price	Financial value assigned to a tree based on factors such as its species, size, age, and usability for products like timber.	The price of mature trees	Al-Okaishi, A. (2020).	+/-
Age	Age refers to the number of years a person has lived from birth to the present time.	Years of respondents	Osterman et al., (2022).	+
Household size	Household size refers to the number of individuals living together in a single dwelling unit. It includes all members, whether related or not, who share living accommodations and typically contribute to household income and resources.	Number of individuals in a household	Netting et al. (2023).	+
Education	Education refers to the level of formal schooling or training that an individual has completed.	Level of education attained by respondents	Fafunwa & Aisiku (2022).	+

Costs and benefits of clean cooking energy adoption

Variable Name	Definition of Variable	Measurement of variables	Authors	Expected Sign
Reduce environmental degradation	Implementing strategies and policies to prevent damage to natural resources and ecosystems, ensuring their sustainability and health.	The number of households that use cleaning and cooking energy	Mohamad, A. P, *et al* (2020) Neto-Bradley, P. (2020).	+/-
Reduce Health risks	Implementing measures and policies to decrease exposure to factors that can lead to disease and health complications, enhancing public health and safety.	Number of people who are not affected by health risks	Mohamad, A. P, *et al* (2020) Kar, A, &Hisham Zerrif, H (2018)	+/-
Time saving	How does time saving affect a household's ability to adopt and use clean cooking energy	efficient use of clean energy and productivity	Mohamad, A. P, *et al* (2020)	+/-
Price	How the cost of clean cooking technologies and fuels influences adoption rates and consumer usage patterns.	Examining how much it costs for an individual to access clean cooking energy	Mohamad, A. P, *et al* (2020) Gould, F. C &Urpelainen, J	+/-
Income	How the financial resources of individuals or households affect their ability to adopt and sustain the use of clean cooking technologies and fuels.	Household income earnings per month	Mohamad, A. P, *et al* (2020)	+/-

Appendix 2: Letter of Introduction

Dear Sir/Madam,

RE: REQUEST FOR DATA COLLECTION FOR ACADEMIC RESEARCH

My name is Advella Ntangeki, a student at Moshi Cooperative University undertaking a master's degree programme and currently at the thesis stage. My research title is "***Impact of Clean Cooking Energy and Afforestation on Environmental Conservation at the Household Level in Tanzania: A Case of Moshi District Council***".

I have chosen you as part of my sample population. Please allow me to administer the questionnaire to collect data for analysis. The questionnaire has multiple sections and will take about 20 minutes to complete. Please respond to the questions to the best of your knowledge and as honestly as possible. There will be no benefits or victimisation for participating in this research, as it will be for academic purposes only. Your identity or that of the farm will be treated with the confidentiality it deserves.

Your facilitation of the above will greatly contribute to the study.

Yours sincerely,

Advella Ntangeki

Yours Sincerely

Appendix 3: Questionnaire for Households

This questionnaire is meant to gather information regarding the **"Impact of clean cooking energy and afforestation on environmental conservation at household level in Tanzania: a case of Moshi district Council".**

Kindly respond to the questions to the best of your knowledge and as honestly as possible.

SECTION A: DEMOGRAPHIC DATA

Section A: Demographic Information

1. Gender
   a. Male [ ]
   b. Female [ ]
2. Marital Status for Households
   a. Single [ ]
   b. Married [ ]
3. Education Level
   a. No formal education [ ]
   b. Primary education [ ]
   c. Secondary education [ ]
   d. Tertiary education [ ]
   e. Other (please specify): _______________
4. Household Size
   a. 1-3 members [ ]
   b. 4-6 members [ ]
   c. 7-9 members [ ]
   d. 10 or more members [ ]
5. Occupation
   a. Agriculture [ ]
   b. Business [ ]
   c. Government employee [ ]
   d. Self-employed [ ]
   e. Other (please specify): _______________

6. Monthly Household Income (Tanzanian Shillings)
   a. Below 498,000 [ ]
   b. 498,000 – 585,000 [ ]
   c. 585,000 – 765,000 [ ]
   d. 765,000 – 985,000 [ ]
   e. Above 985,000 [ ]
7. Age of respondent in years
   a. 18-35 [ ]
   b. 36-45 [ ]
   c. 46-55 [ ]
   d. 55 years and above [ ]

Section B: Questions According to Research Questions

Objective One: Determinants of Tree Planting Practice and Its Contribution to Environmental Conservation at the Household Level in Moshi District Council

8. Do you engage in tree planting at your household?
   a. Yes [ ]
   b. No [ ]
9. How many trees were planted? ________
10. Please indicate whether the following factors influence your tree planting practice by placing a tick (√) in the corresponding box for either "Yes" or "No."

S/N	FACTORS	YES	NO
i.	Provision of fruits		
ii.	Increasing biodiversity		
iii.	Environmental conservation		
iv.	Source of firewood or charcoal		

10. Rate the following statements regarding your tree planting practice by putting a tick (√) in the corresponding box using the scale: (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree)

11. **Do you agree with the following statements about the tree planting practice?-**

SN	Statements	5	4	3	2	1
1.	Tree planting improves my income.					
2.	Planting trees to increase biodiversity.					
3.	Tree planting increases water availability.					
4.	Tree planting increases the supply of firewood.					
5.	You have planted trees for timber production.					

Objective Two: Determinants of Tree Harvesting Practice and Its Contribution to Environmental Conservation at the Household Level in Moshi District Council

12. Do you harvest trees at your household?
    a. Yes [ ]
    b. No [ ]
13. How many trees were harvested? ________________
14. Do households participate in forest management activities?
    a. Never [ ]
    b. Rarely [ ]
    c. Occasionally [ ]
    d. Frequently [ ]
15. Housing type?
    a. Traditional [ ]
    b. Semi-permanent [ ]
    c. Permanent [ ]
16. Please indicate whether the following factors influence your tree harvesting practice by placing a tick (√) in the box for either "Yes" or "No."

S/N	FACTORS	YES	NO
i.	Income purpose		
ii.	Forest management practices		
iii.	Source of charcoal		
iv.	Forest protection targets		
v.	Timber production		

17. Rate the following statements regarding your tree harvesting practice by putting a tick (√) in the corresponding box using the scale: (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree)

Do you agree that the following factors influence your tree harvesting practice?

SN	Statements	5	4	3	2	1
1.	I harvest trees primarily for income.					
2.	I practice sustainable forest management.					
3.	I rely on trees for charcoal production.					

Objective Three: Cost and Benefits of Clean Cooking Energy Adoption and Its Contribution to Environmental Conservation at the Household Level in Moshi District Council

18. Do you use clean cooking energy sources?
    a. Yes
    b. No
19. How much did your household spend on installing clean cooking energy (e.g., improved cook stoves, biogas systems)?
    (a) Less than 125,000 TZS [ ]
    (b) 125,000 - 250,000 TZS [ ]
    (c) 250,000 - 500,000 TZS [ ]
    (d) More than 500,000 TZS [ ]
20. How much does your household spend on cooking fuel per month after adopting clean cooking energy?
    (a) Less than 25,000 TZS [ ]
    (b) 25,000 - 50,000 TZS [ ]
    (c) 50,000 - 75,000 TZS [ ]
    (d) More than 75,000 TZS [ ]
21. How much time does your household save on cooking-related activities daily after adopting clean energy?
    (a) Less than 30 minutes [ ]
    (b) 30 minutes - 1 hour [ ]
    (c) 1 hour - 2 hours [ ]
    (d) More than 2 hours [ ]

21. Have household health issues related to indoor air pollution decreased since adopting clean cooking energy?
    (a) Yes, significantly [ ]
    (b) Yes, slightly [ ]
    (c) No change [ ]
    (d) Health issues increased [ ]
22. How much does your household save annually in energy-related expenses since adopting clean cooking energy?”
    (a) Less than 125,000 TZS [ ]
    (b) 125,000 - 250,000 TZS [ ]
    (c) 250,000 - 500,000 TZS [ ]
    (d) More than 500,000 TZS [ ]
23. Rate the following statements regarding your clean cooking energy behaviour by putting a tick (√) in the corresponding box using the scale: (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree)

Do you agree that the following factors influence your adoption of clean cooking energy? -

SN	**Statements**	**5**	**4**	**3**	**2**	**1**
1.	Clean cooking energy reduces adverse environmental impact.					
2.	Use of clean cooking energy improves our health.					
3.	Use of clean cooking energy saves time.					
4.	The cost of clean cooking energy is affordable.					
5.	Adopting clean cooking energy increases my income.					

Thank you for your participation!

Appendix 4: Interview guide for KII

1. How important is the provision of fruits in your decision to plant trees? Can you explain why?
2. What role do you think tree planting plays in increasing biodiversity in your area?
3. In what ways do you believe tree planting contributes to your household income?
4. How do you perceive the relationship between tree planting and water availability in your household or community?
5. How do you think the age of the household head influences tree planting decisions?
6. How many trees were planted in the year 2022/2023
7. How does tree harvesting contribute to your household income
8. What forest management practices do you follow, and how do they affect your tree harvesting practice?
9. How do market prices for wood products impact your decision to harvest trees?
10. What roles does technology play in your tree harvesting practices
11. How do you think adopting clean cooking energy helps reduce environmental degradation

Appendix 5: Permission letters

JAMHURI YA MUUNGANO WA TANZANIA

OFISI YA RAIS
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

Anuani ya Simu "TAMISEMI" DODOMA
Simu Na: +255 26 2321607
Nukushi: +255 26 2322116
Barua pepe:ps@tamisemi.go.tz

Mji wa Serikali – Mtumba,
Mtaa wa TAMISEMI,
S.L.P. 1923,
41185 DODOMA.

Unapojibu tafadhali taja:-

Kumb. Na. AB.307/323/01/213 **08 Oktoba, 2024**

Katibu Tawala wa Mkoa,
Ofisi ya Mkuu wa Mkoa,
S. L. P 3070,
KILIMANJARO.

Yah: **KIBALI CHA KUFANYA UTAFITI KUHUSU CLEAN COOKING ENERGY, AFFORESTATION AND ENVIRONMENTAL CONSERVATION AT HOUSEHOLD LEVEL IN TANZANIA, A CASE OF MOSHI DISTRICT**

Tafadhali rejea somo tajwa hapo juu.

2. Ofisi ya Rais –TAMISEMI imetoa kibali kwa **Advella Ntangeki, mwanafunzi** kutoka Chuo Kikuu cha Ushirika Moshi (MoCU) kwa ajili ya kufanya utafiti tajwa katika Mkoa wa Kilimanjaro.

3. Muda wa kufanya utafiti huu ni kati ya tarehe 07 Oktoba, 2024 na tarehe 07 Oktoba, 2025. Ofisi ya Rais -TAMISEMI kwa kushirikiana na Taasisi nyingine za Serikali itafanya ukaguzi wakati wowote kujiridhisha na utekelezaji sahihi wa kibali hiki. Takwimu zitakazokusanywa kutokana na utafiti huu ni kwa ajili ya matumizi ya ndani tu na iwapo zitatakiwa kuchapishwa na kusambazwa kibali kutoka Mamlaka husika kitapaswa kuombwa.

4. Kwa barua hii, tafadhali waelekeze Wakurugenzi wa Halmashauri za Mkoa wako ili watoe ushirikiano utakaohitajika kwa ajili ya kukamilisha utafiti huu kama ulivyokusudiwa.

5. Ninakushukuru kwa ushirikiano wako.

Nyanjige C. Lupoja
Kny: KATIBU MKUU

JAMHURI YA MUUNGANO WA TANZANIA
OFISI YA RAIS
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

MKOA WA KILIMANJARO
Anwani ya Simu:'REGCOM'KILIMANJARO
Simu Na. Moshi +255 (027) 2754236/7,
Nukushi Na. +255 (027) 2752184
Barua Pepe :ras@kilimanjaro.go.tz
ras.kilimanjaro@tamisemi.go.tz

Ofisi ya Mkuu wa Mkoa,
17 Barabara ya Florida,
S.L.P. 3070,
25107 MOSHI.

Unapojibu tafadhali taja

Kumb. Na.AD.133/252/01"G"/74

11 Octoba, 2024

Mkurugenzi,
Halmashauri ya Manispaa,
S.L.P. 318,
MOSHI.

MkurugenziMtendaji,
Halmashauriya Wilaya,
HAI, MOSHI, MWANGA,
ROMBOna SAME.

Yah: **KIBALI CHA KUFANYAUTAFITI KUHUSU *CLEAN COOCKING ENERGY, AFFORESTATION AND ENVIROMENTAL CONSAVATION AT HOUSEHOLD LEVEL IN TANZANIA ,A CASE OF MOSHI DISTRICT***

Tafadhali husika na somo tajwa hapo juu.

2. Ofisi ya Mkuu wa Mkoa imepokea barua yenye Kumb. Na. AB. 307/323/01/213 ya tarehe 8/10/2024 imetoa Kibali cha kufanya utafiti kuhusu ***Clean Cooking Energy, Afforestation and Environmental Conservation at Household Level in Tanzania***. Ofisi ya Rais –TAMSEMI ikishiriana na Tume ya Sayansi na Teknolojia (COSTECH) imetoa kibali kwa **Advella Ntangeki,** kutoka chuo kikuu cha Ushirika (MoCU) kwa ajili ya kufanya utafiti tajwa katika Mkoa wa Kilimanjaro.

3. Muda wa kufanya utafiti huo ni kati ya mwezi 7 Octoba, 2024 na mwezi Octoba, 2025. Ofisi ya Rais – TAMISEMI kwa kushirikiana na Taasisi nyingine za Serikali itafanya ukaguzi wakati wowote kujiridhisha na utekelezaji sahihi wa kibali hiki. Takwimu zitakazokusanywa kutokana na utafiti huu ni kwa ajili ya matumizi ya ndani tuu na iwapo zitatakiwa kuchapishwa na kusambazwa kibali kutoka Mamlaka husika kitapaswa kuombwa.

4. Kwa barua hii, unaelekezwa kutoa ushirikiano utakaohitajika na kukamilisha utafiti huo kama ulivyokusudiwa.

5. Nakutakia utekelezaji mwema.

Stephen E. Kivulenge
Kny; KATIBU TAWALA WA MKOA

Kauli Mbiu; *"Serikali za Mitaa, Sauti ya Wananchi, Jitokeze kushiriki Uchaguzi"*

PRESIDENT'S OFFICE
REGIONAL ADMINISTRATION AND LOCAL GOVERNMENT
MOSHI DISTRICT COUNCIL
(All correspondence should addressed to District Executive Director)

HALMASHAURI YA WILAYA MOSHI

Unapojibu tafadhali taja
KILIMANJARO REGION

Simu 2755172/2751865
Fax. 2754305
Baruapepe: ded@moshidc.go.tz.

MOSHI DISTRICT COUNCIL,
P.O. BOX 3003,
MOSHI.

Ref.No.MDC/E.10/16/VOL./113 **Date: 1ST November , 2024**

Ward Executive Officers,
MOSHI DISTRICT COUNCIL

REF: PERMIT TO CONDUCT RESEARCH ADVELLA NTAGEKI

Refer to the heading above.

2. I would like to inform you that **ADVELLA NTAGEKI** from Moshi Co-operative University (MoCU) is granted permission to conduct research with effect from **7TH October, 2024 to 7th October, 2025.**

3. He/She expects to conduct research about" **CLEAN COOKING ENERGY AFFORESTATION AND ENVIRONMENTAL CONSERVATION AT HOUSEHOLD LEVEL IN TANZANIA**

4. Please receive her / him and provide the required cooperation and make sure that they abides by all Government Rules and Regulations.

5. Thank you for your co –operation.

Rehema Matumla
For: DISTRICT EXECUTIVE DIRECTOR
MOSHI DISTRICT COUNCIL.

Copy to:

Advella Ntageki
Research Student.

Kauli mbiu : "*Serikali za Mitaa, Sauti ya Wananchi, Jitokeze kushiriki Uchaguzi*"

Appendix 6: Proofreading certificate

MOSHI CO-OPERATIVE UNIVERSITY (MoCU)
CHUO KIKUU CHA USHIRIKA MOSHI

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info@mocu.ac.tz
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INFORMATION SCIENCES
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Tel: +255 27 2754402 e-mail:
Fax: +255 27 2750806
E-mail: dfbis@mocu.ac.tz

Date: 17th November 2025

Director,
Postgraduate Studies,
Moshi Co-operative University (MoCU)
P.O.Box 474,
Moshi

Dear Sir/Madam,

RE: EDITING AND PROOFREADING CHECKLIST

This letter is to verify that ***Advella Ntangeki*** has successfully completed the editing and proof-reading process of the Dissertation titled ***"Impact of Clean Cooking Energy and Afforestation on Environmental Conservation at Household Level in Tanzania: A Case of Moshi District Council".*** The editing process has been conducted under the supervision of the English Language and Academic writing experts from Moshi Co-operative University (MoCU) in the Communication Skills Unit. Kindly receive the track changes document attached with this letter.,

With Co-operative Greetings,

Dr. Odax Manumbu Lawrence

Vision: To become a Centre of Excellence in Co-operative Education and Practice
Centre of Excellence in Co-operative and Business Management Training of the East Africa Community (EAC)

Appendix 7: Plagiarism report

Exavery ANTHONY

ADVELLA NTANGEKI

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Appendix 8: Manuscript

IMPACT OF CLEAN COOKING ENERGY AND AFFORESTATION ON ENVIRONMENTAL CONSERVATION AT HOUSEHOLD LEVEL IN TANZANIA: A CASE OF MOSHI DISTRICT COUNCIL

By
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Abstract
Clean cooking energy and afforestation practices are essential components in promoting environmental conservation, especially at the household level. The number of Tanzanians using clean cooking energy has increased slightly from 1.5% in 2010 to 6.9% in 2021. This study aimed to analyse the impact of clean cooking energy and afforestation on environmental conservation at the household level in Tanzania: a case study of Moshi District Council. Specifically, the study intended to examine the determinants of tree planting practice and its contribution to environmental conservation at the household level, explore determinants of tree harvesting practice and its contribution to environmental conservation at the household level and determine the costs and benefits of clean cooking energy adoption and its contribution to environmental conservation at the household level in Moshi District Council. A cross-sectional research design was employed. The sample included 381 respondents and 4 key informants, for a total of 385. Data were collected using a survey questionnaire, interviews, and documentary review, with simple random and purposive sampling used to select respondents. This study employed a Binary Logistic Regression Model and a Cost-Benefit technique to analyse the data. The findings showed a positive statistically significant association between fruit trees provision, increasing biodiversity, education, marital status and tree planting practice with $p < 0.05$. Moreover, forest management practices, forest protection targets, education, household size and timber production have a statistically significant relationship with tree harvesting practice ($p < 0.05$). Regarding the adoption of clean cooking energy, the cost-benefit analysis showed a BCR of 1.1. The study concluded that when households understand the ecological importance of trees, such as their role in preserving diverse plant and animal species, stabilising ecosystems, and improving climate resilience, they are more inclined to plant and conserve them. With regard to tree harvesting practices, forest management influences household decisions. Again, the cost-benefit analysis for clean cooking energy adoption showed a BCR of 1.1, meaning that using clean cooking energy saves money, time spent going and returning, and time spent gathering firewood, and reduces health risks associated with medical expenses. This study recommended that, given the strong influence of education on both tree planting and harvesting practices, LGAs should integrate environmental education into their local development agendas.

Keywords: *Clean cooking energy; Afforestation; Environmental conservation; Tree planting determinants; and Tree harvesting determinants.*

1.0 Introduction

Clean cooking energy and afforestation are increasingly recognised as vital strategies for promoting environmental conservation at the household level. Clean cooking technologies such as LPG, biogas, electricity, and improved cook stoves emit fewer pollutants compared to traditional fuels like firewood and charcoal, which contribute to deforestation, indoor air pollution, and greenhouse gas emissions. Afforestation efforts complement clean energy adoption by restoring degraded lands, sequestering carbon, and enhancing biodiversity.

Globally, access to clean cooking energy remains a challenge, with an estimated 2.4 billion people still relying on biomass fuels as of 2021. Sub-Saharan Africa bears a disproportionate burden, as more than 390 million people continue using inefficient and polluting traditional cooking methods. Although initiatives tied to Sustainable Development Goal 7 aim to expand access to modern energy, economic constraints, limited infrastructure, and rising energy prices have slowed progress. Consequently, many households have reverted to firewood and charcoal despite earlier transitions to cleaner alternatives.

Across Africa, clean cooking energy and afforestation have gained prominence due to their potential to mitigate environmental degradation and improve household wellbeing. Improved cook stoves, solar technologies, and biogas systems have been introduced as accessible solutions to reduce reliance on wood fuels. Simultaneously, governments in countries such as Kenya, Nigeria, and Senegal have implemented afforestation programmes to address forest loss driven by agricultural expansion, logging, and urbanisation. Nevertheless, over 90% of East African households continue to depend on biomass fuels, highlighting persistent gaps in adoption and awareness.

In Tanzania, reliance on biomass remains extremely high, with biomass accounting for 82% of primary energy use and 90% of cooking energy. Despite efforts to promote clean energy, only 6.9% of Tanzanians used clean cooking fuels in 2021 an increase from 1.5% in 2010 but still far below global averages. Widespread dependence on firewood and charcoal has intensified deforestation, with an estimated 469,420 hectares of forest cleared annually for household energy needs. Additional challenges such as high upfront costs, limited access to clean energy technologies, weak policy implementation, and inadequate awareness continue to hinder progress.

In Moshi District Council, household cooking practices and afforestation decisions are shaped by economic, environmental, and social factors. Studies have shown that the cost of fuel provision remains the largest contributor to cooking expenses, while perceived long-term benefits such as reduced fuel costs, improved health, and increased agricultural productivity play an important role in shaping household conservation behaviour. Local government initiatives, including annual tree-planting campaigns targeting 1.5 million seedlings and community environmental education programmes, demonstrate ongoing commitment to conservation. However, limited research exists on how clean cooking energy adoption and afforestation practices contribute to environmental conservation specifically at the household level in this district.

To bridge this gap, the present study analyses the impact of clean cooking energy and afforestation on environmental conservation at the household level in Moshi District Council, focusing on the determinants, costs, and benefits of these practices and their contribution to sustainable environmental management.

1.2 Theoretical Ground

The study was guided by the Theory of Planned Behaviour (TPB) developed by Ajzen (1991) and the Resource Dependency Theory (RDT) introduced by Pfeffer and Salancik (1978). The Theory of Planned Behaviour states that human actions are influenced by three main components attitude toward the behaviour, subjective norms, and perceived behavioural control which together shape behavioural intentions and actual behaviour. The theory assumes that when individuals have positive attitudes, supportive social expectations, and adequate control over resources and opportunities, they are more likely to engage in a particular behaviour. In this study, the TPB was used to examine how household attitudes, social influences, and perceived ability affect decisions to plant trees, harvest trees sustainably, and adopt clean cooking energy. The theory helped the researcher understand how behavioural motivations and social pressures influence environmental practices at the household level.

The Resource Dependency Theory assumes that individuals or organisations depend on external resources, and this dependency significantly shapes their decisions and actions. The theory emphasises that access to critical resources such as land, seedlings, water, energy technologies, and financial means determines the extent to which households can participate in environmental conservation. In this study, RDT was used to examine how resource availability, accessibility, and support from external stakeholders influence household engagement in afforestation and clean cooking practices. It also guided the identification of structural constraints, such as high costs, limited access to clean energy technologies, and inadequate institutional support, which hinder sustainable environmental practices at the household level.

Together, the two theories provided a comprehensive foundation for analysing both the behavioural and resource-related factors that shape household decisions. The TPB guided the understanding of internal motivations and perceptions, while the RDT supported the examination of external resource conditions and institutional influences. These theories enabled the researcher to interpret how psychological attitudes and resource dependencies interact to promote or hinder environmental conservation efforts at the household level.

1.3 Research Methodology

1.3.1 Study Area and Research Design

This study was conducted in the Moshi District Council, Tanzania. The district was selected because it is experiencing high levels of deforestation driven by heavy household dependence on firewood and charcoal, with 96% of rural households relying on firewood as their primary cooking fuel (Mosses *et al.,* 2023). According to the 2022 Tanzania Population and Housing Census, the district has 535,803 people living in 145,669 households (NBS, 2022), and recent reports show continuous forest loss, with 25 ha of natural forest lost in 2024 alone (Global Forest Watch, 2025). These conditions make the district an appropriate setting for studying the adoption of clean cooking energy and its potential environmental benefits.

To examine the adoption of clean cooking energy and its contribution to reducing deforestation and improving household well-being, a cross-section research design was adopted. This design was suitable because it enabled systematic assessment of existing household cooking practices, energy choices, and environmental challenges, while providing a structured understanding of patterns and relationships within the study population (Mertler, 2019).

1.3.2 Study Participants, Sampling Techniques, and Data Collection Methods

The study involved 381 household respondents drawn from selected wards within Moshi District Council, along with four Key Informants from relevant institutions. Participants included household heads as primary energy users, as well as Officers from the Moshi District Council and the Tanzania Forest Services Agency (TFS), who are directly involved in clean energy promotion and forest conservation activities.

A purposive sampling technique was used to select the four key informants two officers from the Moshi District Council and two from TFS due to their specialised roles and experience in overseeing clean cooking energy initiatives and afforestation programmes. In addition, simple random sampling was applied to select household respondents to ensure that all households had an equal chance of participation and that the findings accurately represented community-level cooking practices.

Data collection relied on both primary and secondary sources. Primary data were gathered through household surveys, key informant interviews, and field observations. Secondary data were collected through documentary reviews, including academic publications, environmental reports, institutional documents, and credible online databases.

1.3.3 Data Analysis Techniques

The study used both qualitative and quantitative data analysis approaches. Quantitative data were analysed using descriptive statistics, enabling clear summarisation of numerical information related to household income, cooking energy expenditure, installation costs, and time savings associated with clean cooking adoption. This approach facilitated comparison across households and supported the calculation of the cost–benefit ratio of clean energy use. Microsoft Excel 2019 was used for statistical processing and generation of tables and charts to visually present key findings.

Qualitative data obtained from interviews and open-ended survey responses were analysed using qualitative content analysis. This method enabled the identification of emerging themes related to household perceptions, behavioural drivers of clean cooking adoption, environmental awareness, and institutional insights from key informants. Through this combined analytical approach, the study generated a comprehensive understanding of both the numerical trends and contextual factors influencing clean cooking energy adoption in Moshi District Council.

1.4 Findings and Discussion

1.4.1 Tree Planting Practice and Its Contribution to Environmental Conservation at the household level in Moshi District Council

The first objective of this study aimed at examining the determinants of tree planting practice and its contribution to environmental conservation at household level in Moshi District Council. A Binary Logistic Regression Model was used to assess this objective. A Binary Logistic Regression Model is widely used when the dependent variable is dichotomous and the aim is to examine the relationship between 1 or more independent variables and the likelihood of an event occurring. In this study, the model estimates the probability that a household plants trees based on several independent variables, including the provision of fruit trees, biodiversity, water availability, firewood, timber production, education, marital status, and housing type.

Table 1: Binary Regression results on determinants of tree planting practice and its contribution to environmental conservation at the household level in Moshi District Council

Determinants	Coefficient	Std. Err.	T	P>|t|	[95% Conf.	Interval]
Provision of fruits trees	0.2017	0.0582	0.35	0.029*	0.9424	0.1346
Biodiversity	0.2600	0.0645	4.03	0.000**	0.1329	0.3865
Water availability	0.0003	0.0299	0.01	0.999	-0.585	0.0592
Firewood	-0.0088	0.0176	-0.50	0.619	-0.4341	0.0259
Timber production	0.0237	0.0166	1.43	0.001*	-0.0090	0.0564
Education	0.0898	0.0195	4.59	0.000**	0.1290	0.0535
Marital status	0.0626	0.0451	2.39	0.017*	0.1513	0.0262
Housing type	-0.0132	0.0398	0.33	0.739	-0.0649	0.0915
_cons	1.3037	0.2579	5.06	0.000	0.7966	1.8108

Log likelihood value = 28 22, Likelihood ratio statistics $X^2{}_1$ = 92.21, R^2 = 56.28%, % of correct prediction = 68.4%, Number of observation (N) =381, **statistically significant at P < 0.01, *statistically significant at P < 0.05.

The regression analysis revealed that the provision of fruit trees, household appreciation of biodiversity, and timber production all had positive and statistically significant effects on tree-planting practices. Households were motivated to plant fruit trees due to long-term livelihood and environmental benefits, consistent with earlier findings by Kulindwa (2016). Similarly, households that valued biodiversity were more likely to engage in tree planting, reflecting strong environmental awareness and reinforcing the Theory of Planned Behaviour, which explains how internal motivations and perceived social pressures shape tree-planting decisions. These results align with studies by Brancalion and Holl (2020) and Sharma et al. (2020), who found that biodiversity awareness enhances reforestation efforts. Although timber production also showed a positive influence, this contrasts with studies such as Kansanga et al. (2021) and Amare and Darr (2020), which argue that long-term forestry investments require additional institutional and technical support.

The study further found that education and marital status had significant positive effects on tree-planting practices, though these results diverged from some earlier research. Higher education levels increased the likelihood of tree planting, despite contrasting findings from Robinson (2016), who argued that education enhances environmental engagement but may also lead to reduced participation when individuals shift toward urban livelihoods. Marital status also positively influenced tree planting, as married households often prioritise long-term investments beneficial to family welfare. However, this differs from Zande and Mzuza (2022), who noted that additional dependents may limit the ability to engage in long-term environmental activities. Overall, the findings suggest that a combination of socioeconomic factors, environmental awareness, and perceived long-term benefits collectively shape household decisions to engage in tree-planting practices.

1.4.2 Determinants of Tree Harvesting Practice and Its Contribution to Environmental Conservation at the household level in Moshi District Council

The second objective of this study was to examine the determinants of tree harvesting practice and its contribution to environmental conservation at the household level in Moshi District Council. A Binary Logistic Regression Model was used to assess determinants of tree harvesting practice at the household level in Moshi district Council. In this study, the model estimates the probability that a household harvests a tree based on several independent variables, including forest management practices, forest protection targets, firewood availability, education, household size, and timber production

Table 2: Determinants of tree harvesting practice and its contribution to environmental conservation at the household level in Moshi District Council

Determinants	Coefficient	Std. Err.	T	P>|t|	[95% Conf.	Interval]
Forest mgt practices	0.9042	0.0574	0.000**	0.116	0.2033	0.0225
Forest protection targets	0.0770	0.0489	0.047*	0.117	0.1731	0.0193
Firewood	0.0086	0.0155	-0.440	0.660	0.0372	0.2361
Education	0.0852	0.0198	0.029*	0.000	0.0462	0.1242
Household size	0.0920	0.0113	0.001*	0.859	0.0241	0.0201
Timber production	0.0809	0.0143	0.000**	0.950	0.0291	0.0273
_cons	1.1730	0.1316	8.91	0.859	.9142	1.4319

Log likelihood value = 36.48, Likelihood ratio statistics X^2_1 = 84.16, R^2 = 58.63%, % of correct prediction = 62.6%, Number of observation (N) =381, **statistically significant at $P < 0.01$, *statistically significant at $P < 0.05$.

The regression analysis revealed that forest management practices, forest protection targets, and education all had positive and statistically significant relationships with household tree-harvesting behaviour in Moshi District Council. Effective community participation in forest management appears to encourage regulated harvesting, supporting Luswaga and Nuppenau's (2020) and Yami and Mekuria's (2022) argument that participatory approaches strengthen conservation outcomes. Likewise, forest protection targets were found to influence household practices, aligning with Bakehe and Hassan (2023), who linked protection efforts to reduced reliance on biomass fuels. However, these findings contrast with Swallehe (2022), who stresses that weak policy implementation limits effectiveness at the household level. The results further showed that education significantly shapes tree-harvesting behaviour, supporting Börner et al. (2020), who highlight education's role in fostering informed and responsible forest use.

Household size and timber production were also significantly associated with tree-harvesting practices, though the findings presented a more nuanced picture. While larger households are commonly believed to exert more pressure on forest resources, the results suggest that factors such as access to alternative energy sources, cultural norms, and local regulations may weaken this relationship, partially supporting Mantey and Teye's (2021) insights into forest dependence. Timber production also showed a significant association, yet the study indicates that harvesting decisions are shaped more by socio-economic and institutional factors than by timber extraction alone. This contradicts Blerk et al. (2021), who emphasised timber production as a major driver of forest degradation. Overall, the findings show that forest management dynamics in Moshi District Council are influenced by a combination of community participation, environmental policies, socio-economic characteristics, and resource-use motivations.

Cost and Benefits of Clean Cooking Energy Adoption and Its Contribution to Environmental Conservation

The third objective of this study was to reveal the costs and benefits of adopting clean cooking energy at the household level in Moshi District Council. Both qualitative and quantitative methods were employed to achieve this objective. This objective sought to assess both the economic and non-economic costs and benefits of adopting clean cooking energy, including initial investment, fuel savings, time efficiency, health improvements, and environmental conservation. The cost elements related to the adoption of clean cooking energy at the household level in Moshi District Council include the cost of installing clean cooking energy and the monthly cost of using it, as indicated in Table 3.

Table 3: Costs of adopting clean cooking energy

Variable costs	Costs (TZS)
Amount spent on installing clean cooking energy	156 496.06
Amount spent monthly on clean cooking energy	36 581.60
Total variable costs	193 077.66
Net revenue	21 922.34

The findings indicate that the initial and recurring costs of clean cooking energy remain major barriers to adoption among households in Moshi District Council. Although 69% of households spent less than 125,000 TZS on installation, the average initial cost of 156,496.06 TZS combined with a monthly expenditure of 36,581.60 TZS totals approximately 193,077.66 TZS, an amount that is high relative to household income levels. This limits the uptake of clean cooking systems, particularly among poorer households, reinforcing evidence from Schilmann et al. (2021), Alananga (2024), and Fernandez-Vallado (2025), who emphasize the need for subsidies, microcredit, and pay-as-you-go models to reduce financial barriers.

Monthly spending patterns also show that while most households spend between 25,000 and 62,500 TZS, ongoing fuel costs remain a significant burden, causing some households to revert to cheaper biomass alternatives such as charcoal and firewood, which contributes to environmental degradation. These results align with Nzengya et al. (2021) and Nabukwangwa et al. (2023), who found that fuel affordability strongly determines sustained use of clean cooking technologies in low-income settings.

Based on discounted variable costs and benefits, a Benefit-Cost Ratio (BCR) analysis of clean cooking energy adoption was conducted. This included amount spent on installing clean cooking energy, amount spent monthly on clean cooking energy, total discounted variable costs and total discounted benefit as presented in Table 4

Table 4: Benefit-cost ratio analysis of clean cooking energy

Discounted variable costs and benefits	Costs (TZS)
Amount spent on installing clean cooking Energy.	142 269.15
Amount spent monthly on clean cooking energy	33 256.00
Total discounted variable costs	175 525.15
Total discounted benefit	195 454.55
BCR	**1.1**

The cost–benefit analysis showed that households in Moshi District Council incur a discounted cost of 175,525.15 TZS for adopting clean cooking energy but gain benefits valued at 215,000 TZS, resulting in a favourable BCR of 1.1. This demonstrates that clean cooking energy yields substantial financial, health, and time-saving benefits, including reduced firewood collection, fewer medical expenses, and lower exposure to indoor air pollution. Interview feedback supported these findings, with respondents highlighting major time savings over 88% reported gaining at least 45 minutes daily, and many saved up to 2 hours and 30 minutes.

As one of the key informants said:

> *"…Using clean energy sources such as gas stoves, solar cookers, or electric stoves drastically reduces the time spent cooking, as these technologies heat up quickly and require less monitoring than traditional biomass fuels like firewood or charcoal. The quick ignition and consistent heat of these stoves enable users to prepare meals more efficiently, especially during peak hours such as early mornings and evenings…"* (KII 1, Moshi DC November 2024).

Another participant pointed out that:

> *"...Traditional fuels require significant time to collect (especially firewood), which is eliminated by adopting clean energy solutions. This saves women and children, who are often responsible for fuel collection, several hours per week, reducing physical strain and creating time for education, rest, or economic pursuits..."* (KII 2, Moshi DC November2024).

Key informants further explained that clean energy technologies heat faster, require less supervision, and eliminate long hours spent collecting fuel, especially for women and children, allowing more time for income-generating activities, childcare, and rest.

Health improvements were also widely reported, with 86.4% of households noting significant reductions in respiratory and eye-related illnesses after shifting from traditional biomass fuels. Clean cooking energy was similarly credited with mitigating environmental degradation, with 99.7% of respondents stating that it helps reduce deforestation by lowering reliance on firewood and charcoal. These findings align with global evidence showing that clean cooking reduces pollution-related diseases and slows forest loss. The adoption behaviour is well explained by the Theory of Planned Behaviour, as households were influenced not only by financial gains but also by positive health outcomes, social encouragement, and confidence in using clean cooking systems. Interview insights reinforced that households value both tangible and intangible benefits, supporting broader transitions toward sustainable household energy use.

1.4.3 Theoretical reflection

The study applied the Theory of Planned Behaviour (Ajzen, 1991) as its main theoretical framework. This theory posits that individual behaviour is influenced by attitudes toward the behaviour, subjective norms, and perceived behavioural control. In the context of this study, household decisions to adopt clean cooking energy were shaped not only by perceived financial benefits but also by social influences, such as observing neighbours or community leaders using clean energy, and by confidence in their ability to sustain its use. Additionally, the Human Capital Theory (Schultz, 1961) was referenced to explain how education empowers households to make informed decisions about energy use, improving both economic and health outcomes. Finally, the Sustainable Livelihoods Approach (Chambers & Conway, 1992) was considered to understand how clean energy adoption contributes to broader household well-being by enhancing access to time, health, and environmental resources.

The findings revealed that clean cooking energy adoption provides multiple benefits beyond direct financial gains, including reduced time spent on cooking and fuel collection, improved household health, and decreased environmental degradation. Over 88% of households reported saving at least 45 minutes daily, while 86.4% experienced significant improvements in health outcomes due to reduced indoor air pollution. Environmental benefits were also near-universal, with 99.7% of respondents acknowledging reduced reliance on firewood and charcoal, thereby contributing to forest conservation. The Theory of Planned Behaviour helps explain these patterns, as households' positive attitudes, reinforced by social norms and confidence in managing clean cooking systems, drove continued use. Human Capital Theory emphasizes the role of education in equipping households with knowledge to make these decisions, while the Sustainable Livelihoods Approach highlights how adopting clean energy strengthens household assets, reduces vulnerabilities, and improves quality of life.

1.5 Conclusion and Recommendations

1.5.2 Conclusion

Firstly, the results highlight the crucial role of environmental consciousness in influencing household-level afforestation efforts. When households understand the ecological importance of trees, such as their role in preserving diverse plant and animal species, stabilising ecosystems, and improving climate resilience, they are more inclined to plant and conserve them. Many households prefer long-term investment for the family's future; therefore, timber species often appeal to households that typically prioritise long-term gains and view land tenure as an appreciated asset. Increasing land values in the future increases households' willingness or ability to commit to long-term forestry investments.

Secondly, regarding tree harvesting practices, forest management can influence household decisions and has a meaningful impact on them. This may be because many forest management initiatives in the area are effectively implemented due to strong community engagement, suggesting that current forest management practices in Moshi District Council may, through a participatory approach to tree planting, influence environmental conservation. On the other hand, larger households exert greater pressure on forest resources due to increased demand for cooking fuel, construction materials, or income from forest products.

Lastly, the cost-benefit analysis for clean cooking energy adoption showed a BCR of 1.1, indicating that the benefits outweigh the costs. This means that using clean cooking energy saves money, time spent going and returning, and time spent gathering firewood, and reduces health risks that could lead to medical expenses. This concludes that the immediate financial gain outweighs the costs, and that clean cooking energy remains worthwhile when considering long-term social, environmental, and health benefits. This includes reduced indoor air pollution, lower fuelwood demand, and improved household well-being, which are not fully captured in the monetary calculation. Moreover, households benefit significantly from time savings after adopting clean cooking energy, as traditional cooking methods using biomass fuels emit high levels of indoor air pollutants, such as carbon monoxide, which are linked to respiratory diseases, eye irritation, and other chronic health problems.

1.5.3 Recommendations

Based on the findings, the following recommendations are provided to improve access to clean cooking energy and support environmental conservation through household-level afforestation in Tanzania. Given the strong influence of education on both tree planting and harvesting practice, LGAs should integrate environmental education into local development agendas. This could be achieved by incorporating environmental content into primary and secondary school curricula, as well as by organising community seminars, workshops, and public sensitisation forums in collaboration with local leaders. Special attention should be given to educating youth and rural populations, who are most likely to engage in unsustainable harvesting.

NGOs should take the lead in raising awareness of the environmental and economic consequences of poor tree harvesting practices. These campaigns can include door-to-door education, radio programmes, and participatory theatre that communicates messages in local languages. Involving respected community figures can enhance credibility and local buy-in.

NGOs and environmental organisations should strengthen community reforestation by partnering with schools, women's groups, and youth clubs. Providing seedlings, tools, and technical knowledge on proper tree spacing, species selection, and post-planting care can improve survival rates and environmental Impact.

International donors and development partners should prioritise clean energy interventions in their development portfolios. By funding projects that provide affordable, context-appropriate technologies, they can reduce households' reliance on firewood and charcoal. Projects should include technical training, user support, and follow-up services to improve sustainability.

Community leaders, including village elders and religious leaders, should actively promote sustainable practices during public gatherings, religious services, and local celebrations. Their involvement can shift community norms and encourage hesitant households to adopt environmentally friendly practices.

Households that are already engaging in tree planting or using clean cooking energy should be encouraged to share their experiences through village forums or peer-learning sessions. By showcasing both the challenges and benefits they have encountered, they can serve as role models for others in the community, thereby accelerating broader behavioural change.

1.6 Area for further research

Future studies should adopt a longitudinal approach to assess the long-term socio-economic and health impacts of clean cooking energy adoption. Such studies would help capture delayed benefits, such as reduced healthcare costs, improved respiratory health, and long-term environmental outcomes, such as forest regeneration. While this study examined socio-economic factors, future research should investigate the cultural and behavioural dimensions that influence tree-planting and harvesting decisions. Understanding local traditions, beliefs, and values around land use and tree management could provide more context-specific policy interventions. This study did not conduct a gender-disaggregated analysis. Future studies could explore how gender roles and responsibilities affect tree planting, harvesting, and the adoption of clean energy technologies. This would help in designing inclusive policies and interventions that empower both men and women.

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