Assessment of Afforestation Activities in Embu and Kirinyaga Counties of Kenya

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Abstract

This study assessed afforestation activities in Embu and Kirinyaga counties in Kenya and the contributions of the Upper Tana Natural Resources Management Project (UTaNRMP) to livelihood and environmental sustainability. Quantitative and qualitative research methods were adopted for the study. The representative sample of 421 households was randomly selected and interviewed with the aid of a well-structured questionnaire. Focus group discussions and key informant interviews were also conducted. Data were analysed using descriptive and inferential statistics.

Results revealed that afforestation in the catchment area has improved and the presence of community forest associations (CFAs) has led to increases in forest cover in most of the forests as areas initially degraded have been rehabilitated and there has been enhanced species regeneration. For instance, the New Njukiri CFA in Embu West, Kirimari Ward, has planted 150,000 tree seedlings, 75% exotic and 25% indigenous tree species, in 2 years (2015-2017) with an average survival rate of 75%, while the Kangaita Community Forest Users Association has rehabilitated 55 hectares of the Kangaita Forest in Kirinyaga County. The UTaNRMP has led to improvements in the level of mutual accountability, conservation awareness, and learning. Communities have

embraced new sources of income like ecotourism, beekeeping and the Plantation Establishment and Livelihood Scheme (PELIS) which has helped in increasing forest cover as well as improving food security. The study revealed improved income as the average household monthly income was over 20,000Ksh. Similarly, the average household meals per day was 3 meals and 81.7% of the households indicated no hunger in the last 1 month before the study. Results also revealed that social and economic factors significantly influenced livelihood diversification and afforestation in the catchment area.

Overall, the UTaNRMP has contributed significantly to livelihood diversification, increased level of afforestation, enhanced community-based mutual accountability and learning as well as ensured environmental sustainability. However, there is the need to put in place a sustainable natural resources management framework for enhancing a sustainable balance in afforestation and livelihood in Kenya.

Keywords: Climate change, Agricultural livelihood, Afforestation, Adaptation, Environmental sustainability.

Introduction

The sustainability of humans depends on the proper use of available environmental capital such as soil, water, and vegetation (Keesstra et al., 2016). Forests and tree lots play an important role in the environment for provision of the necessities of life, and a habitat that ensures that benefits are obtained from forest ecosystems goods and services. Globally, an estimated 2.4 billion people worldwide benefit from agroforestry systems across one billion hectares (FAO, 2018).

Forests are areas of at least 0.5 hectares with tree crown cover of more than 10%. They are designated as protected areas which host game parks and forest reserves (FAO 2001b). They make tangible contributions to the national economy by supplying renewable sources of energy in the form of wood fuel and charcoal. According to Aguilar et al. (2012), afforestation pertains to areas that have not been forested for about 50 years

and above, while reforestation applies to forested land that was turned over to another use.

Afforestation is of specific importance as it reduces the negative effects of torrential rainfall through its main components, such as the canopy of trees, the vegetation, litter, specific forest soil, loose and powerful high-capacity drainage systems due to root development (Mita and Matreata, 2005).

Kenya has approximately 1.42 million hectares of closed canopy forest and it is considered to be a low forest country with a forest cover of 7.2%, which is significantly lower than the internationally accepted threshold of 10%. Forests in Kenya are classified into six broad categories: The High Volcanic Mountains and High Ranges, the Western Plateau, the Dry Northern Mountains, the Southern Hills, the Coastal Forest, and the Riverine Forest. The country's forests are estimated to contribute to 3.6% of Kenya's GDP (NFP, 2014), excluding charcoal and direct subsistence uses. The value of Kenya's forests cannot be overemphasized. Being a finite, significant economic resource, they should be well managed. To achieve Kenya's vision 2030 of effective use of the land to achieve socio-economic and political development, forest cover needs to be increased from 7.2% to 10% coverage under a protected area system. Forested catchment supplies 75% of all freshwater for farms, industry and homes while the Upper Tana Catchment Area of Kenya provides water and supplies hydroelectric power to the population.

Description of the UTaNRMP

The Upper Tana Natural Resources Management Project is an eight-year project (2012-2020) that is funded by the Government of Kenya, the International Fund for Agricultural Development (IFAD), the Spanish Trust Fund and the local community. The project has the goal of contributing to reduction of rural poverty in the Upper Tana River Catchment Area among the target population of about 205,000 poor households living in the targeted river basins whose livelihoods revolve around the use of the natural resources in the Upper Tana catchment.

This goal is pursued via two development objectives which reflect the poverty-environment nexus, namely: increased sustainable food production and incomes for poor rural households living in the project area

and sustainable management of natural resources to provide environmental services.

UTaNRMP was implemented through four (4) components, namely: a) community empowerment (US$ 4.1million / 6% of total project funds); b)sustainable rural livelihoods (US$ 22.3 million / 32.3% of project funds); c) sustainable water and natural resources management (US$ 32 million / 46.5% of project funds); and d) project management and coordination (US$ 10.5 million / 15.2% of total project funds).

The sustainable water and natural resources component has two sub-components: sustainable water resources and sustainable management of forest and agricultural ecosystems.

The sustainable management of forest and agricultural ecosystems sub-component addresses the rehabilitation of degraded forest reserves which includes: activities such as building the capacity of community associations in participatory forest management, seedling nursery management and the rehabilitation of degraded forest areas (UTaNRMP, 2017. Also UTaNRMP, through this sub-component encourages efficient use of fuelwood such as fuel-efficient stoves, biogas generators and charcoal kilns through the provision of matching grants, together with training in the manufacture/fabrication and use of such equipment. This sub-component is also concerned about human-wildlife conflicts and soil and water conservation on farmlands.

The sub-components targets

Activity	**Project Target**
School Greening Programme	1972 schools to be reached
Forest Rehabilitation	2000 Ha of forest to be rehabilitated
Wildlife Control Fence	60km of fence to be constructed
Matching Grants to Common Fence	400 No. common interest groups to be funded
Energy Savings Jikos	165 Jikos for demonstration
Efficient Charcoal Kilns	33 kilns for demonstration

Theoretical Framework

According to Victor and Bakare (2004), many people participate in afforestation activities if they are able to or expect to get important livelihood sustaining products from the forests. Some studies indicate that factors such as socioeconomic benefits, age and education influence people's participation in afforestation projects. However, more households participate in afforestation activities if they can get important livelihood sustaining products from the forests, such as fuelwood and fodder (Maskey et al., 2003).

However, Chowdhury (2004) argues that the majority of farmers participate in afforestation projects because of anticipated economic benefits, environmental benefits and because of social status. He observes that the poor socio-economic background of farmers regarding occupation and level of income influences the extent of their participation in afforestation projects. He also observed that people's level of education influences their participation in afforestation projects. Age is also one of the factors that have been observed to determine community participation in afforestation activities. Some young farmers participate in afforestation activities because they can plant trees and harvest them within their lifetime (Victor and Bakare, 2004).

Maskey et al. (2003) argue that older people tend to participate more in afforestation activities than younger people because they are retired and have free time to participate in meetings. They further observe that landholding significantly influences their participation in forest activities with the assumption that wealthier people are more likely to participate in higher levels of environmental management.

Diverse perspectives from the social and economic sciences have been brought together to study the factors influencing farmers' adoption of rural innovations like tree planting (both in agroforestry and farm forestry systems), and the factors that lead to some forest users practicing better afforestation than others. Likewise, a diverse range of theoretical and methodological approaches have been used to study these factors (e.g. Amacher et al. 1993, Scherr 1995, Thacher et al. 1997, Salam et al. 2000, Byron 2001, Pattanayak et al. 2003, Mercer 2004, Walters et al. 2005).

The theoretical framework used in this study is drawn from existing studies related to the socio-economic, perceptional and other possible factors that can influence tree planting activity in tropical and sub-tropical countries.

Conceptual Framework

The perception of afforestation as well as the factors that affect and determine participation and engagement in afforestation activities are explained in Figure 1. A major factor stated in figure is government policies and strategies. Policy and decisions made can have both negative and positive impact on afforestation. For instance, incentives like linking communities with inputs such as seedlings, extension services information, farm mentoring and encouraging cooperative societies and community-based organizations could positively affect afforestation. In addition, better efficiency in energy use in the household, such as using improved cooking appliances like Jiko Kisasa, Maendeleo Jiko, Upesi Jiko, Fireless Jiko and other energy saving jikos could increase afforestation. Increased green energy sources like biofuel, biogas, solar power and better access to energy-saving cooking appliances could lead to high level of afforestation.

Environmental condition is also a major factor that affects afforestation. Diseases and pests of trees and seedlings reduce the survival rate of trees and consequently affects afforestation since low survival rate results in low afforestation. Moreover, increased community awareness on environmental management will increase the likelihood of engagement in tree planting, nursery management and other forest-related activities like beekeeping, mushroom collection and herbal collection. Availability of extension services cannot be over stated as increased training engagement and increased application of new knowledge will contribute positively to increased tree cover.

The level of extension services and research goes a long way in encouraging and making households participate in afforestation activities. Extension facilitates the adoption of improved technologies through awareness creation and information dissemination that results in the acquisition of skills, knowledge and training that will help improve efficiency.

Community group awareness and engagement are very important for regular participation, value addition and influence, and decision to be better. When people discuss the number of tree seedlings they have planted and the number that has survived, others tend to be encouraged to do better. Improved access to forests, especially farm forests would enhance forest-related engagement. Also reduced cost of seedlings, transportation to market to get the seedlings, transportation to the farm, and improved income all have positive effects on adoption of afforestation in a community.

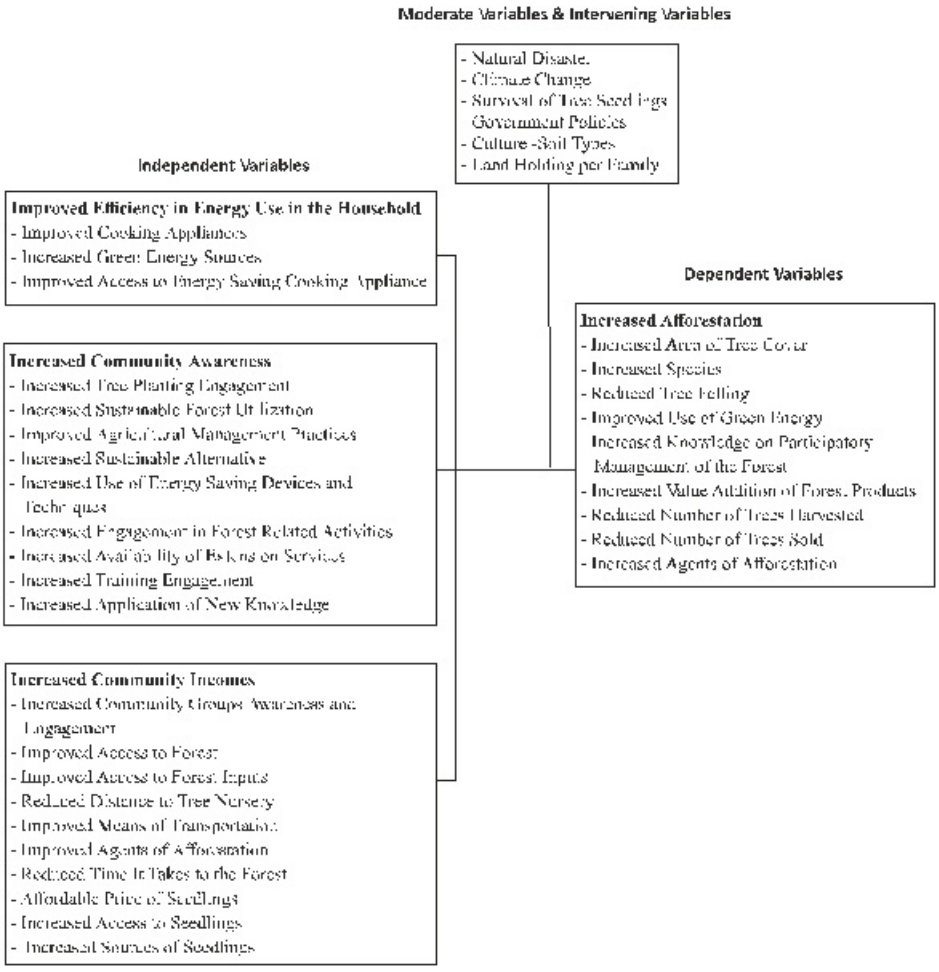

Figure 1: Operational Concept of Afforestation Activities.

Source: Authors' compilation.

Materials and Methods

This study was carried out in Embu and Kirinyaga counties, Upper Tana Catchment Area, Kenya. The catchment area covers the six counties of Murang'a, Nyeri, Kirinyaga, Embu, Tharaka-Nithi and Meru and is home to 5.2 million people. Temperature in the area is estimated at an average of between 9°C and 28°C and the area receives substantial rainfall with an average annual precipitation of 1206mm. The wettest season is experienced between March and July while the hottest is between January and mid-March. The land is largely arable and well-watered by a good number of rivers and streams. Agriculture is the main driver of the economy in this catchment with over 70% of the residents being small-scale farmers.

Both primary and secondary data were used for this survey. The secondary data were collected from journal reports, newsletters, UTaNRMP baseline surveys, interview reports, published research works, the Internet and books. The primary data were collected through key informant interviews, focus group discussions (FGD), individual household respondent interviews, questionnaires and observations and a mixed-method evaluation design. Quantitative and qualitative data collection methods were adopted.

Questionnaires were administered through enumerators after the objectives of the survey had been properly explained and they were properly trained on how the questions should be answered. Testing of survey instruments was carried out in the survey areas after which the responses were reviewed and necessary corrections were made to the instruments.

Stratified random sampling was employed to select the households to be interviewed. The target population of the project area (Embu; 516,212,183 sq km and Kirinyaga; 537,054, 357 sq km) was stratified along the river basins in the area constituting the first stratum. Each river basin (first tier stratum) was then divided into three sub-strata representing the upper, middle and lower sections of the river basin (second tier stratum). Since the population along the river basin is not equally distributed, and taking into consideration that the upper and lower zones of the river basins were normally less densely populated than the middle zones of the river basin, the sample of each river was then divided in the ratio 1:2:1 for the upper, middle and lower sections respectively (UTaNRMP, 2017).

The sample size per river basin was then determined proportionately depending on the number of FDA's per river basin. This decision was based on the level of activities by the UTaNRMP in the river basins, cost limitation and time limitation of the study. Embu and Kirinyaga counties were used for this research.

Table 1: River basins in Embu and Kirinyaga counties

County	River Basins	Length (Km)	Size	Total No. of FDAs	Proportionate Sample Size	Adjusted Sample Size	Total
Embu	Rupingazi	78	354	4	44	60	135
	Thuci		152	5	55	75	
Kirinyaga	Nyamindi	78	453	10	110	110	286
	Thiba	78	715	15	165	176	
	TOTAL			36	374	421	421

River basins in Embu: Rupingazi, Kabingazi, Mutonga/Thuci, Thura, Rwanjoga, Gangara, Itimbogo, Itabua/Rupingazi.

River basins in Kirinyaga: Kirwara, Kiwe, Rwamuthabmi, Thiba, Nyamindi, Mugaka

Sampling technique

Conchran's sample size formula (Conchran, 1977) was used to calculate the sample:

$$n= \frac{Z^2 P (1-P)}{d^2}$$

Data collected was analysed using descriptive statistics and the tools include: tables, simple frequency distribution and measures of central tendency such as mean and percentage.

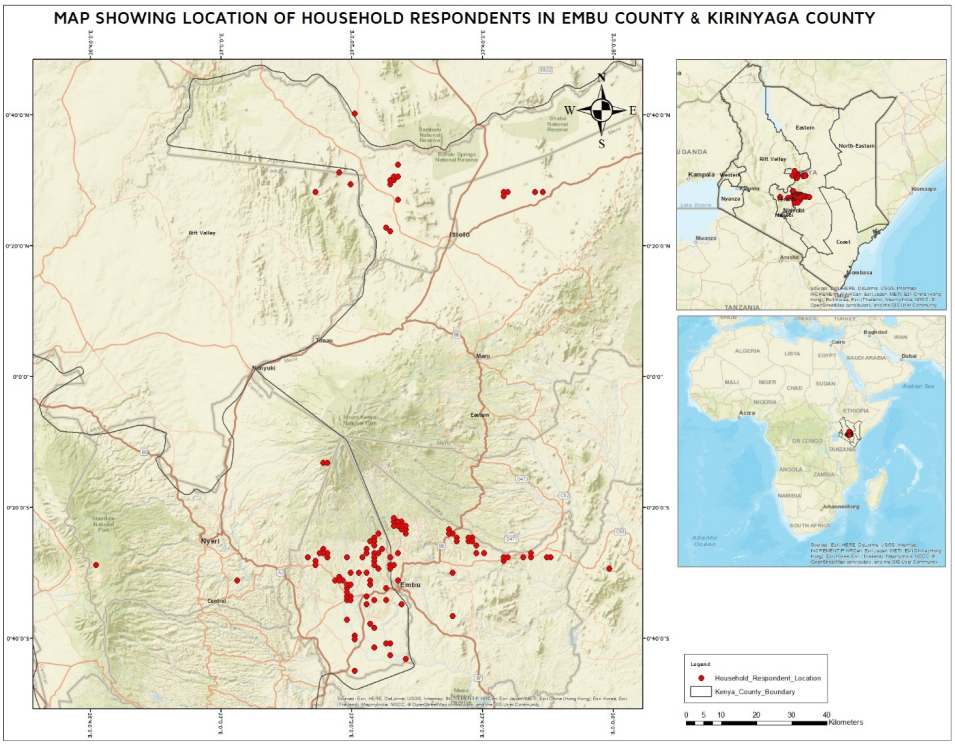

Figure 2: Map showing location of respondents in Embu and Kirinyaga.

Source: Field survey, 2018.

Results and Discussion

The socio-economic characteristics examined include variables such as age, gender, marital status, educational attainment, etc., of the household respondents in the study area. The efficiency in energy use, awareness of sustainable environmental management information as well as major factors influencing afforestation were discussed.

Table 2 presents selected socio-economic characteristics of the respondents. The result of the analysis show that more than four-fifths (83.4%) of the respondents were between the ages of 11 and 60 years and are considered to be in their economically active years while only a few (3%) were aged 71years and above. The average age of the respondents stood at 49.1±12.2 years, which implies that the household members are aging. This

could eventually negatively affect their engagement in afforestation activities.

Also, about half of the household respondents (57.7%) were males. Based on this result, it can be deduced that out of 10 people engaged in forest related activities in the study area, 7 will be men. Concerning marital status, a greater percentage of the respondents were married (85.5 %), while only about 7.4% were either single, separated or divorced. In other words, married household heads constituted the majority in the study area.

Table 2: Selected socioeconomic characteristics of the respondents (n=421)

Variables	Frequency	Percentage
Gender		
Male	240	57.0
Female	181	43.0
Age (Years)		
11-40	109	25.9
41-70	299	71.0
≥71	3	12.63
Mean	49.1	
SD	12.2	
Marital Status		
Single	30	7.1
Married	360	85.5
Divorced	4	1.0
Widow	25	5.9
Widower	2	0.5
Engagement in Sale of Trees and Charcoal		
Yes	358	85
No	63	15

Energy use in the households

Cooking Appliances Used in Households

Table 3 reveals an average of 69.3% households use three-stone Jiko compared to the baseline report of 83%. This indicates 16.5% reduction in the use of inefficient energy appliances, thus a positive effect on afforestation. In line with this, 20% of households in Thuci used Maendeleo Jiko and 27.7% of households in Thiba used gas cookers. This should be encouraged and improved upon for improved afforestation. However, 76.6% and 51.6% of households in Rupingazi still use three-stone Jiko and normal charcoal Jiko respectively despite the benefit of energy-efficient stoves. This result reveals that there is a high prevalence of environmental pollution in Rupingazi which is detrimental to afforestation.

Table 3: Cooking appliance used in households

Cooking Appliance	Nyamindi (%)	Rupingazi (%)	Thiba (%)	Thuci (%)
Three-stone Jiko	68.6	76.6	55.9	76.0
Normal charcoal Jiko	32.4	51.6	38.0	46.7
Maendeleo Jiko	8.8	10	15.2	20.0
Upesi Jiko	2.9	0	8.2	1.3
Jiko Kisasa/Kuni Mbili	18.6	6.7	14.7	5.3
Kenya ceramic Jiko	2.9	1.7	2.7	0.0
Rocket Jiko	2.0	3.3	11.4	1.3
Uncladded liner	0.0	0.0	0.5	4.0
Kerosene stove	14.7	6.7	10.3	16.0
LPG cooker/Meko	8.8	8.3	18.0	18.7
Fireless Jiko	1.0	3.3	2.2	8.0
Paraffin stove	10.8	18.3	11.4	14.6
Gas cooker	14.7	20.0	27.7	12.0
Electricity cooker	1.0	0.0	2.1	2.7

Source: Field survey, 2018.

Households Energy Usage

Table 3 reveals that 21% of households in Embu and Kirinyaga counties use energy sources other than firewood and charcoal. This indicates an improvement in choice of energy sources as 51% of households indicated the choice of firewood as a major source of energy in Embu and Kirinyaga compared to the baseline of 77.2% reflecting 33.9% positive change. This implies improved efficient use of energy, thus a positive effect on afforestation.

Table 3: Household Energy Usage

Energy sources	Frequency	Percentage
Firewood	215	51.0
Charcoal	118	28.0
Biofuel	4	1.0
Biogas	13	3.0
LPG	21	5.0
Electricity	8	2.0
Solar power	4	1.0
Kerosene	38	9.0

Source: Field survey, 2018.

Challenges to Usage of Energy-saving Jikos

Table 4: Challenges to usage of energy-saving jikos

Challenges to Usage of Energy-saving Jikos	Nyamindi (%)	Rupingazi (%)	Thiba (%)	Thuci (%)
Access to Technology	17	15	28	15
Lack of Awareness	23	33	30	40
Inflexible Attitude to New Tech	14	12	13	17
Lack of Funds	38	42	38	32
High Cost of Technology	27	11	46	14
No Technical Know-how	8	10	10	16
No Tangible Reason	2	8	2	1

Source: Field survey, 2018.

Table 4 reveals that 42% of households in Rupingazi, and 38% of households each in Nyamindi and Thiba cited lack of funds as a major constraint to usage of energy-saving jikos, even though a minimum of two people in a household of four in the river basin were working. In Thuci, 40% of households had low level of information on the importance and use of energy-saving jikos; reduced awareness leads to reduced afforestation.

Awareness of Sustainable Environment Management

Table 5: Awareness on Sustainable Environment Management(SEM)

SEM	Frequency	Percentage	Position
Tree Planting Engagement	406	96.4%	1st
Livestock Keeping	397	94.3%	2nd
Reduce Fuelwood Sales/Domestic Use	380	90.3%	3rd
Reduce Tree Felling	379	90%	4th
Reduced Use of Charcoal	378	89.8%	5th
Use of Energy Saving Jikos	372	88.4%	6th
Reduce Timber Sales/Domestic Use	364	86.5%	7th
Participation in Conservation Activities	363	86.3%	8th
Application of Knowledge from Training	363	86.3%	8th
Use of Irrigation System	358	85.1%	9th
Environment Management Advocacy	313	84.4%	10th
No Stealing of Wildlife/Poaching	353	83.9%	11th
Reduce Bush Fires	352	83.6%	12th
Adherence to Forest Restriction	350	83.1%	13th
Engagement in NRM Training	335	79.8%	14th
Engagement in Forest-related Activities	333	79.1%	15th
Flexibility of Traditional Preference	331	78.6%	16th
Legal Harvesting of Forest Products	324	77%	17th

Source: Field survey, 2018.

Ranking of awareness on sustainable environment management

Table 5 reveals that 96.5% of the households in the study area were aware of tree planting engagement. This reflects a high level of engagement

in tree planting in the study as increased awareness on tree planting should lead to engagement in the act of planting. Also, about three-quarters (77%) of households indicated low level of awareness regarding legal harvesting of forest products compared to the other environment management choices. This can be attributed to the fact that some household members believe there should be easy access to the forest for harvesting of products since they belong to the community. In all, over three-quarters of households in the study area were aware of sustainable environment management, which indicates a higher tendency towards improved afforestation.

Effect of household incomes

Household Assets Owned

Table 6: Household assets owned

Asset Owned	Average Number	Min-Max	Std.
Household Asset			
TV	0.8	0-4	0.57
Phone (Handset mobile)	2.3	0-12	1.70
Car	0.1	0-2	0.35
Fridge	0.1	0-2	0.32
Gas Cooker	0.6	0-6	0.69
Computer	0.1	0-3	0.40
Bicycle	0.5	0-3	0.63
Iron	0.5	0-3	0.59
Motor cycle	0.26	0-2	0.46
Farm Implements			
Panga	3.0	0-14	1.83
Jembe	1.6	0-22	1.97
Jembe Fork	1.2	0-22	1.47
Sickle	0.3	0-5	0.86
Secateurs	0.4	0-6	0.77
Milking Can	0.6	0-4	0.78
Fishing Gear	0.03	0-4	0.3
Knapsack Sprayer	0.6	0-4	0.62

Source: Field survey, 2018.

Table 6 shows that the majority of households had a phone (handset mobile), implying better communication with community group members and also extension agents. Mostly all households have a Panga, Jembe, Jembe fork. This implies genuine engagement in farming as it is anticipated that the higher the number of farm implements, the higher the output, and the higher the income, and hence level of afforestation.

Major activities influencing afforestation

Tree Planting Engagement

Table 7 indicates that the majority of households that planted trees in Nyamindi planted 1-20 trees while Thiba households had the highest percentage (37%) of 1-20 trees planted. In the same vein, households in Rupingazi planted mainly 1-20 trees but with highest planting (13.3%) of 201 and above and the highest level of no engagement in tree planting (13.4%) compared to other river basins. In Thuci, 17.4% of households planted over 100 trees. This result implies better tree planting engagement and thus improved tree cover in the survey area.

Table 7: Tree planting engagement

Tree Planting Engagement in Each River Basin	Nyamindi (%)	Rupingazi (%)	Thiba (%)	Thuci (%)
1-20	28.4	33.3	37.0	33.3
21-50	21.6	23.4	21.0	25.3
51-100	22.4	11.6	16.3	12.0
101-200	9.8	5.0	6.5	10.7
201 & above	6.7	13.3	5.8	6.7
Total Percentage of Engagement in Tree Planting per River Basin	88.9	86.6	86.6	88.0
Total Percentage of No Engagement in Tree Planting per River Basin	11.1	13.4	13.4	12.0

Source: Field survey, 2018.

Survival Rate of Trees Planted

Table 8 reveals that about half of the trees planted had over 50% survival rate and thus improved afforestation.

Table 8: Survival rate of trees planted

Survival Rate	Frequency	Percentage
1-20	110	26.1
21-40	70	16.6
41-60	78	18.7
≥61	163	38.6

Source: Field Survey, 2018.

Tree Planting by Household Head Educational Level

Table 9 reveals that the higher the level of education of the household head, the higher the engagement in tree planting. Most of the households (91.4%) with household heads that had college/university education engaged in tree planting. This implies that education has a positive effect on afforestation. This may be as a result of better understanding of the multiplier effects of tree planting.

Table 9: Tree planting by household head educational level

Education Level	Percentage
None	64.2
Primary	87.1
Secondary	87.9
Vocational Training	83.3
College/University	91.4

Source: Field survey, 2018.

Tree Planting by Age

Table 10 shows that over half of the households' respondents (56.3%) that participated in tree planting were between the ages 11 and 50. 41.1% were between the ages 51-70 and only 2.7% were between 71-100. This implies that households tend to reduce their tree planting activity once they turn 50 years which can affect the level of afforestation negatively.

Table 10: Tree planting by age

Age	%
11-30	6.6
31-50	29.7
51-70	41.1
71-100	2.7

Source: Field survey, 2018.

Tree Planting by Access to Inputs

Table 11 indicates that 81.5% of households that had access to inputs such as seeds, seedlings, herbicides and pesticides, engaged in tree planting. This result could be an indication that access to inputs has a positive influence on any form of level of afforestation.

Table 11: Tree planting by access to inputs

Access to Inputs	%
Yes	81.5
No	18.5

Source: Field Survey, 2018

Household Tree Cutting Engagement

Table 12 reveals that less that half (33.7%) of the respondents are not engaged in tree cutting engagement which is postive for afforestation.

Table 12: Household tree cutting engagement

Tree cutting engagement	%
Yes	66.3
No	33.7

Source: Field survey, 2018.

Average Number of Trees Harvested Yearly

Table 13 shows that the majority of the trees harvested (71%) were between 1 and 20. Less harvesting of trees indicates higher probability of improved afforestation.

Table 13: Average number of trees harvested yearly

Average Number of Trees Harvested Annually	(%)
1-20	71.0
21-50	20.8
51-100	3.6
101-200	3.2
201 & above	1.4

Source: Field survey, 2018.

Effective Measures Used by the Community to Address the Cutting Down of Trees

Table 14 shows that the majority of the respondents believed that effective law regulation, advocacy/awareness and restrictions have aided the reduction in cutting of trees.

Table 14: Effective measures used by the community to address the cutting down of trees

Measures used by the Community to address the cutting down of Trees	Percentage
Effective Law Regulation	43.4
Advocacy/ Awareness	30.4
Restrictions	16.0
Capacity Building	7.3
Monitoring Engagement	3.0

Source: Field survey, 2018.

Conclusion

The major goal of this study was to determine factors influencing afforestation in the study area. The findings have shown better living standards; the majority of the households can afford three meals a day. Also households have acquired more assets such as phones and farm implements as 2 out of 4 household members are productive and financially contribute to the family and thus improved livelihood.

Also, improved efficiency in energy use has had positive effect on afforestation in the study area. The results reveal a 16.5% reduction in the use of inefficient energy appliances, 21% use of energy sources other than firewood and charcoal, 88.4% awareness on the use of energy-saving Jikos, about 88% engagement in tree planting, over 33% non involvement in tree cutting activity and only 8.2% engagement in harvesting of above 50 trees yearly.

Furthermore, it is deduced from the study that households are very much aware of information on sustainable environment management. There is over 80% awareness on engagement in tree planting, reduced bushfires, livestock keeping, reduced use of charcoal, application of environment management training gained, environment management advocacy, participating in conservation activities, no stealing of wildlife/poaching, adherence to forest restrictions, reduced fuelwood collection, use of irrigation systems, reduced timber sales and domestic use.

Improved community incomes have positively affected afforestation in the study area as households indicated that their main sources of income are from farming, casual labour, small-scale business and employment which helped in the provision of meeting household needs as at when due.

The major factors influencing afforestation in the study area include: level of education of household heads (the higher the educational level of household heads the higher their engagement in tree planting and vice-versa); age (56.3% of respondents that indicated households tree planting engagement are between ages 11 and 50), access to inputs (81.5% of households that engaged in afforestation had access to tree seedlings). Also, engagement in forest management community groups like the community forest associations, properly addressing felling of trees through majorly

effective law regulation, advocacy and awareness positively influenced afforestation.

In all, there is efficiency in energy use, high level of awareness on sustainable environment management practices, livelihood improvement and increased afforestation in the catchment area.

Overall, the UTaNRMP has contributed significantly to livelihood diversification, increased level of afforestation, enhanced community-based mutual accountability and learning as well as ensured environmental sustainability.

However, there is still need for household members to be aware of the importance and how to use energy-saving jikos so as to improve afforestation, reduce tree felling, manage time effectively, reduce work load and other health-related challenges. In the same vein, technical support is needed to increase the survival rate of tree seedlings and manage pest infestation of seedlings as well as trees. In particular, there is crucial need for more households to be better involved in positive and productive forest-related activities like bee-keeping, mushroom collection and eco-tourism, that would help improve livelihood. Tree felling needs to be addressed more seriously, especially through effective law regulations, advocacy and awareness.

Recommendations

Based on revealed findings, this study recommends that:

- Households should be introduced to awareness creation programmes on the importance of energy-saving jikos that would increase and encourage their interest in using the energy-efficient stoves as well as green energy sources. Sensitization projects should be done in institutions, social groups, public and private organizations, etc. Household members between the ages of 11 and 30 should be a major target and the media should be effectively used during and after each awareness programme, especially the social media, to increase awareness level and improve the use of energy-efficient appliances.
- Seedlings should be more accessible for the planting of indigenous species alongside exotic species of trees and more household

members between the ages of 11-30 should be encouraged to engage in tree planting.

- Institutional support should be more efficient, effective and timely and monitoring and follow-up process should be carried out on a regular basis. Also, more energy jiko stoves should be made available in markets closest to households, especially in Thiba and Thuci river basins.
- The different community groups in all the river basins, especially Rupingazi and Thuci, should be encouraged to engage in more capacity-building programmes. Grants should be more available for small- and large-scale forest-related activities, especially bee keeping and mushroom growing. Marketing and extension agents should monitor beneficiaries of such grants to ensure they do not divert funds to buy other personal needs so as to improve the livelihood of households and ensure improved afforestation.
- Household tree felling engagement should be further addressed mainly through effective law regulation, effective community forest associations, advocacy and awareness, training and capacity building.
- Community groups should facilitate household access to funds for increased stream of income and improved livelihood.
- Household members should be better engaged in community-based organizations, community forest associations or forest user groups, especially through creating effective awareness of the presence of the groups in the community, organization of natural resources management-oriented entrepreneurship programmes in the various communities, better orderliness and management and improved group transparency.

References

Aguilar L., Araujo, A., and Quesada-Aguilar A., (2012) Reforestation, Afforestation, Deforestation, Climate Change and Gender http://cmsdata.iucn.org/downloads/gender_factsheet_forestry.pdf

Amacher, G.S., Hyde, W.F. & Rafiq, M. (1993) Local adoption of new forestry technologies: An example from Pakistan's northwest frontier province. *World Development* 21(3):445–453.

Byron, N. (2001) Keys to smallholder forestry. *Forests, Trees and Livelihoods* 11(4):279-294

Chowdhury, S. A., (2004). Participation in Forestry: A Study of People's Participation on the Social Forestry Policy in Zathila and Betaga Villages, Gazipur, Bangladesh Bangladesh: Myth or Reality? Department of Administration and Organization Theory, University of Bergen, p. 112.

FAO 2001b. Global Forest Resources Assessment 2000. FAO Forestry Paper 140, Rome, Food and Agriculture

FAO 2018. Forest and Sustainable Cities. International Day of Forest. http://www.un.org/en/events/forestsday/

Keesstra, S.D., Bouma, J., Wallinga, J., Tittonell,P., Smith, P., Cerda, A., Montanarella,L., Quinton,J.N., Pachepsky,Y., van der Putten, W.H., Bargett,R.G., Moolenaar,S.,Mol,G.,Jansen,B.,and Fresco,L.O.(2016). The significance of soils and soil science towards realisation of the United Nations Sustainable Development Goals. *SOILS*, 2111-128. doi: 10.5194/ soil21112016, 2016

Maskey V, Gebremedhin TG, Dalton TJ (2003). A Survey Analysis of Participation in a Community Forest Management in Nepal. Res. Paper 8.

Mercer, D.E. 2004. Adoption of agroforestry innovations in the tropics: A review. Agroforestry Systems 61(2): 311–328.

MITA, Pompiliu, and Simona MATREAȚA. (2005) "The role of afforested areas upon the surface runoff variation "Analele Universitații Spiru Haret Seria Geografie nr. 6, 2003

National Forest Policy (NFP) (2014), Republic of Kenya. https://bit.ly/2TBrPDj

Pattanayak, S. K., Mercer, D. E., Sills, E., & Yang, J. C. (2003) Taking stock of agroforestry adoption studies, *Agroforestry Systems* 57(3): 137-150.

Salam, M.A., Noguchi, T. and Koike, M. (2000) Understanding why farmers plant trees in the homestead agroforestry in Bangladesh. *Agroforestry Systems* 50(1): 77–93.

Scherr, S.J. (1995) Economic factors in farmer adoption: patterns observed in Western Kenya. *World Development* 23: 787–804.

Thacher, T., Lee, D.R., & Schelhas, J.W. (1997) Farmer participation in reforestation incentive programs in Costa Rica. Working paper 97-11. Department of Agricultural, Resource and Managerial Economics; Cornell University, Ithaca, New York.

Upper Tana Natural Resources Management Project (UTaNRMP). (2014) Baseline Survey Report. Kamfor Company Limited. https://bit.ly/2EZIZ3v

Upper Tana Natural Resources Management Project (UtaNRMP). (2017) Impact Assessment Survey. Infodev Consultants Limited https://bit.ly/2u5yzKv

Victor, A.J. and Bakare Y. (2004). Rural Livelihood Benefits from Participation in the Taungya Agroforestry System in Ondo State, Nigeria. *Small Scale Forest Economics, Manage. Policy*, 3(1): 131-138.

Walters, B.B., Sabogal, C., Snook, L.K. & de Almeda, E. (2005) Constraints and opportunities for better silvicultural practice in tropical forestry: An interdisciplinary approach. *Forest Ecology and Management* 209(1-2): 3–18.