



Agroforestry practices and factors influencing their adoption by communities in the drylands of Eastern Kenya

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Abstract Agroforestry is one of the key sustainable land management practices recommended for the drylands that are characterized by a myriad of problems among them land degradation that is exacerbated by climate change. Adoption of agroforestry practices has largely remained low and largely unexplained especially in drylands of Kenya. Socio-economic factors such as education level, occupation, age, land size, income, gender, marital status, cultural beliefs and family size are linked to agroforestry adoption among smallholder farmers. This study sought to determine the factors that influence adoption of agroforestry practices by households in Makeni County of Kenya, where agroforestry has been promoted by various organizations. Structured questionnaires were used to collect data from 240 household heads through face-to-face interview. The data was analyzed using a binomial logistic regression model that allowed for determination of factors that influence the adoption of agroforestry practices by household heads in the study area. The model has shown that the adoption of agroforestry practices were significantly influenced ($P < 0.05$) by level of education, age, income, gender, marital status and family size of the respondents in the study area. The key policy implication of

this study is that efforts aimed at promotion of agroforestry in the drylands should put into consideration these variables for sustainable adoption and out scaling of agroforestry in the drylands.

Keywords Agroforestry practices · Makeni county · Socio-economic factors · Adoption

Introduction

Drylands cover 41.3% of the earth's land surface with a greater proportion of it (72%) in developing Countries (MEA 2005). Drylands are estimated to be a home to about 2 billion people (Reynolds et al. 2007). About 90 percent of the estimated 2 billion people living in drylands are in developing countries (MEA 2005). They are faced by numerous challenges including natural resource degradation, declining land productivity and frequent drought which are exacerbated by climate variability (Jama and Zeila, 2005). Conversely livelihoods options are limiting and crop production is a risky venture making food insecurity and poverty rampant in the drylands (Wekesa et al. 2012). It is evident that drylands have experienced rapid population growth have similarly witnessed accelerated rangeland degradation as demand for arable land increases and transitions to cultivated agriculture become more pronounced than reliance on livestock production systems (Jama and Zaila 2005).

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In Kenya, drylands account for about 80% of the total land area (Nguluu et al. 2014). These areas are threatened by high rate of deforestation partly from the immigrant population from the high potential areas that engage in agriculture and charcoal production. Incidences of poverty are rampant with an average of 65% of the population living below poverty line compared to the national average of 26% (Barrow and Mogaka, 2007; Thornton et al. 2002). In Makueni County; which is classified as dryland, incidences is rampant deforestation due to illegal logging and charcoal burning. This has contributed to environmental degradation that is exacerbated by climate change and variability leading to drying of most of the rivers, erratic rainfall and prolonged drought that threaten the survival of the people (CIDP 2018–2022).

There is increasing attention to drylands due to intermittent crises in these regions particularly in Africa; calling for significant development assistance and frequent humanitarian aid (De Leeuw et al. 2014). In Kenya, the government is keen to mitigate deforestation and expand forest cover to improve people's livelihoods in drylands to at least 10% forest cover as stated in the Constitution of Kenya. However, options for expansion of tree cover in Kenya's high agricultural potential areas are limited as these areas only account for about 20% of the country's total area; are highly populated and have no room for expanding tree cover. The only remaining areas with potential for tree planting are the Kenyan drylands (Jama and Zeila, 2005). Therefore, Agroforestry, as a land use whereby a deliberate attempt is made to integrate and manage both trees and agricultural crops on the same landscape (Pilote et al. 2017) is a critical entry point for dryland sustainable productivity. There is increasing attention to agroforestry by scientists and communities worldwide to address a wide range of households needs (Alavalapati et al. 2003; Edinam et al. 2013; Nair 2009). Smallholder farmers around the world could potentially reverse dryland degradation, improve the environment and enhance their livelihoods by adopting agroforestry (Jose 2009). Due to the various benefits of agroforestry, many international bodies such as United Nations and World Bank, Governments and Non-Governmental Organizations (NGOs) have advocated for its adoption globally (Pilote et al. 2017). In Kenya, the government is mandated through the Constitution to achieve and

maintain a tree cover of at least 10% of the land areas in Kenya (The constitution of Kenya 2010).

However, Agroforestry adoption has been surprisingly low considering the well documented benefits (Faulkner et al. 2014; Trozzo et al. 2014). Despite all the potential of agroforestry practices and the effort to promote them among smallholders farmers, their adoption have remained low and so have their impact (Anne and Lennart 2013, Ajayi and Kwesiga 2003, Mercer 2004). There exists knowledge gap in that there is disaggregated research which has let to both the scientific and technical knowledge on trees and agroforestry in drylands and information on their contribution to dryland livelihoods remained scanty and fragmented (De leeuw et al. 2014). Most agroforestry studies are oriented towards quantitative estimates of physical and economic benefits making social aspects less visible (Pattanayak et al. 2003).

In Makueni County of Kenya, Drylands Natural Resources Centre (DNRC) which is an NGO has been working with over 700 small scale farmers of the County on dryland agroforestry project since 2008. However, there has been no research done to investigate factors influencing agroforestry adoption by households in the study area. In Makueni County, adoption of agroforestry practices is low despite its recognized potential in terms of sustainable land use management in the drylands. Understanding how and why farmers make long term land use decisions and applying that knowledge to the design, development and marketing of agroforestry innovations is very important in realizing full potential of agroforestry to food security, livelihoods and the environment in the drylands. Empirical evidence in factors influencing agroforestry practices adoption at household levels is critical in guiding the successful promotion and out-scaling of Agroforestry practices in the drylands. Socio-economic factors like income, occupation, education level, cultural elieves, land size, age, family size, labor and income are linked to agroforestry adoption among smallholder farmers (FAO 2013). This study was designed to determine agroforestry practices and factors influencing their adoption by households in the Semi-Arid Makueni County of Kenya.

Material and methods

Study area

The study was conducted in Makueni County of Kenya that lies between latitude 1° 35' South and longitude 37° 10' East and 38° 30'. The County was selected based on the numerous agroforestry projects in the area. The October–December rains deliver most of the precipitation as compared to the March–May rains. The average annual rainfall is 150–650 mm (Gichuki 2000), which is characterized by high rainfall variability leading frequent crop failure. The annual mean temperatures range between 21 and 24 degrees Celsius and elevation is 800–1600 m. The natural vegetation is mostly grassland and dense shrub land or woodland. Most of the dominant tree species are *Terminalia brownii*, acacias spp., *Croton megalocarpus*, *Mangifera indica*, *Grevillea robusta* among others that are considered to be drought resistant and grow well with little rains (FAO 2016). They generate a wealth of environmental services such as habitat for biodiversity, protection against water and wind erosion and desertification. They help water infiltration and contribute to soil fertility through litter and by nitrogen fixation (FAO 2005). Some of the tree species *Terminalia brownii* are fast growing which sometimes are cut down for sale and proceeds used to buy food and help to reduce poverty (FAO 2016). The dominant soils belong to ferrosols and are either Rhodic (red color) or Xanthic (yellow color) and few are Aerosols and are naturally low in phosphorus (Jaetzold et al. 2006). The County covers an area of 7965.8 km² and has a population of 884,527 people with an annual growth rate of 2.8%. The average family size according to 2009 census is 5.5 (CIDP 2018–2022). Major economic activity include: charcoal production, illegal logging, and subsistence farming with the main crops being maize, beans and pulses (Jaetzold et al. 2006). The livestock population is primarily goats and chickens with few milk and beef cattle whose numbers are limited because of insufficient supply of feeds during dry season. The study area and households density practicing various agroforestry practices are presented in Fig. 1 Map of the study area.

Data collection and analysis

Multistage sampling procedures were used in the selection of the study site. First, Counties in Kenya were stratified to those which are classified as drylands. The second stage involved selecting the County with the highest promotion of Agroforestry. Makueni County was chosen as it has been promoting tree planting both at institutional and household level as enshrined in its Development Plan (CIDP 2018–2022). Counties are further divided into divisions. Next stage was to identify divisions in which there is ongoing agroforestry project which led to two divisions being chosen; Kisau and Waia Divisions where individual households were sampled.

Sample size

The sample size was calculated based on the equation of Krejcie and Morgan formula (as cited by Kathuri and Pals 1993).

$$N_0 = \frac{Z^2 P(1 - P)}{D^2}$$

$$N_0 = \frac{1.96 \times 1.96 \times 0.5 \times 0.5}{0.05 \times 0.05} = 384.16$$

where by Z is given as 1.96, P is the probability of getting a farmer practicing agroforestry which is 50% (0.5), D is the degree of accuracy which is 0.05 and No. is the infinite population which is 384. Given that the number of households working on agroforestry projects in the study area is 1200. Substituting in the formula below:

$$N = \frac{N_0 \cdot N}{N_0 + (N - 1)}$$

$$N = \frac{384 \times 1200}{384 + 1199} = 291.0928$$

where N is the number of known households (1200), No. is infinite number which is 384. Therefore the sample (N=291) obtained from the calculations above is the optimum size for a representative study in the study area. However, only 240 households were sampled due to limited resources. 240 Structured questionnaires were used to collect data from

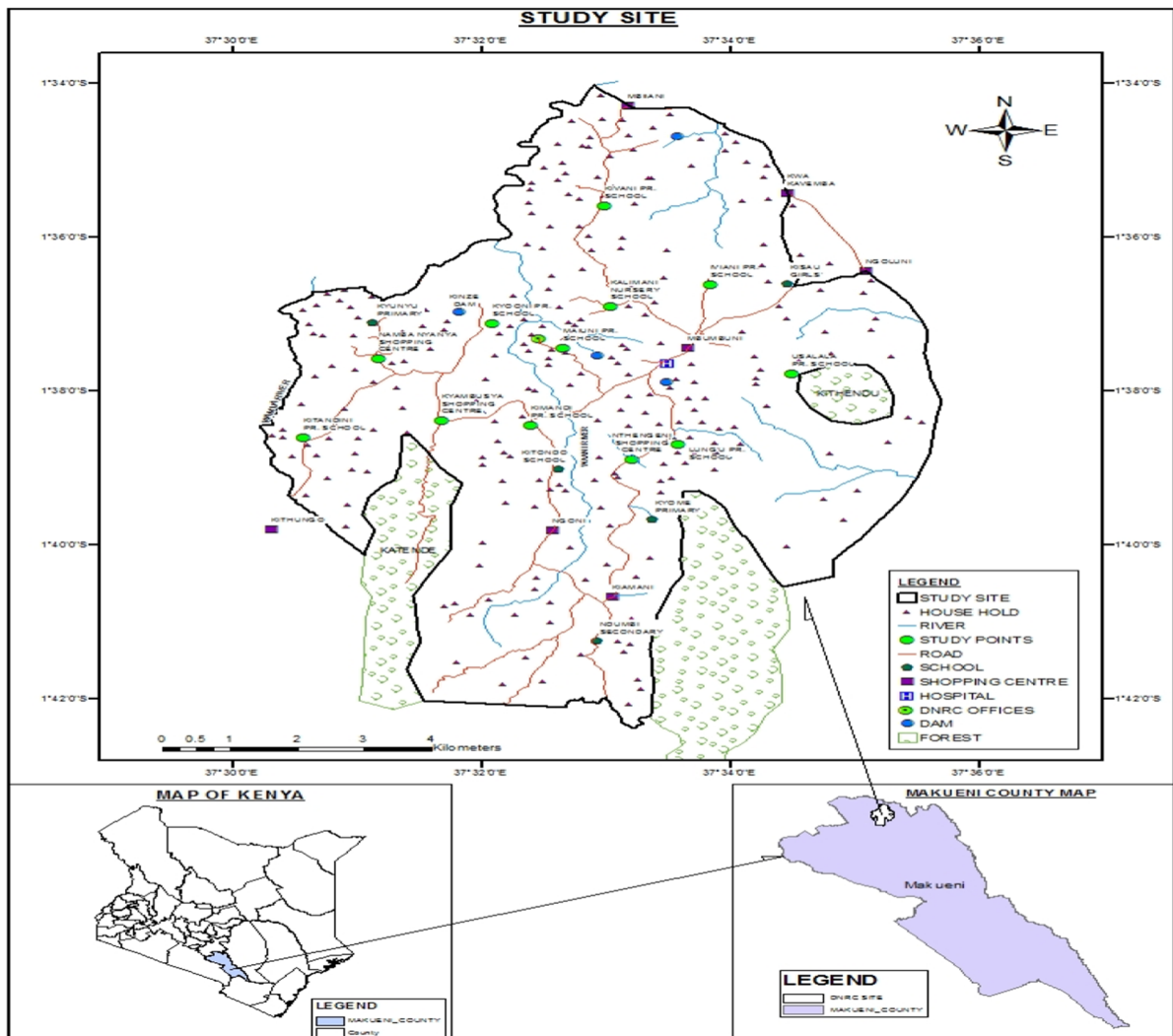


Fig. 1 Study area

the household heads through face-to-face personal interviews. A pre-test of the questionnaires was done to check for clarity and improve the reliability. Using a checklist of different tree species provided in both local and botanical names, the respondents were asked the main tree species in their farms at different agroforestry practices. This was also affirmed through observation. The most common five tree species were ranked. The data was subjected to both descriptive and regression analysis using SPSS computer software to determine which agroforestry practices were dominant.

A binomial logistic regression was run to determine whether the adoption of agro forestry could be predicted by socio-economic and cultural believes factors of the household head in the study area. There were ten variables analyzed. They include: Adoption of agroforestry which is dependent variable showing whether the participant are adapters or not: "Yes" or "No" coded as 1 and 0 respectively, education, which is the highest academic level; age of the household head, land size, income, gender, cultural believes, marital status, family size, and (10) caseno, which is the case number. The caseno variable is used to make

it easy for you to eliminate cases such "significant outliers", "high leverage points" and "highly influential points" that you have identified when checking for assumptions. It is not used directly in calculations for a binomial logistic regression analysis.

Table 1 gives the explanatory variables subjected to binomial logistic regression analysis.

Table 6 has a subscript which states, "The cut value is 0.500". This means that if the probability of a case being classified into the "yes" category is greater than 0.500, then that particular case is classified into the "yes" category. Otherwise, the case is classified as in the "no" category.

Table 7 contains the Cox and Snell R Square and Nagelkerke R Square values, which are both methods of calculating the explained variation.

Results and discussion

Socio-demographic characteristics

Results indicate that 80% of the respondents were female while 20% were male. The age bracket of these respondents ranged from 40 to 59; accounting for 46.7% of the total respondents. It was also established that most of the respondents were married (64.2%) with 8.8% single, 20.8% windowed and 1.6% divorced. The family size ranged between 4 and 6 members (56.25%). Findings show that 41% of the household head in the study area primarily attained primary school levels (Table 2). Most of households (61.7%) own less than 3 acres of land followed by those with 3–6 acres (23.8%). Farming (83.3%) was the main occupation of the household heads.

Table 1 Definitions of explanatory variables used in the binomial logistic regression

Variable	Definition	Hypothesized influence on dependent variable +/–
A	Age	+
FS	Family size	+
MS	Marital status (married) (yes =1, no =0)	+
G	Male or female	–
CB	Cultural believes (traditional believes and taboos that influence tree planting, management and ownership)	–
LEDU	Level of education attained by household head	+
LS	Land size (farm size in acres)	+
I	Income (participants financial status)	+

Dominant agroforestry practices

The dominant agroforestry practices in the study areas (Fig. 2) were: live fences, trees in the home-stead, woodlots, parklands, home gardens, fruit orchards and grazing lands.

Dominant tree species and their uses

The agroforestry practices in the households were dominated by tree species (Table 3). *Grevillea Robusta* was the most dominant tree species in the study area (83.2%). *Acacia tortilis* was the least dominant (45.8%) among the top five trees species found in the study area. The trees are mainly used for fencing, construction, firewood and charcoal. Only *Acacia tortilis* provided fodder.

Socio-economic factors

The results (Table 4) show that education level (58.3%) and land size (65%) were main factors reported to influence agroforestry adoption while marital status influenced the least (20.8%). This were household heads perceptions on how land size influence adoption of agroforestry practices.

Binomial logistic analysis (Table 5) show that education ($p=0.003$), age ($p=0.021$), income ($p=0.039$), gender ($p=0.000$), Marital Status ($p=0.001$) and Family size ($p=0.021$) added significantly to the model but land size ($p=0.799$) and Cultural believes ($p=0.199$) did not add significantly influence the model at 95% confidence level.

In the classification Table 6 has a subscript which states, "The cut value is 0.500". This means that if the

Table 2 Socio-demographic characteristics of interviewed households

Variables	Category	Frequency	(%)
		(n = 240)	
Age in years	Below 19	25	10.4
	19–29	24	10.0
	30–39	32	13.3
	40–49	60	25.0
	50–59	52	21.7
	60 and above	47	19.0
Gender	Male	48	20
	Female	192	80
Marital status	Married	154	64.2
	Single	21	8.8
	Separated	11	4.6
	Windowed	50	20.8
	Divorced	4	1.6
Family size	1–3	20	8.3
	4–6	135	56.25
	7–9	45	18.75
	Above 9	40	16.7
Education level	No formal education	68	28.3
	Primary	100	41.7
	Secondary	28	11.7
	Certificate	20	8.3
	Diploma	24	10.0
Land ownership	With title deed	100	41.7
	Without title deed	116	48.3
	Leased land	24	10.0
Land Size	< 3 acres	148	61.7
	3–6 acres	57	23.8
	7–10 acres	23	9.6
	Over 10 acres	12	5.0
Main occupation	Farmer	200	83.3
	Civil servant	24	10
	Business person	16	6.7

probability of a case being classified into the "yes" category is greater than 0.500, then that particular case is classified into the "yes" category. Otherwise, the case is classified as in the "no" category.

The Nagelkerke R^2 value is 0.763 (Table 7). This implies that 76.3% of the variation in the dependent variable (adoption of agroforestry) is explained by the independent variables (education, age, land size, income, gender, marital status, cultural believes and family size), while the remaining 33.7% of variations

are explained by other factors not covered in this study.

Discussion

Results on socio-demographics indicated that 80% of the respondents were female while 20% were male. In Makueni County, most men have moved to urban centers in search for employment leaving their wives at home to take care of the family. The average family size consisted of 6 people, which is slightly higher than the national average of 5 persons per household (KNBS 2019). The larger family sizes needs more forests products for provision of firewood/ charcoal for domestic and commercial purposes, posts for fencing homes and construction. A significant proportion of the respondents had no formal education. Well educated members often migrate to urban centers in search for jobs to improve their livelihood thus sifting the level of literacy with rural settings being dominated by those with low literacy levels. Rural households mostly diversify their livelihoods so as to spread the risks and reduce dependence on one particular livelihood activity (Hossain et al. 2005). Most of the respondents (83.3%) undertake farming which is in agreement with the country's main occupation in the rural areas. Farming is buffered against risks through diversified activities mainly through livestock rearing and growing multi-purpose agroforestry trees. Thus agroforestry is a key strategy in risk aversion in the study area.

Main factors influencing household adoption of agroforestry

Adoption of agroforestry practices was influenced by community's social and economic characteristics such as cultural and biophysical environment (Wafuke 2012). In agreement, the main factors that significantly influenced adoption of agroforestry in the study area were education of the household head, age, income gender, marital status and family size. Education level of the household head was found to positively influence household's adoption of Agroforestry. This means that holding other factors constant, more educated household heads are likely to adopt agroforestry than uneducated or less educated household head. Education enables household access

Fig. 2 Dominant agroforestry practices

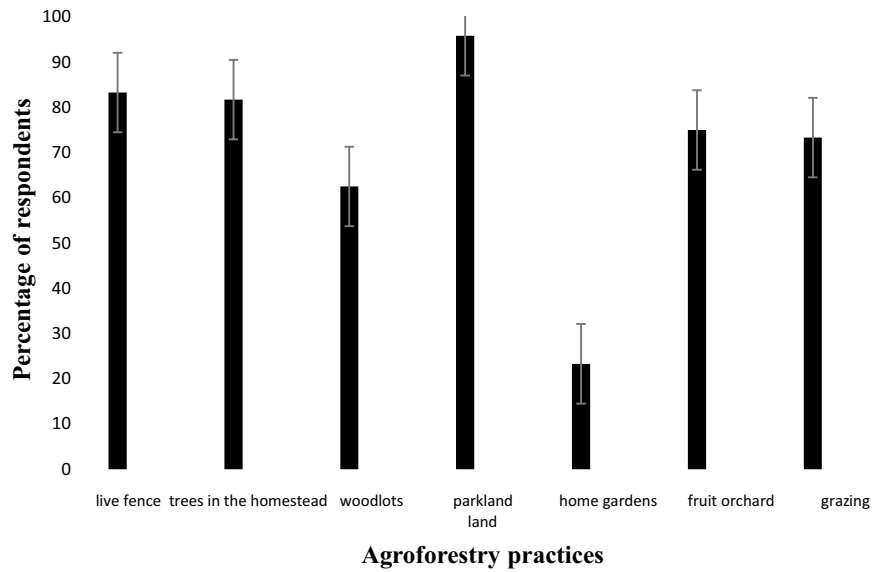


Table 3 Dominant tree species in various AF practices and their uses

Dominant tree species	Percent frequency in different AF practices	AF practices commonly found	Uses
<i>Grevillea robusta</i>	83.2	Life fence, homestead trees, woodlots, scattered trees in the farm	Fence, construction, firewood, shade
<i>Eucalyptus camadulensis</i>	74.6	Homestead trees, woodlots, scattered trees, Fallow/grazing area	Firewood, construction, charcoal, shade
<i>Croton megalocarpus</i>	66.3	Homestead trees, Scattered trees in cropland, Fallow/grazing area	Firewood, charcoal, shade construction
<i>Terminalia brownii</i>	54.1	Woodlots, Fallow/ grazing area	Construction, firewood, charcoal, medicine, shade
<i>Acacia tortilis</i>	45.8	Fallow /grazing area, Scattered trees in the farm	Firewood, charcoal, fence, fodder, shade, construction

Table 4 Socio-economic factors influencing the adoption of agroforestry practices

Socio-economic factors	% Frequency			
	Very great extend	Some extend	Not sure	No extend
Age	30	4.2	5.8	60
Marital status	20.8	31.3	12.5	35.4
Education	58.3	30	4.2	7.5
Family size	55	20	8.3	16.7
Cultural beliefs	4.2	6.3	7.1	82.5
Land size	65	20.8	8.3	5.8
Income	50	21.7	12.5	15.8
Mean responses	40.4	22.9	8.3	28

Table 5 Variables in the equation

Model		B	S.E	Wald	df	Sig	Exp (B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1 ^{aInc}	Education	0.085	0.992	9.132	1	0.003	1.089	1.03	1.151
	Land	0.006	.721	.065	1	0.799	1.006	0.923	1.051
	Age(1)	1.950	5.783	5.356	1	0.021	7.026	1.348	2.625
	Income	0.006	0.048	4.266	1	0.039	0.906	0.824	0.995
	Gender	0.000	20.550	4.000	1	0.000	1.000	0.321	0.000
	Cultural believes	3.768	16.706	3.201	1	.199	1.211	0.541	0.768
	Marital Status	0.000	15.996	4.331	1	0.001	1.02	0.551	0.685
	Family Size	.000	15.996	3.741	1	0.021	1.021	0.741	0.923
	Constant	-21.203	0.420	4.266	1	0.615	0.187		

^aVariable(s) entered on step 1: Education, Land size, Age, Income, gender, cultural believes, marital status, and family size

Table 6 Classification Table^a

Observed		Predicted			Percent- age correct
		Adaption of agro- forestry		Yes No	
		Yes	No		
Step 1	Adaption of agroforestry	Yes	200	55	85.7
		No	91	62	78.0
	Overall percentage				90.0

^aThe cut value is 0.500

Table 7 Model summary

Step	-2 Log likeli- hood	Cox and Snell R square	Nagelkerke R square
1	8.997 ^a	0.538	0.763

^aEstimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found

information on particular technology and become more aware of its advantages thus enhancing the probability of adopting it. The more households are aware of the importance of trees and how they relate to the environment and livelihood, the more they are likely to embrace it. This corroborates results of a study by Twaha et al. (2016) who found out that education level correlated positively to agroforestry adoption while assessing the socio-economic factors that affect agroforestry adoption in Eastern Agro-ecological zones of Uganda. The results are also similar to those found by Zerihun et al. (2014) which

reviewed education level of the household head significantly effect on the adoption of Agroforestry practices while investigating the determinants of agroforestry technology adoption in Eastern Cape Province in South Africa.

Land size of the household was found to positively influence adoption of the dominant agroforestry practices in the study area. The results are similar to those found by Orisakwe et al. (2012) which showed that land size of the respondents had positive relationship to levels of adoption while investigating the adoption of improved agroforestry technologies among contact farmers in Imo state, Nigeria. The results are also similar to those found by Wafuke (2012) which showed land size positively influenced adoption of agroforestry technologies in his research on the adoption of agroforestry technologies among small scale farmers in Trans-Nzoia location in Kenya. This also corroborates results of a study by Kabwe (2009) who found that land size positively influenced the adoption of agroforestry in his research on factors influencing adoption of agroforestry among smallholder farmers in Zambia. Study by Zerihun et al. (2014) in Eastern Cape Province, South Africa on determinants of agroforestry technology adoption in Eastern Cape Province in South Africa also found out that land size of the household head significantly affect the adoption of Agroforestry practices. It's necessary therefore to help farmers with planning on how to integrate agroforestry on land they perceive as small in relation to what they have to use it for. Stakeholders should consider household land holdings to guide the design of the agroforestry practices that suit different household land sizes in the drylands.

Increase in age of the household head significantly increased the adoption rate of agroforestry. The results are similar to those found by Ajayi et al. (2003) in his research on the adoption of improved fallow technologies for soil fertility management in Zambia that showed age had significant influence on the adoption of agroforestry. According to FAO (1989), adopters of tree planting are mostly older people. Aged people have life experience of the importance of agroforestry thus adopting agroforestry in their farms. It's assumed that older people still practice traditional African culture which was pro-conservation and attached a lot of value on trees thus increasing adoption of agroforestry with age. The results could also imply that young people in the study area are involved in both informal and formal employment and businesses which give quick money unlike long term benefits associated with trees thus low adoption of agroforestry among the young people.

The results show that income positively influenced household adoption of agroforestry. The results are similar to those found by Phiri et al. (2004) who demonstrated that farmers' wealth status and tree planting being higher among households classified as wealthier than among the very poor households in his study on the associations of wealth status and gender with planting of improved fallows in Eastern Province Zambia. The results are similar to those found by Zerihun et al. (2014) in his research on determinants of agroforestry technology adoption in Eastern Cape Province in South Africa that reviewed income of the household head significantly affect the adoption of Agroforestry practices. The results are similar also to those found by Odhiambo (2010) in his study on the positive deviance in the adoption of agroforestry technologies within lower Nyando basin, Kenya. Farmers with higher income would be able to afford to pay for labor to dig holes and establish agroforestry thus increasing the adoption rate. The poor could be busy looking for limited alternative sources of livelihood thus having little time to invest in agroforestry whose returns are long term.

The results shown that gender significantly influenced agroforestry adoption by household at the study site. The results are similar to those found by Oino and Mugure (2013) in their study on farmer-oriented factors that influence adoption of agroforestry practices in Kenya.

Increase in household size significantly increased the adoption of agroforestry in the study area. The results are similar to those found by Twaha et al. (2016) in their research on enhancing adoption of Agroforestry in in the Eastern Agro-ecological of Uganda. The reason for this could be due to the fact that household with many family members involved in farming are likely to adopt agroforestry because of abundant labor supply from the family members.

The study shown that there was significant relationship between marital status and adoption of agroforestry in the study area. This corroborates results of a study by Twaha et al. (2016) who found out that the percentage of married household heads who adopted agroforestry was higher than those who are not married in their study in assessing the socio-economic factors that affect agroforestry adoption in Eastern Agro-ecological zones of Uganda. This could due to the fact that as farmer marries, his household size increases resulting into additional food requirement (Ofuoku et al. 2009) thus more adoption rate of agroforestry to meet the increased food demand.

Conclusion and recommendation

The purpose of this study was to determine factors that influence the adoption of the dominant agroforestry practices in the study area. The study provided empirical data on understanding the key socio-economic factors affecting the adoption of agroforestry practices by households in the drylands. Education level, the age of the household head, income, gender, marital status and family size were significantly influencing the adoption of agroforestry practices by the households in the study area.

To successfully promote and out-scale agroforestry in the drylands and realize its full potential, policies aimed to increasing adoption of agroforestry practices in the drylands need to address these variables. Awareness creation and agronomic training among the household head and especially the youth with low education is key. Further, there is need for the policy to focus on financial packages that can support the poor households in agroforestry initiatives as well as designing agroforestry practices that fit different household sizes and gender in the drylands.

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References

- Ajayi O, Franzel S, Kuntashula E, Kwesiga F (2003) Adoption of improved fallow technology for soil fertility management in Zambia; empirical studies and emerging issues. *Agrofor Syst* 59(3):317–326
- Alavalapati J, Nair P (2003) Socioeconomics and institutional perspectives of agroforestry World Forests, Society and Environment: Markets and Policies. pp 71–81
- Anne J, Lennart O (2013) More than trees. Understanding the agroforestry adoption gap in Subsistence Agriculture. Insights from narrative walks in Kenya. S-22100, Lund, Sweden
- Barrow E, Mogaka H (2007) Kenyas’s drylands. Wastelands or an undervalued national Economic Resource
- County Government of Makeni (2018) *Makeni County Integrated Development Plan (CIDP) 2018–2022. Report.* <https://repository.kippira.or.ke/xmlui/bitstream/handle/123456789/646/2018-2022%20Makeni%20County%20CIDP.pdf?Sequence=1&isAllowed=y>
- De Leeuw J, Njenga M, Wagner B, Iiyama M (2014) Resilience: An assessment of the resilience provided by trees in the drylands of Eastern Africa. Nairobi, Kenya. ICRAF. p 166
- Edinam K, Hassan B, Mawutor K (2013) Analysis of socio-economic conditions Influencing adoption of agroforestry practices. *Int J Agric* for 3(4):178–184
- Faulkner P, Owooh B, Dassi J (2014) Assessment of the adoption of agroforestry technologies by limited resources Farmers in North Carolina. *J Ext* 52(5):40–52
- Food and Agriculture Organization (FAO) (2005) Carbon sequestration in dryland soils. World Soils Resources Reports 102. FAO. Rome
- Food and Agricultural Organization of the United Nations (1989) Forestry and food security, FAO Forestry paper N. 90 FAO. Rome Italy
- Food and Agriculture Organization (FAO) (2016) Trees, Forests and land use in drylands. The first global assessment. FAO. Rome
- Food and Agriculture Organization (FAO) (2013) Advancing agroforestry on the policy agenda. A guide for decision – makers by G. Buttoud. Agroforestry working paper No. 1
- Gichuki F (2000) Makeni district profile: rainfall variability, 1950–1997. Drylands Research Working Paper 2. Crewkerne, UK. Drylands Research
- Hossain M, Alam M, Rahman M, Rahaman M, Nobl M (2005) Financial variability of shifting cultivation versus agroforestry project. A case study in Chittagong hill tracts. *Int J Biol* 1:29–34
- Jaetzold R, Schmidt H, Hornetz B, Shisanya C (2006) Farm management handbook of Kenya. Vol. 11C Eastern Province. Natural Conditions and farm management information. Ministry of Agriculture, Nairobi Kenya
- Jama B, Zeila A (2005) Agroforestry in the drylands of eastern Africa: a call to action. ICRAF Working Paper – no. 1. Nairobi, Kenya: World Agroforestry Centre
- Jose S (2009) Agroforestry for ecosystem services and environmental benefits: an overview. *Agroforest Syst* 76(1):1–10
- Kabwe G, Bigsby H, Cullen R (2009) Factors Influencing adoption of Agroforestry among Smallholder farmers in Zambia. Paper presented at the 2009 NZARES Conference, Tahuna Conference Centre –Nelson, New Zealand, August 27–28
- Kathuri N, Pals D (1993) Introduction to Educational Research. Kenya. Egerton University. Educational Media Centre
- Kenya National Bureau of Statistics (KNBS) report (2019) <http://dc.sourceafrica.net/documents/119074-Kenya-National-Bureau-of-Statistics-Economic.html>
- Mercer D (2004b) Adoption of agroforestry innovations in the tropics: review. *Agrofor Syst* 61(1):311–328
- Mercer DE, Miller RP (1998) Socioeconomic research in agroforestry: progress, prospects, priorities. *Directions Trop Agrofor Res* 38:177–193
- Millennium Ecosystem Assessment MEA (2005) Dryland systems. Chapter 2. Washington DC
- Nair P, Nair V, Kumar B, Haile S (2009) Soil carbon sequestration in tropical agroforestry systems: a feasibility appraisal. *Environ Sci Policy* 12:1099–1111
- Ngululu S, Karanja J, Kimatu J, Gicheru P, Musimba N, Njiru E, Kathuli P, Nzioki H, Akuja T, Muli B, Nzombe N (2014) Refining Dryland Farming systems as a means of Enhancing Agrodiversity and food security in Eastern Kenya A review. Council for innovative research. *J Adv Agric* 3(1):142–149
- Odhiambo KK (2010) Positive deviance in the adoption of agroforestry technologies within lower Nyando basin, Kenya. MA thesis, Kenyatta University
- Ofuoku A, Egho E, Enujoke E (2009) Integrated pest management (IPM) adoption among farmers in Central agro-ecological Zone of the Delta State Nigeria. *Adv Biol Res* 3(1–2):29–33
- Oino P, Mugure A (2013) Farmer-oriented factors that influence adoption of agroforestry practices in Kenya. Experiences from Nambale District. Busia County. *Int J Sci Res* 2(4):442–449
- Orisakwe L, Ogomuo F (2012) Adoption of improved agroforestry technologies among contact farmers in Imo State, Nigeria. *Asian J Agric Rural Dev* 2(393-2016–23889):1–9
- Pattanayak S, Mercer D, Sills E, Yang J, Cassingham K (2003) Taking stock of agroforestry adoption studies. *Agrofor J* 57(3):173–186
- Phiri D, Franzel S, Mafongoya P, Jere L, Katanga R, Phiri S (2004) Who is using the new Technology? The association of wealth status and gender with the planting of improved the fallows in Eastern Province Zambia. *Agric Syst* 79(2):131–144
- Pilote K, Jewel A, Yohan L, Don K (2017) Benefits and challenges of agroforestry adoption; a case of Musebeya sector, Nyamagabe District in Southern Province of Rwanda. *For Sci Technol* 13(4):174–180
- Reynolds JF, Smith DMS, Lambin EF, Turner BL, Mortimore M, Batterbury SPJ, Downing TE, Dowlatabadi H, Fernandez RJ, Herrick JE, Huber-Sannwald E, Jiang H, Leemans R, Lynam T, Maestre FT, Ayarza M, Walker B (2007)

- Global desertification: building a science for dryland development. *Science* 316:847–851
- The constitution of Kenya 2010
- Thornton P, Henninger N, Kristjanson R, Atieno F, Odera (2002) Mapping Poverty and Livestock in the developing world. International livestock Research Institute, Nairobi
- Trozzo K, Munsell J, Chamberlain J (2014) Landowner interest in multifunctional agroforestry riparian buffers. *Agrofor Syst* 88:619–629
- Twaha A, Clement M, Bananas K, Nakileza B, Frank M, Paul N, Elizabeth B, Ann T, Kassim S (2016) Enhancing adoption of agroforestry in the eastern agro-ecological one of Uganda. *Int J Sci Environ Eng* 1:20–31
- Wafuke S (2012) Adoption of agroforestry technologies among small scale Farmers in Trans.nzoia location, lugari district, Kenya. Unpublished M.Sc. Thesis, Egerton University
- Wekesa L, Muturi G, Mulatya J, Esilaba A, Keya G, Ihures S (2012) Economic viability of melia Vonkensii production of smallholdings in drylands of Kenya. *Int Res J Agric Sci Soil Sci* 2(8):364–369
- Zerihun M, Muchie M, Worku Z (2014) Determinants of agroforestry technology adoption in Eastern Cape Province, South African. *South Afr Innov Summit J* 1(1):51–63

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