Research Journal of Agriculture and Forestry Sciences ISSN 2320-6063
Vol. **3(6),** 6-15, June **(2015)** *Res. J. Agriculture and Forestry Sci.*

Prevalence and Adoption of Agroforestry Technologies and Practices in Semi-Arid Regions of West-Pokot County, Kenya

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Available online at: www.isca.in, www.isca.me
Received 28th April 2015, revised 16th May 2015, accepted 5th June 2015

Abstract

Apart from being few, studies on agroforestry in ASALs have failed to consider different categories of farmers depending on the number of years they have practiced the technology. This has led to scanty information to the advocators of agroforestry and individual farmers in need of agroforestry information. This study therefore determined effective agroforestry technologies suitable for Kenya's ASALs based on the prevalence and adoption levels in Chepareria and Lelan sub-locations of West-Pokot County. The study employed independent group research design. A total of 181 households were selected (90 in Chepareria and 91 in Lelan from a target population of 2199 households). Data was collected through questionnaires, key informants drawn from field officers and contact farmers, and direct field observation. Mann-Whitney U test and kruskal Wallis test were used to analyze data with the aim of determining significant differences between and among independent groups. The results indicated that most common agroforestry technologies include boundary tree planting, home-garden, woodlot, scattered trees, alley cropping, and fodder bank. The six technologies across the study area were dominated by boundary tree planting (Chepareria 63.4%, Lelan 68%). However, there was no significant difference in the prevalence of agroforestry technologies between the sub-locations (U = 1685, d.f= 1, N= 181, P= 0.378). In addition, the difference in the adoption levels of the six technologies between the sub-locations was statistically insignificant (U = 3196.500, N= 181, d.f 1, P > 0.05). However, kruskal Wallis test indicated significant difference within adoption levels in sub-location [(Chepareria χ^2= 312.132, d.f =5, N = 90, P =.0000), (Lelan $\chi2$ =145.674, d.f = 5, N = 91, P=.0000)]. At the adopters' level, boundary planting had a significantly higher number of households as compared to any other technology. In this regard, extension officers need to organize for training to create awareness and empower farmers on least prevalent and non-adopted technologies.

Keywords: Agroforestry technologies, adoption, prevalence.

Introduction

Based on the available moisture for plant growth, 88% of Kenyan land is ASAL, with the potential value of about Kshs 180 billion per year[1]. This indicates that ASALs represent a very important socio-economic asset in the country. However, ASALs like West-Pokot experience unreliable and varied low rainfalls ranging from 100-1200 mm per year, frequent and high velocity winds along with hot temperatures that results to a fragile ecosystem which is disadvantaged both economically and environmentally. These affects food security, fodder availability, fuelwood accessibility, soil fertility, and biodiversity as a result of destroyed habitats and vegetal species among other effects that threaten human, plant, livestock and wildlife existence[2,3].

In dealing with these conditions, researchers are constantly searching for survival techniques that are environment-friendly and conservation conscious[3]. In the process, Coe et al., Johansson et al., and Jerneck, and Olsson have recommended that agroforestry is the most promising survival technique to mitigate problems in ASALs by increasing biological diversity and food security among other ecological goods to improve people's livelihood[4-6]. As an effect, Agroforestry concepts have been introduced in West-Pokot by government and Non-governmental organizations like Vi-Agroforestry in targeting small scale farmers with the aim of increasing food security, energy security and wealth creation[4]. Contrary, some technologies and practices have received low adoption as a result of unawareness of their long term benefits, high investment costs, and technological knowhow required in their implementation, while others compete directly with food crops for light, nutrients and water[7]. However, most studies on agroforestry have concentrated in high potential areas that are facing intense population pressure, leading to little documentation of agroforestry in ASALs for use by development facilitators, policy-makers and individual farmers[5-8]. In addition, studies assessing agroforestry adoption fail to consider different farmer categories based on the number of years the famer has practised the technology by providing information based on a single snapshot.

As an effect, this study determined the prevalence and adoption levels of agroforestry in the Semi-arid areas of West-Pokot County using Chepareria and Lelan sub-locations. As a result, the study aimed at answering two hypotheses i. The prevalence of agroforestry technologies and practices in Chepareria and Lelan sub-locations of West-Pokot County are the same, ii. Adoption levels of agroforestry technologies in Chepareria and Lelan sub-locations of West-Pokot County are the same.

Materials and Methods

The study was undertaken in West-Pokot County within the latitudes of 10^0 10' N and 30^0 40'N and longitudes of 34^0 50'E and 35^0 50'E, focusing on Lelan and Chepareria Sub-Locations. Lelan is located in Pokot South with an altitude range of 2361-2877 m above the sea level and annual rainfall range of 1100-2700 mm per annum. The average temperature ranges from 10-26°C with frequent and high velocity winds.. The population density is 64.45/Km2 with a total of 1246 households. The region is characterised by mixed economy as crops like maize, beans and pyrethrum are grown and dairy cattle reared in well-fenced estates. The land ownership is highly privatized.

Chepareria is located in Pokot-West with a population density of 47.25/Km2 and 953 households. Temperatures range from 15°C to 30°C, with highest temperatures causing high evapo-transpiration that affects crops negatively. The area's altitude ranges from 1700 m to 2000 m above sea level, with irregular and unpredictable annual rainfall ranging from 500 mm to1600 mm. There are also significant variations in soils, with lower parts characterised as semi-arid having fragile infertile soils. The main economic activity is agropastoralism, while a few farmers in the upper parts have adopted improved livestock breeds.

The two sub-locations experience land and environmental degradation including gully erosions, sedentarization and droughts; resulting to high absolute poverty levels of about 68%. In this regard, organizations like VI Agroforestry initiated rehabilitation and regeneration programs like enclosure systems and on farm tree planting. The main approach used includes creation of tangible examples to convince participants of the importance of land rehabilitation and regeneration.

Independent group research design that involves assigning each group of participants to one condition of independent variable was used. The design was selected due to the study approach that involved comparing prevalence and adoption levels of agroforestry technologies and practices in independent areas of West-Pokot County.

The two sub-locations were selected based on purposeful sampling technique. This was based on farming practices, where farmers in Lelan and Chepareria practice mixed and agro-pastoral farming respectively. Systematic random sampling was used in selecting individual farmers in Lelan and Chepareria Sub-locations. The initial starting point was selected randomly there after every 5th household was included in the sample.

Sample size determination was based on Israel 2012 logarithm table at ±10% precision, 95% Confidence Level based on the total population. As a result, 91 and 90 households out of 1246 and 953 households in Lelan and Chepareria respectively were selected.

Direct field observation was used in the identification of agroforestry technologies, the species being planted and how they were being practised. Data was collected in form of photographs after obtaining permission from the farmer. Questionnaires were also administered to farmers to collect information on the type of technology and practices, number of years the farmer has adopted the technology and practices, and reasons for adoption. Two enumerators in each sub-location were selected based on their academic qualifications with the help of assistant chiefs. They were trained on data collection procedures and ethical concerns, and each a located a route to administer the questionnaires. Key Informant Interviews involved face-to-face interviews with the leaders in the region among them agricultural extension officer, Vi-agroforestry officer, Kerio valley development authority officer, and West-Pokot county conservancy officer.

Mann-Whitney *U* test was used to determine the significant differences in the prevalence and adoption levels of agroforestry technologies and practices between the independent groups of data from Lelan and Chepareria at 95% confidence level. Kruskal Wallis test was used to test significant difference within adoption levels in each sub-location at 95% confidence level.

Results and Discussion

Prevalence of Agroforestry Technologies in West-Pokot: The results in figure-1 indicated that boundary tree planting was the most prevalent with 63.4% and 68% of respondents in Chepareria and Lelan practicing it respectively.

Mann Whitney *U* indicated that the differences in the prevalence of agroforestry technologies in Chepareria and Lelan sub-locations of West-Pokot County were statistically insignificant (Mann Whitney *U* test, U = 1685, df= 1, N= 181, P= 0.378). As a result, we fail to reject the null hypothesis that the prevalence of agroforestry technologies between Lelan and Chepareria sub-locations are statistically the same.

Boundary tree planting: Boundary tree planting was the most prevalent with farmers dominantly planting *Croton megalocarpus, Cupressus lusitanica* and *Grevillea robusta* around the perimeter of their properties figure-2. Farmers preferred *Croton megalocarpus* and *Grevellia robusta* species because of their fast growth rate, and high multi-purposefulness. *Cupressus lusitanica* was also preferred due to its high timber quality and aesthetic values. The technology and practice was also helpful in demarcating land, provides fuelwood, and reduces soil erosion among other protective benefits and was easy to establish and manage[3,9-11]. However, farmers were unaware of using boundary planting to reduce evaporation demands.

Home-garden agroforestry: Under home-garden, farmers were growing food crops such as cassava, bananas, sweet potatoes, vegetable (Kales /sukuma wiki) inter-cropped with tree species such as *Croton megalocarpus* figure-3. This involved planting trees at the homestead vicinity as explained by Buyinza *et al* [12]. This reasons for its adoption cut across Chepareria and Lelan and included its diversified benefits like food production within a short period of time (e.g. vegetables, passion fruits) while waiting for long term wood products from trees[8]. The findings concur with Jyoti *et al*. that most of the trees adopted in home-garden technology are multipurpose in nature[11,13]. However, poor weather conditions like long periods of drought and unreliable rains hinders its adoption, though NGOs were introducing improved tree species like grafted mangoes that grow better and faster in ASAL conditions.

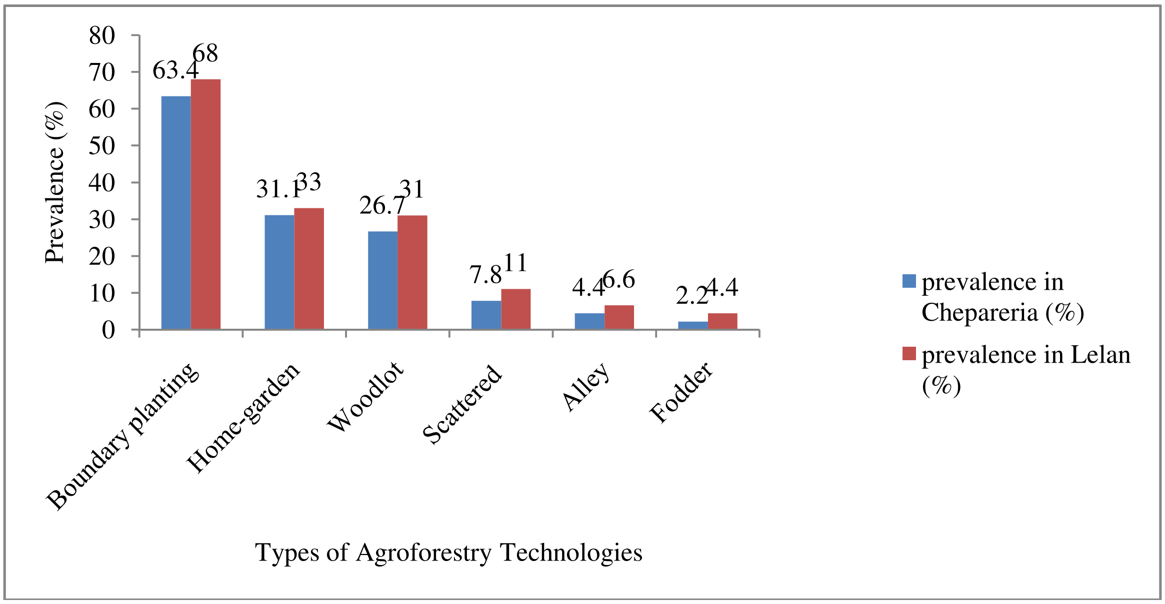


Figure-1
Prevalence of Agroforestry Technologies in West-Pokot, Kenya

Figure-2
Boundary Planting Technology

Woodlot: The main drivers of woodlots establishment (figure-4) in Chepareria and Lelan were production of poles and timber to be sold for family income generation, and to some extent provision of construction poles, and rarely fuelwood[3,14,]. Field observations that indicated *Eucalyptus species* were the most preferred species because of their good adaptation to local climatic conditions. In Lelan, climatic conditions favour both *Eucalyptus* and *Cupressus lusitanica* species. However, functions like biodiversity conservation as stated in literature were unknown to farmers in West-Pokot[3].

Scattered tree planting on farms: The irregular pattern of scattered trees on farm (fiqure-5) and their functions like preventing soil erosions, providing shade to crops, animals and herders during hot seasons were similar to the findings by Mutonyi and Fumgo[15]. However the prevalence was low as compared to the findings in literature because farmers perceived that scattered trees were competing with food crops for light and nutrients, and hinder mechanization of farm practices[7]. However, NGOs are educating farmers on agroforestry species like *Grevellia robusta* and *Terminalia brownie*.

Alley cropping: Despite its low prevalence, alley cropping was being practiced by planting passion fruits between lines of agroforestry trees (figure-6) especially *Sesbania sesban* to reduce soil erosion, providing fodder, food and fuelwood. However, the reasons for low prevalence was due to high technological knowhow which many farmers lacked and was labour intensive just as explained by Parwada et al.[7]. However, as stated by Coe *et al*., and Mutonyi and Fumgo, lack of market for the fruits was hindering commercial adoption of the technology[4,15,]. In this regard, farmers were receiving training and subsidies in terms of seeds and seedlings from Nature Kenya and Vi Agroforestry through CBOs.

Figure-3
Home-garden

Figure-4
Woodlot Technology

Figure 5
Scattered Trees on Farm

Figure-6
Alley Cropping Technology

Fodder bank: Fodder bank technology (fiqure-7) was the least prevalent technology in Chepareria and Lelan. Farmers planted Napier (*Pennisetum purpureum*) and *Sesbania sesban* along with other tree species like *Croton megalocarpus* and *Dombeya cosanii*. The purpose of this technology was to provide fodder during dry seasons and increase soil fertility as explained by Chandra *et al*.[16]. These concur with Yadav and Bisht that tree fodder is valuable during winter and summer when green fodder is less both in quality and quantity[17]. However, prevalence is low because of larger pieces of land that provided enough resources for grazing, and high cost demanded in maintaining the technology in terms of weeding and manure application. The percentage of farmers practicing fodder bank technology in Lelan was higher than those in Chepareria because farmers in Lelan practised mixed farming with zero grazing while in Chepareria farmers were agro-pastoralists. This implied that the demand for fodder foliage was higher in Lelan than Chepareria.

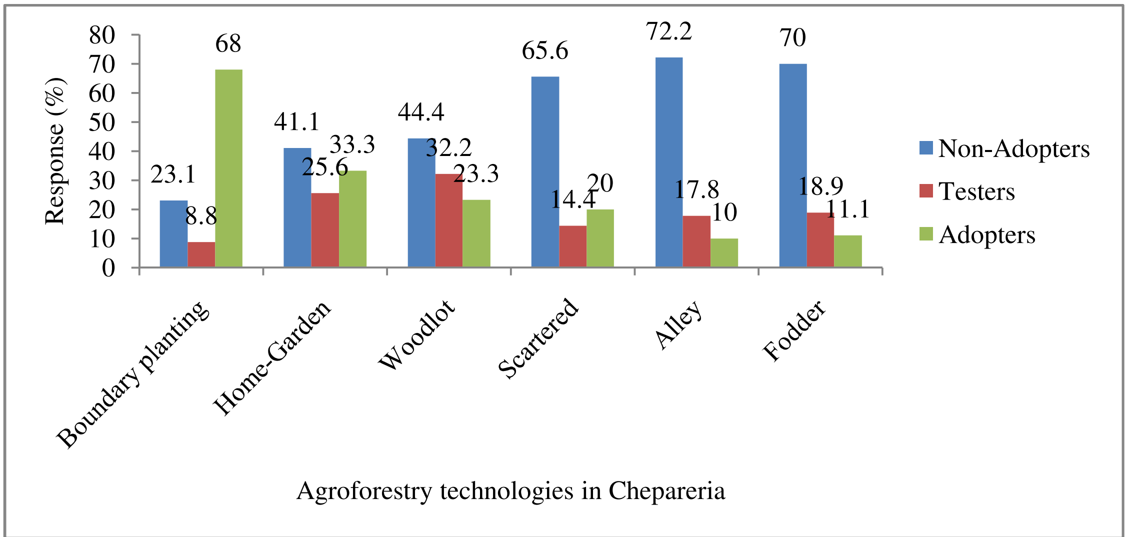
Adoption Levels of Agroforestry Technologies: The information on the adoption levels of the six agroforestry technologies based on the number of years the farmer had practised the technology was as indicated in Figure-8 and Figure-9. Man Whitney *U* test indicated that the adoption levels of agroforestry technologies between Chepareria and Lelan were statistically insignificant (U = 3196.500, N= 181, d.f 1, P > 0.05). However kruskal Wallis test indicated significant difference in adoption levels within sub-location [(Chepareria χ^2= 312.132, d.f =5 N = 90, P =.0000), (Lelan $\chi2$ =145.674, d.f = 5, N = 91, P=.0000)]. This implied that adoption levels of the six agroforestry technologies within sub-locations were significantly different. The results of pair-wise analysis to identify the unique technologies at each adoption level are as indicated in table-1.

Table-1
Test Statistics for Adoption Levels between Agroforestry Technologies that are Unique

	Chepareria			**Lelan**		
	Adopters	**Testers**	**Non-adopters**	**Adopters**	**Testers**	**Non-adopters**
Boundary vs Home-garden						
Mann-Whitney U	9190.000	7245.500	2272.000	14092.000	9658.500	1562.000
Z	-6.250	-4.098	-3.000	-4.132	.000	.000
Exact Sig. (2-tailed)	.000	1.000	.000	.000	1.000	1.000
Boundary vs Woodlot						
Mann-Whitney U	6265.000	213.000	3288.000	7596.000	132.000	2178.000
Z	-5.085	.000	-3.760	-7.672	.000	-3.760
Exact Sig. (2-tailed)	.000	1.000	.000	.000	1.000	.000
Boundary vs Scattered						
Mann-Whitney U	6390.000	125.000	6528.000	2418.000	7621.000	5618.000
Z	-9.245	.000	-5.9975	-8.060	-3.987	-7.981
Exact Sig. (2-tailed)	.000	1.000	.000	.000	.000	.000
Boundary vs alley						
Mann-Whitney U	7340.000	180.000	3246.000	9240.000	170.500	2838.000
Z	-8.887	.000	-6.765	-7.998	.000	-7.432
Exact Sig. (2-tailed)	.000	1.000	.000	.000	1.000	.000
Boundary vs Fodder						
Mann-Whitney U	8630.500	140.500	29805.000	11116.000	170.500	28904.000
Z	-6.600	.000	-7.094	-7.000	.000	-6.997
Exact Sig. (2-tailed)	.000	1.000	.000	.000	1.000	.004
Home-garden vs Woodlot						
Mann-Whitney U	18338.500	1234.500	479.000	1290.000	125.500	290.000
Z	0.000	.000	0.000	.000	.000	0.000
Exact Sig. (2-tailed)	1.000	1.000	1.000	1.000	1.000	1.000
Home-garden vs Scattered						
Mann-Whitney U	8630.500	140.500	29805.000	11116.000	170.500	28904.000
Z	-6.600	.000	-7.094	-7.000	.000	-6.997
Exact Sig. (2-tailed)	.000	1.000	.000	.000	1.000	.004
Home-garden vs alley						
Mann-Whitney U	7890.000	632.500	9840.500	26660.000	728.500	11579.500
Z	-5.455	.000	-8.791	-6.253	.000	-2.791
Exact Sig. (2-tailed)	.000	1.000	.000	.000	1.000	.000
Home-garden vs Fodder						
Mann-Whitney U	267040.000	824.500	5760.000	25294.000	728.500	4686.000
Z	-6.430	.000	-6.087	-5.430	.000	-5.986
Exact Sig. (2-tailed)	.000	1.000	.000	.000	1.000	.000

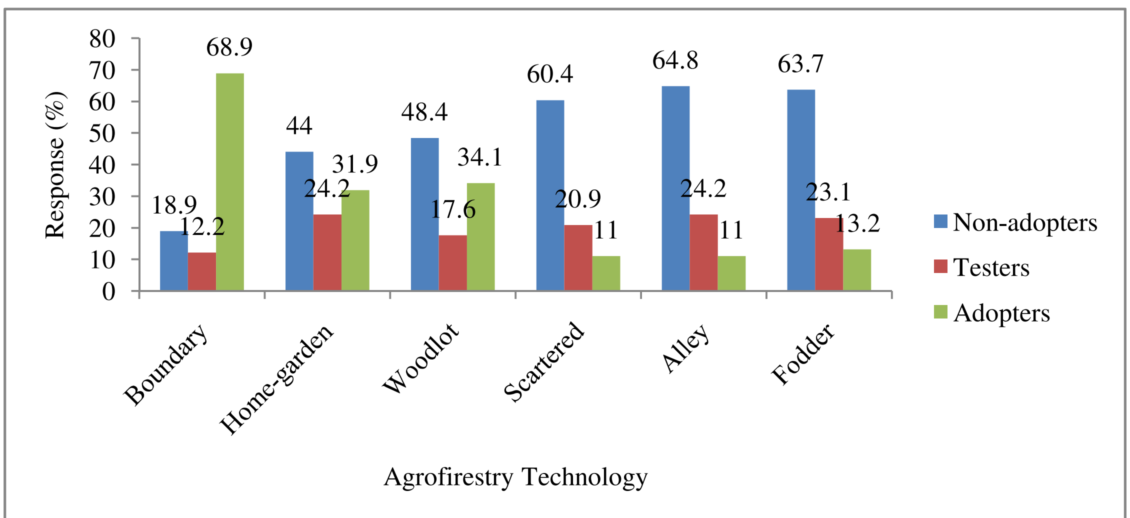
	Chepareria			**Lelan**		
	Adopters	**Testers**	**Non-adopters**	**Adopters**	**Testers**	**Non-adopters**
Woodlot vs Scattered						
Mann-Whitney U	32900.000	349.000	4730.500	21131.000	264.000	5890.500
Z	-7.580	.000	-6.002	-5.891	.000	-3.998
Exact Sig. (2-tailed)	.001	1.000	.000	.002	1.000	.000
Woodlot vs alley						
Mann-Whitney U	25670.000	569.000	8670.000	23580.000	372.000	6385.500
Wilcoxon W	8380.000	985.000	34320.000	9290.000	868.000	24770.500
Z	-6.060	.000	-8.000	-5.057	.000	-4.234
Exact Sig. (2-tailed)	.000	1.000	.000	.000	1.000	.000
Woodlot vs Fodder						
Mann-Whitney U	1411.000	475.000	5670.000	2422.000	372.000	6534.000
Z	-4.434	.000	-4.328	-3.345	.000	-3.900
Exact Sig. (2-tailed)	.000	1.000	.000	.000	1.000	.000
Scattered vs Alley						
Mann-Whitney U	214.000	389.000	560.000	228.000	582.000	350.000
Z	0.000	.000	.000	000	.000	.000
Exact Sig. (2-tailed)	1.000	1.000	1.000	1.000	1.000	1.000
Scattered vs Fodder						
Mann-Whitney U	141.000	490.000	458.000	282.000	459.000	534.000
Z	.000	.000	.000	.000	.000	.000
Exact Sig. (2-tailed)	1.000	1.000	1.000	1.000	1.000	1.000
Alley vs Fodder						
Mann-Whitney U	395.000	365.000	467.000	362.000	389.000	240.000
Z	.000	.000	.000	.000	.000	.000
Exact Sig. (2-tailed)	1.000	1.000	1.000	1.000	1.000	1.000

Figure-7
Fodder Bank



Key: non-adopter= 0 years, testers = practised ≤ 3years, Adopter= practised > 3 years

Figure-8
Adoption levels of Agroforestry Technology and Practices in Chepareria, West-Pokot



Key: non-adopter= 0 years, testers = practised ≤ 3years, Adopter= practised > 3 years

Figure-9
Adoption Levels of Agroforestry Technology and Practices in Lelan, West-Pokot

Adopters: The results indicated that number of adopters of boundary planting was statistically higher both in Chepareria and Lelan as compared to all other technologies**.** This was because boundary planting was the oldest agroforestry technology because extension programs on its significance in demarcating private lands, protecting crops and buildings from strong winds started in early 1990s. On the other hand, extension programs on other technologies started between 2005 and 2006 by NGOs like Nature Kenya and Vi Agroforestry. As a result, based on the five-stage-model summarized by Kelly, boundary planting was the most adopted agroforestry technology in West-Pokot because it was at a confirmation stage, while other technologies like alley and home-garden at knowledge and persuasion stage[18]. This was because farmers were aware of benefits from boundary planting due to earlier extension programs.

Testers: There was no significant difference between adoption levels among all the technologies in Chepareria as indicated in table-1. This was because most people were still testing the technologies as they continued learning their benefits from neighbours that had adopted the technology, and trials by extension officers. On the other hand, results indicated that number of adopters of; home-garden, woodlot, alley, and fodder were on the increase as farmers were learning more about the benefits of the technologies from earlier adopters especially in Lelan. This concurred with Lukuyu *et al*. that extension officers do play an important role in increasing adoption of improved agricultural practices and systems by mobilizing and training farmers through demonstration plots[19].

The situation was different in Lelan where significant differences were observed between boundary planting and scattered trees as indicated in table-1. This was because scattered trees on farm were deemed a hindrance of mechanization in agricultural lands. As a result, the number of farmers testing the technology was low because it was incompatible with existing practices[20].

Non-adopters: The number of non-adopters of boundary planting technology was significantly lower than non-adopters of all other five technologies in Chepareria and Lelan. This was because of extensive awareness of economical, social and environmental benefits of boundary planting, as compared to other technologies. However, alley cropping in Chepareria and Lelan had higher percentages of non-adopters because many farmers were lacking necessary technological knowhow as demanded by the technology, and inadequate markets for their products.

Conclusions

A total of six agroforestry technologies namely; boundary planting, home-garden, woodlot, scattered trees, alley cropping, and fodder banks were being practised in Lelan and Chepareria sub-Locations of West-Pokot County. Amongst them, boundary planting and fodder bank were the most and least prevalent technologies in West-Pokot respectively. In this regard, extension programs concentrating on the best agroforestry technologies, tree/shrub species that can thrive well in ASALs together with their benefits should be encouraged by the extension officers to improve prevalence of already existing or introduce new agroforestry technologies in Kenyan ASALs.

Boundary planting had the highest percentage of adopters while alley cropping technology had the highest percentage of non-adopters both in Lelan and Chepareria sub-locations. This was because extension programs on boundary planting started in early 1990s to promote land demarcation and soil erosion prevention. As a result, Farmers should be educated by extension officers on the long-term benefits of various agroforestry technologies that have higher rates of non-adopters so that they start testing or even adopt the technology in future.

Acknowledgement

Special thanks to the Research and Extension Committee of the University of Kabianga for their funding.

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