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Research Application Summary

Determinants of adoption of agroforestry systems in the drylands of Kenya

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Abstract

Drylands typically suffer from unsustainable land uses which have evolved in the recent past. They face innumerable problems such as climate variability including extreme events such as drought, natural resources degradation, declining agricultural productivity and high population which are exacerbating retrogressive development pathways in these regions. Dryland populations are generally typically impoverished on a global scale with over half of the population living below poverty line. In order to sustainably address these challenges in the drylands, sustainable land use and management is an important imperative. Agroforestry as a dynamic, ecologically based natural resources management system, through the integration of trees on farms and in the agricultural landscapes, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. This is a critical entry point for dryland productivity and sustainability. Well designed and implemented dryland agroforestry provides leverage points to alleviating poverty, providing food security and livelihoods, maintaining healthy ecosystems, conserving biodiversity and mitigating greenhouse gas effects through carbon sequestration. There was thus need to determine factors that influence adoption behavior of agroforestry at farm level. Understanding of how and why farmers make a 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. This study identified gaps by establishing ecological, social and economic factors that influence adoption of dry lands agroforestry systems. From the 240 households interviewed, age, gender, marital status, land size, education, income, cultural beliefs, extension services, conservation, time on practicing agroforestry and knowledge of trees on crops were the main determinants of adoption. A multinomial logistic regression model showed that the socio-economic factors (age, education level, family size cultural believes and income) significantly influence adoption of agro forestry($P < 0.05$). However, family size did not significantly influenced adoption ($P > 0.05$). The level of education had the greatest influence (B=0.532) followed by land size (B=0.336) and age (B=0.333).To realize high rate of adoption and benefit from the multiple benefits of agroforestry in drylands, there is need to pay attention to the identified determinants of adoption to realize full potential of dryland agroforestry.

Key words: Agroforestry, carbon sequestration, climate variability, drylands, Kenya

Résumé

Les zones arides souffrent généralement d'utilisations non durables des terres qui ont évolué dans un passé récent. Ils sont confrontés à d'innombrables problèmes tels que la variabilité climatique, y compris des événements extrêmes tels que la sécheresse, la dégradation des ressources naturelles, la baisse de la productivité agricole et une population élevée qui aggravent les voies de développement rétrogrades dans ces régions. Les populations des zones arides sont généralement appauvries à l'échelle mondiale, plus de la moitié de la population vivant sous le seuil de pauvreté. Afin de relever durablement ces défis dans les zones arides, l'utilisation et la gestion durables des terres sont un impératif important. L'agroforesterie en tant que système de gestion des ressources naturelles dynamique et écologique, grâce à l'intégration des arbres dans les exploitations agricoles et dans les paysages agricoles, diversifie et soutient la production pour des avantages sociaux, économiques et environnementaux accrus pour les utilisateurs des terres à tous les niveaux. Il s'agit d'un point d'entrée essentiel pour la productivité et la durabilité des zones arides. Une agroforesterie des zones arides bien conçue et mise en œuvre fournit des leviers pour réduire la pauvreté, assurer la sécurité alimentaire et les moyens de subsistance, maintenir des écosystèmes sains, conserver la biodiversité et atténuer les effets des gaz à effet de serre grâce à la séquestration du carbone. Il était donc nécessaire de déterminer les facteurs qui influencent le comportement d'adoption de l'agroforesterie au niveau des exploitations. Comprendre comment et pourquoi les agriculteurs prennent des décisions à long terme sur l'utilisation des terres et appliquer ces connaissances à la conception, au développement et à la commercialisation d'innovations agroforestières est très important pour réaliser le plein potentiel de l'agroforesterie. Cette étude a identifié des lacunes en établissant des facteurs écologiques, sociaux et économiques qui influencent l'adoption des systèmes agroforestiers des terres arides. Parmi les 240 ménages interrogés, l'âge, le sexe, l'état matrimonial, la taille des terres, l'éducation, le revenu, les croyances culturelles, les services de vulgarisation, la conservation, le temps passé à pratiquer l'agroforesterie et la connaissance des arbres sur les cultures étaient les principaux déterminants de l'adoption. Un modèle de régression logistique multinomiale a montré que les facteurs socio-économiques (âge, niveau d'éducation, taille de la famille, croyances culturelles et revenus) influencent de manière significative l'adoption de l'agroforesterie ($P < 0,05$). Cependant, la taille de la famille n'a pas influencé de manière significative l'adoption ($P > 0,05$). Le niveau d'éducation a eu la plus grande influence ($B = 0,532$) suivi de la taille des terres ($B = 0,336$) et de l'âge ($B = 0,333$). Pour réaliser un taux d'adoption élevé et bénéficier des multiples avantages de l'agroforesterie dans les zones arides, il est nécessaire prêter attention aux déterminants de l'adoption identifiés pour réaliser le plein potentiel de l'agroforesterie des zones arides.

Mots clés : Agroforesterie, séquestration du carbone, variabilité climatique, zones arides, Kenya

Introduction

Globally, areas in which annual evapotranspiration exceeds rainfall and in which agricultural productivity is limited by poor availability of moisture are regarded as dryland ecosystems (Jama and Zeila, 2005). Recent developments have given increasing attention to the dryland environments arising from intermittent crises in these regions particularly in Africa; calling for significant development assistance and frequent humanitarian aid (De Leeuw *et al*., 2014). These situations are being orchestrated by innumerable challenges such as climate variability, frequent drought, natural resources degradation, declining agricultural productivity and high population increment (Jama and Zeila, 2005). Further, rapid exploitation of dryland woodlands to give way for agriculture, raw materials, human settlement and fuel wood production has accelerated environmental degradation in the dryland ecosystems. The cause-effect relationship of population-environmental degradation in the dryland areas cannot be under estimated; it is evident that dryland areas that have experienced rapid population growth have similarly witnessed accelerated rangeland degradation as demand for arable land increases and transitions to cultivated agriculture become pronounced than reliance on livestock production systems (Jama and Zaila, 2005; Egeru *et al*., 2014). Incidences of poverty are pronounced in the drylands with an average of 65% of the drylands population living below poverty line compared to the national average of 26% (Thornton *et al*., 2002; Barrow and Mogaka, 2007).

In Kenya, drylands account for 89% of the country's total land area (GOK, 2015). These areas represent a very important socio-economic region with a potential value of about KShs 180 billion annually (Kirbride and Grahn, 2008; Muga *et al*., 2011). But these areas are threatened by high rate of deforestation due to population pressure caused by immigration of farming communities from the high potential areas who come and clear the woodlands for agriculture and charcoal production. Drylands of Kenya experience erratic rainfall, frequent drought, harsh climatic conditions and declining soil fertility caused by continuous cultivation (KARI, 1999). As the size of the land becomes smaller, families cannot afford to let land sit fallow and replenish. They have to take every inch of their land and farm or graze constantly. This steady use lowers the level of organic matter in the soil, making it difficult to grow crops. Climate variability is also threatening this fragile ecosystem (FAO, 2010; De Leeuw *et al*., 2014).

The Government of Kenya is keen to mitigate deforestation and expand forest cover to improve people's livelihoods in drylands through policies like the Kenya's new Constitution which strives to achieve at least 10% forest cover, while the Kenya Vision 2030 targets environmental management through promotion of farm forestry and dryland forestry. The Kenya Forest Act No. 7 of 2005 recognizes the importance of farm forestry as it diversifies farm productivity and provides both subsistence and income through products such as timber, fuel wood, herbal medicine, and fodder and soil conservation.

But options for expanding 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. ROK (2005) states that Kenya's forests are found in prime regions of high agricultural potential where people are in dire need for agricultural land. Since Kenya's economy is agricultural based, there is need to balance between community development needs and the conservation of forests. The only remaining areas with potential for tree planting are the Kenyan drylands (Jama *et al*., 2005). It is therefore against this background that efforts to promote agroforestry are encouraged. Ludeki *et al*. (2004) has recommended farm forestry as an opportunity to protect existing forests. Agroforestry as a dynamic, ecologically based natural resources management system that through the integration of trees on farms and in the agricultural landscapes diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (Leaky, 1998). This is a critical entry point for dryland productivity and sustainability. Well designed and implemented dryland agroforestry provides leverage points to alleviating poverty, providing food security and livelihoods, maintaining healthy ecosystems, conserving biodiversity and mitigating greenhouse gas effects through carbon sequestration.

There is increasing attention to agroforestry by scientists and development community wordwide (Nair 1993; Alavalapati *et al*., 2003; Edinam *et al*., 2013) because it can address a wide range of household needs. Owing to disaggregated research, the scientific and technical knowledge on trees and agroforestry in drylands and information on their contribution to dryland livelihoods is scattered, fragmented or siloed (De leeuw *et al*., 2014). This has over time hampered the collection and analysis of information about socio-economic benefits leaving this scope generally weak and minimally explored (Paul, 1987). According to Nair (1998), the concern over low adoption rates of agroforestry is real. Despite all the merits of agroforestry, adoption is low (Anne and Lennart, 2013). Further research is needed in developing a better understanding of adoption uncertainty and insights into why farmers adopt and modify adopted systems (Mercer, 2004). The most common knowledge gap in socio-economic research on agroforestry is understanding factors influencing adoption behavior of agroforestry on farm level (Mercer and Miller, 1998). Understanding of 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. This study aims to fill the identified gaps by raising a pertinent question on what are the ecological, social and economic factors that influence adoption of dominant dryland agroforestry systems. Drylands Natural Resources Centre (DNRC), a local NGO has been working with smallholder farmers in Makueni County on a dryland agroforestry project since 2008. However, there has been no follow up research done to assess factors affecting their adoption. The key objective of this study was to establish ecological, social and economic factors that influence adoption of the dominant agroforestry systems in the study area.

Material and methods

The study was conducted in Makueni County of Kenya that lies between latitude 1º 35' South and longitude 37º 10' East and 38 º 30'. The County was selected based on the recent high concentration of tree promotion projects. There are two rainy seasons in this region. The short rains, which deliver most of the precipitation, occur in October-December and long rains in March-May. The average annual rainfall is 150-650 mm (Gichuki, 2000), which is characterized by high rainfall variability often leading to crop failure. The annual mean temperatures is in the range of 21-24 degrees Celsius and elevation is 800-1600m.The natural vegetation is mostly grassland and dense shrub land or woodland. The dominant soils belong to ferralsols and are either rhodic (red colour) or xanthic (yellow colour) with few aerosols and are naturally low in phosphorus (Mbuvi, 2000). The County covers an area of 7,965.8 km^2 and has a population of 884,527people with an annual growth rate of 2.8 %. The average family size according to 2009 census is 5.5 (Makueni District Strategic Plan, 2005).

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 concentration of agroforestry projects. In this case Makueni was chosen. Next was to identify divisions in which there was an ongoing agroforestry project which led to two divisions being chosen which are Kisau and Waia Divisions. Using Krejcie and Morgan's formula for sample size, 240 households were randomly selected for structured interviews. The farmers included those working with and those not working with DNRC.

Results and discussion

To determine which agroforestry systems were dominant, a frequency analysis was run using SPSS program as shown in Table 1. Out of the seven agroforestry systems/practices in the study area, scattered trees in the farm was ranked the highest (94.2%) and the lowest ranked was home gardens (20.8%).

After determining which agroforestry systems were in the study area, the interviewed farmers were asked to determine to what extent given factors influenced their adoption of agroforestry using the following key: 1 = very great extent, 2 = some extent, 3 = not sure, 4 = No extent. The results showed that marital status (58.3%) and land size (65%) influenced agroforestry adoption the most while education influenced it the least (20.8%) (Table 2).

A multinomial regression model was employed to identify the determinant variables that influence households to adopt an agroforestry system in the study area .The formula for multinomial regression model used was:

$$Y = A + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n + \varepsilon$$

Where:

A= constant, Y= adoption of agroforestry system, β_1, β_2, β_3 , …, β_n are regression coefficients and x_1, x_2………xn are the explanatory variables while [is the error term, which tends to zero in large samples.

The regression equation is:

Adoption of Agro forestry farming = 0.290 + 0.333 X_1 + 0.532 X_2 + 0.011 X_3 + 0.075 X4 + 0.181 X5 + 0.336 X6 + 0.060 X7 (Table 3)

These results show that the socio-economic factors (age, education level, family size, cultural believes and income) significantly ($P < 0.05$) influenced adoption of agroforestry. However marital status did not significantly influence adoption ($P > 0.05$). The level of education had the greatest influence (B=0.532) followed by land size (B=0.336) and age (B=0.333). Other factors that influenced the adoption of agroforestry were extension services (84%), knowledge in conservation (78%) and knowledge in effects of trees on crops (85%).

Conclusions

This study provides an empirical data in understanding the key determinants of adoption of the dormant agroforestry in the drylands. Recognizing and tackling the key determinants of adoption of agroforestry by smallholder farmers in drylands is key. It will enable active participation, adoption and spread of agroforestry in the drylands thus realizing its full potential.

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Table 1. Dominant dryland agroforestry systems in the study area

Agroforestry system/ practice		Farmers working with DNRC		Farmers not working with DNRC		Mean		Ranking (Dominant System)	Std. deviation
	N=240	n=120		n=120		n=120			
		F	%	F	%	F	%		
Life fence	Have	100	83.3	80	66.7	90	75.0	5	4.1667
	Do not have	20	16.7	70	58.3	30	25.0	1	4.167
Homestead tree	Have	98	81.7	100	83.3	99	87.5	3	0.016
	Do not have	22	18.3	20	16.7	15	12.5		
Woodlot	Have	75	62.5	38	31.7	57	47.5	6	5.708
	Do not have	45	37.5	82	68.3	63	52.5		
Scattered trees in the farm	Have	115	95.8	110	91.7	113	94.2	1	0.108
	Do not have	5	4.2	10	8.3	7	5.8		
Home Gardens	Have	28	23.3	22	18.3	25	20.8	7	0.150
	Do not have	92	76.7	98	81.7	95	78.2		
Fruit orchards	Have	90	75.0	72	60.0	81	79.2	4	2.016
	Do not have	30	25.0	48	40.0	25	20.8		
Fallow (grazing land)	Have	88	93.3	110	91.7	99	92.5	2	1.017
	Do not have	32	6.7	10	8.3	21	7.5		

Table 2. Social and economic factors influencing adoption of agroforestry systems/practice

	1	2	3	4	Total	
Factors	F %	F %	F %	F %	F	%
Age	72(30%)	10(4.2%)	14(5.8%)	144 (60%)	240	(100%)
Education	50(20.8%)	75(31.3%)	30(12.5%)	85(35.4%)	240	(100%)
Marital status	140 (58.3%)	72(30%)	10(4.2%)	18 (7.5%)	240	(100%)
Family size	132 (55%)	48(20%)	20(8.3%)	40 (16.7%)	240	(100%)
Cultural beliefs	10 (4.2%)	15 (6.3%)	17 (7.1%)	198(82.5%)	240	(100%)
Land size	156 (65%)	50 (20.8%)	20 (8.3%)	14(5.8%)	240	(100%)
Income	120 (50%)	52 (21.7%)	30 (12.5%)	38 (15.8%)	240	(100%)
Mean responses	97 (40.4%)	55 (22.9%)	20 (8.3%)	68 (28.3%)	240	(100%)

F% = Frequency percentage

Table 3. Multinomial logistic Regression Model assessment of factors influencing adoption of agroforestry in Kenya

Model	Unstandardized	Standardized coefficients	t coefficients	Sig.	
	B	Std. error	Beta	B	Std. error
1 (Constant)	.290	.065		4.431	.000
Age (X1)	.333	.024	.607	13.806	.000
Education (X2)	.532	.056	.607	9.533	.000
Marital status (X3)	.011	.051	.016	.220	.826
Family size (X4)	.075	.062	.049	1.204	.000
Cultural beliefs (X5)	.181	.031	.239	5.762	.000
Land size (X6)	.336	.051	.401	6.629	.000
Income (X7)	.060	.064	.039	.939	.002

Dependent Variable: Adoption of Agro forestry farming

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