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Socio-economic factors affecting agro-forestry technology adoption in Nyando, Kenya

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Abstract

Agro-forestry (AFR) technologies are perceived to improve livelihoods and natural resource sustainability of the rural households. Despite their aggressive promotion by multiple national and international agencies, the adoption of AFR technologies has been minimal in Kenya. This study conducted a survey to examine the socio-economic factors that affect the adoption process in Nyando, Kenya. Results revealed that farmers with bigger farms and higher education were more likely to adopt the new technology. Additionally, farmers were quicker to adopt technology if they had an increase in crop yields and had stayed longer in the study area. Generally, wealthier famers tended to adopt more AFR technology than those with less income. Access to information was the only factor strongly correlated with the rest of the independent variables. The results suggest that, adoption would be more enhanced with a clear focus on extension activities, income enhancing AFR practices and soil amelioration technologies. This study may be replicated in other parts of Kenya and East Africa to improve the level of AFR technology adoption for sustainable rural development.

Key words: *adoption, agro-forestry technologies, farmers, socio-economic factors*

INTRODUCTION

Agro-forestry (AFR) is the intentional mixing of trees and shrubs into crop and animal production systems to create economic, environmental, and social benefits [ERDMANN 2005]. AFR practices creates a more diverse landscape to achieve multiple goals and create proper microclimatic conditions for high value specialty crops [WORKMAN, ALLEN 2011]. At the landscape scale, AFR leads to the generation or enhancement of the desired ecological processes essential for sustainable land use [ALEMU 2012]. It is also believed that AFR can provide reliable framework for soil and water conservation at much lower cost than the traditional methods such as terraces, banks and ditches [JACKSON *et al*. 2000].

The need for detailed research on AFR systems has never been more urgent in Africa. According to REYES [2008], AFR is one of the fundamental disciplines for sustainable development in Africa; especially for livelihood improvement and sustainable land management.

Since most of these smallholder farm parcels are over exploited, declining productivity is pushing farmers to seek more fertile lands. Compounded with unsustainability of traditional farming systems and land use pressure, the land is rapidly degraded [CLAY *et al.* 1998; PENDER *et al.* (eds.) 2006; ZARE *et al*. 2014]. Many AFR technologies like improved fallows have been in trial to help replenish the degraded soils because poor farmers cannot afford to buy inorganic fertilizers [FRANZEL 1999; KANG, WILSON 1987]. Recent adoption studies indicate that both trialing and adoption of these technologies are low [KWESIGA *et al.* 2003].

After Kenya's independence in 1963, there was little public farm forestry activity until early 1980s. Most of the AFR work was pioneered by Cooperative for Assistance and Relief Everywhere (CARE) international and government of Kenya setting up AFR extension project (AEP) in western Kenya. Other nongovernmental organizations (NGOs) followed up, borrowing from AEP technology and philosophy [SCHERR 1995]. Degraded soils, fuel wood decline, scarcity of building materials, wind damage and dry season fodder shortage were the main issues to be addressed [SCHERR 1995]. In these areas, most farmers were smallholder with 82% cultivating less than 2 hectares of cropland. They also protected and established fruit and medicinal species like mangoes. At the time, the most economically important trees were species for pod and leaf fodder, construction and shade [SCHERR 1995]. By the end of British colonial period (1963), Kenya's agriculture stagnated and fallow periods shortened due to land use intensification and declining soil fertility and crop yields. Due to population increase, farm sizes declined such that by 1989 most AEP participants had less than a hectare of cropland [SCHERR 1995]. Shrinking land sizes has made intercropping, boundary plantings and field boarders among the most common AFR practices in Western Kenya [SCHERR 1995].

A survey of low resource endowed households in western Kenya indicated that farm revenue made up a paltry 7% of the total household income. In these areas, most farmers were exposed and vulnerable to multiple stressors including land fragmentation, diseases and chronic poverty [GABRIELSSON *et al.* 2013]. Even in the most optimistic scenario where farm revenues were increased 400%, these farmers would have to supplement their income through off-farm activities. In contrast, high resource endowed farmers earned 63% of total household income from the farms. Furthermore, medium resource endowed farmers had four times as much land therefore earning revenues seven times higher than their low resource endowed counterparts [SHEPHERD, SOULE 1998]. An evaluation of farm returns showed that low resource endowed farmers were barely breaking even when family labour was valued at market rate. High resource endowed farmers had more success due to use of inorganic fertilizers and intensive dairy cattle enterprises [SHEPHERD, SOULE 1998]. In another study of improved fallows and biomass transfer by first generation farmers in western Kenya, various reasons were given for poor technology uptake or abandonment. The major reasons provided by farmers were; small farm size (63%), no noticeable increase in crop yields (18%), lack of market for seed (18%), improved fallows did not provide edible products (3%), lack of labour (3%) and lack of knowledge (2%) [KIPTOT *et al.* 2006].

Almost 70% of Kenya's population consists of rural based subsistence families whose sole source of energy is fuel wood and charcoal [MWANGI 2013]. The Kenyan smallholder farmer is bedevilled with many challenges, including low productivity, extreme reliance on rain fed agriculture, floods, drought and poor technology [ALILA, ATIENO 2006; MUCHENA, HILHORST 2000]. There is increased encroachment into protected forest lands with population increase, causing catastrophic deforestation [BLEHER *et al.* 2006; LAMBRECHTS *et al.* 2003; REYES 2008]. Land fragmentation is common with population increase but farmers are always reluctant to adopt technologies on agriculturally productive land [CURRENT *et al.* 1995; KABWE *et al.* 2009]. AFR technologies give an alternative solution to poor smallholder farmers who would otherwise have a reduction in crop yields [SANCHEZ *et al.* 1997]. However, unless farmers widely adopt these technologies, the potential benefits of AFR for livelihood improvement and sustainable environmental management will not be realized [RULE *et al.* 2000].

The best measure of the social success of new or improved AFR technology is the readiness with which farmers accept the technologies to improve their lives. If innovations do not take into account the social context in which these farmers operate, then the adoption rates will be reduced [KABWE *et al.* 2009]. The factors affecting AFR adoption are increasingly variant, hence the need to understand the specific factors influencing AFR technology adoption [AJAYI *et al.* 2007]. Once these factors affecting AFR adoption are identified, policies may be tailored to promote technology transfer and improve acceptance of AFR practices among target populations.

High population pressure, land fragmentation, easy access to labour, complex land tenure systems and poor market infrastructure are the key issues making AFR subject of study in Africa. This study conducted a survey to examine the socio-economic factors that affect the AFR technology adoption process in Nyando, Kenya. Farmers in Nyando, Kenya face many challenges in light of global climate change, population expansion, and deforestation. AFR technologies have the potential to alleviate some of these problems, especially in long-term development scenarios by allowing farmers to use fewer resources, mitigate biotic and abiotic crop stress, and provide a more stable income over time. Thus, this preliminary study on AFR adoption in Kenya is critical to understanding AFR technology transfer and AFR as a sustainable land use solution for smallholder farmers. The next section will discuss the experimental setup, variables and general methodology adopted. The major results are discussed in section 3, evaluation is done on the independent variables to assess their impact and establish whether they met the threshold of significance. A critical discussion of the findings from results is also provided. The study concludes by highlighting the lessons learned and giving recommendations.

METHODS

STUDY AREA

The study area was Nyando in Kisumu County on the shores of Lake Victoria in Kenya East Africa (Fig. 1). The district lies within latitudes 0° (equator) 0.42° South and longitudes 34.07° and 35.35° East. The terrain is flat with the highest population density of 469 persons per km^2. Settlement is determined by the physical geography of the

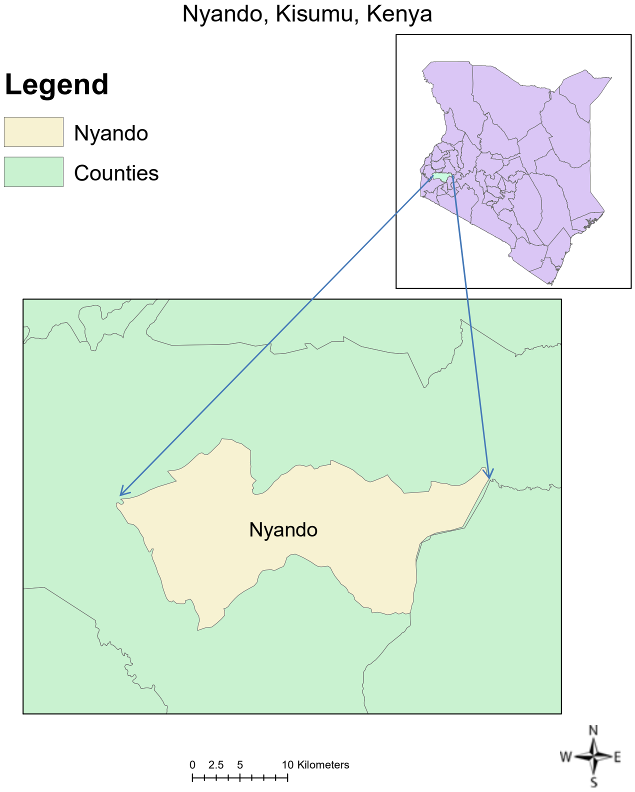

Fig. 1. Map of study area; source: own elaboration

district and relative agricultural potential. Large-scale plantation farming is done on the sugar belt. The highlands have high agricultural potential but farm sizes are increasingly becoming smaller with increased fragmentation of land. On the other hand, lowlands are bedevilled by perennial flooding. Nyando area represents a typical arid and semi-arid area in Africa [FENG, FU 2013], therefore the study can be used as a benchmark for other areas facing similar challenges (e.g, global warming and land degradation).

SURVEY DESIGN

Probability sampling was used in this study. Personal interest of the farmer to engage in the study was also a key consideration. The study considered only farmers practicing AFR to ensure that the participants were involved in the study. The sample size was determined using Fishers formula [MUGENDA 1999]:

$$n = \frac{Z^2 pqD}{d^2(N-1)+Z^2pq} \qquad (1)$$

Where: n = the desired sample size; Z = the standard normal deviate (1.96), which corresponds to 95% confidence interval; D = proportion in target population that has characteristic being measured =1400; p = 0.5; $q = (1 – p)$; d = level of statistical significance set (0.05); N = target population

$n = [1.96^2 \cdot 0.5 \cdot (1 – 0.5) \cdot 1400]$:
: $[0.05^2 (1400 – 1) + 1.96^2\ 0.5 \cdot 0.5)] = 301$
$n = 301$

Due to fieldwork logistics, remoteness and costs, 10% of the target population was randomly taken as a representative sample. To forestall the challenges of a smaller sample size, we accommodated a lower confidence level of *, ** and *** indicating level of statistical significance at 15%, 10%, and 5%, respectively. The sample was 59.4% male and 40.6% females. Farmers were selected for their exposure to AFR based on a list of contact farmers held by International Centre for Research in Agro-forestry (ICRAF), also known as World Agro-forestry Centre. Appointments were made through the contact farmers, for the farmers to be present at households during the administration of questionnaires. Personal interviews in local language were conducted and responses recorded on the questionnaires. The chief representative of the contact farmers assisted with clarifications and translations as necessary. On each farm visit, an initial survey of the property was conducted to assess which of the most common technologies had been adopted. These technologies included: trees for shade, boundary trees, trees for fodder, windbreaks/shelterbelts, and trees for soil amelioration.

ANALYSIS

The responses to the individual questionnaires were processed and analysed using STATA software [StataCorp LLC 2007]. Logistic regression was done to determine which set of factors were significant for technology adoption in the study area [HOSMER *et al.* 2013]. Dependent variable was the outcome (adoption or non-adoption) while the independent variables were decision maker (husband or wife), farm size, education status, total income, percent of income from crops, access to information and years of residence. Logistic regression was applied to identify the relationship between "outcome" (dependent variable) and the seven independent variables.

RESULTS AND DISCUSSION

HOUSEHOLD CHARACTERISTICS

Table 1 shows household characteristics of the farmers in the study area. Perennial flooding along the flood plain has led to increased landslides and land dereliction thereby causing land fragmentation and reduction in the average family parcel sizes. In fact, the average farm size is 5.5 acres. Most farmers in the study area have been residents for approximately 21 years and have attained at least primary education. A large sample of farmers who had frequent access to information mostly adopted AFR technology and accrued at least 10% of their income from crops. Of all the households sampled, most decisions were made by husbands while the mean household income was approximately $288 annually.

CORRELATION ANALYSIS

Table 2 shows the correlations between independent variables and outcome. Farm size was positively correlated with farmers' decisions on AFR technology adoption, like-

Table 1. Characteristics of farmers in the study area

Specification	Mean	Median	Standard deviation	Minimum	Maximum
Farm size (acres)	**5.54**	4.1	5.45	0.1	23
Education level (dummy = 1 if has primary or above education)	**0.84**	1	0.37	0	1
Decision maker (dummy = 1 if decision maker is husband)	**0.59**	1	0.5	0	1
Total income (US $)	**288.4**	147.5	354.46	0	1414.75
Years of residence	**21.44**	23.5	9.73	4	40
Access to information (dummy = 1 if has frequent access to information)	**0.63**	1	0.49	0	1
% income from crop	**10.25**	8	24.71	0	97

Source: own study.

Table 2. Correlation matrix

Specification	Farm size	Education level (dummy = 1 if has primary or above education)	Decision maker (dummy = 1 if decision maker is husband)	Total income	Years of residence	Access to information (dummy =1 if has frequent access to information)	% income from crop
Farm size	1.000						
Education level (dummy = 1 if has primary or above education)	0.148	1.000					
Decision maker (dummy = 1 if decision maker is husband)	0.139	0.005	1.000				
Total income	**0.447**	0.096	0.010	1.000			
Years of residence	0.143	0.128	0.224	0.388	1.000		
Access to information (dummy = 1 if has frequent access to information)	**0.293**	**0.378**	**0.542**	**0.384**	**0.271**	1.000	
% income from crop	0.006	0.187	0.108	0.052	–0.061	–0.037	1.000
Adopted agro-forestry (AFR) technology	**0.518**	**0.206**	0.040	**0.653**	**0.402**	**0.228**	**0.219**

Source: own study.

ly due to the ability of these farmers to conduct trials on small portions of land without sacrificing a large percentage of the overall farm returns [CURRENT *et al.* 1995; NEUPANE *et al.* 2002; SCHERR 1995]. There was a strong connection between wealth and AFR technology adoption, because farmer's needs and objectives were influenced by capital asset endowments [IIYAMA *et al.* 2008; LINIGER *et al.* 2011; REED *et al.* 2013].

Years of residence had a strong positive correlation with AFR technology adoption. Longer years of residence could be associated with strong land tenure security leading to AFR adoption. Similar findings by LINIGER *et al.* [2011], emphasized the need for land tenure security for AFR technology adoption. Correlation between AFR adoption and education status was also strong. Education was an influential factor because more education was associated with better information management [LIU, HUANG 2013; TRAORE *et al.* 1998].

According to LIU and HUANG [2013], cost and benefits that accrue from adoption of conservation technologies strongly influenced farmers' decisions to adopt them. Similarly in this study, crop yields were very critical for decision making on whether to adopt AFR technologies. Moreover, household incomes had the highest correlation with farm size which also had the strongest correlation with AFR technology adoption. This was ironical because AFR technologies are designed for poor households to uplift their agricultural and economic productivity [SCHERR 1999].

Access to information was another key factor which had significant positive correlation with AFR technology adoption. In fact, access to information was the only independent variable positively correlated to all the other factors affecting AFR adoption. Similar studies on farmers in Nile Basin of Ethiopia revealed lack of information as the main reason for failure to adopt soil conservation practices [BEKELE, DRAKE 2003; LIU, HUANG 2013]. Household decision makers did not have significant correlation with AFR technology adoption.

REGRESSION ANALYSIS

Results from regression analysis identify a set of socio-economic factors that may influence the decision to adopt AFR technologies (Tab. 3). Farmers with larger farms were more likely to adopt AFR technologies. One possible explanation is that larger farms can enjoy economies of scale where the fixed cost of technology adoption is spread out over more acres of land. CURRENT *et al.*

Table 3. Socio-economic factors that affect agro-forestry (AFR) technology adoption in Nyando, Kenya, Logit regression

Dependent variable	Adopted AFR technologies
Farm size	0.513*** (2.21)
Years of residence	0.250** (1.92)
Total income	0.213** (2.12)
% income from crop	0.0848** (1.84)
Education level (dummy = 1 if has primary or above education)	5.148** (1.83)
Decision maker (dummy = 1 if decision maker is husband)	–1.306 (–0.94)
Access to information (dummy = 1 if has frequent access to information)	0.426* (1.51)

The *t*-statistics are reported in parentheses; *, ** and *** indicate level of statistical significance at 15%, 10%, and 5%, respectively.
Source: own study.

[1995] also found that farm size was positively correlated with AFR technology adoption decisions in Caribbean and Central America countries. These findings, however, cannot be generalized to all AFR technologies. For example, KABWE *et al*. [2009] found that land constraint was associated with improved fallowing practices among small landholder farmers in Zambia.

If farmers had stayed in the area longer, households were more likely to adopt AFR technologies, probably because more years of residence brought more secure property rights over land. LINIGER *et al*. [2011] found that long term land use strategies without a secure land tenure system were associated with lower AFR adoption among farmers. KABWE *et al*. [2009] also observed that lack of land tenure security hampered female farmers from adopting improved fallow practices in Kenya. Studies by MUGI--NGENGA *et al*. [2016] in eastern Kenya also revealed that land and capital were the main limiting factors in AFR adoption.

The estimated coefficient on total income is positive and statistically significant. This indicates that farmers with higher income were more likely to adopt AFR technologies, probably because they can afford the installation costs such as labour, seeds and implements. Results reveal that adoption rates were higher when farmers had increased income from crop yields. This is consistent with the findings from FRANZEL [1999] and MUCHENA and HILHORST [2000], who found that triability of AFR technologies increased when farmers perceived low fertility of soil as their immediate problem, because fertility was strongly associated with crop yields.

Micro-level factors were also key to technology adoption [MCDONALD, GLYNN 1994]. For instance, more educated farmers were more likely to adopt AFR technology in Nyando. However, whether the decision maker was the wife or the husband did not have a statistically significant effect on the likelihood of AFR technology adoption. The estimated coefficient on the variable that measures access to information is positive and statistically significant. Study findings also revealed that, farmers who were frequently exposed to AFR technology were more inclined to adoption.

AGRO-FORESTRY TECHNOLOGY ADOPTION PARADOX: CONFLICTING PERSPECTIVES FROM STAKEHOLDERS

Under normal circumstances, farmers who appreciate the merits of AFR will incorporate some technologies into their farming practices if they can afford it [PASTUR *et al.* 2012]. However, these farmers especially those in Nyando have limited land and more pressing needs such as household food production. AFR therefore remains complex because these layers aren't readily observable. For instance, experts highlight multiple benefits of AFR systems wondering why farmers are not adopting the technologies. On the other hand, peasant farmers view AFR practices as risky and question why they should adopt them. Development and AFR agencies have long-term multi-scalar views that tend to conflict with peasant farmers' multiple yet mainly single-scalar and short term views. Peasants have an urgency to put food on the table which cannot be postponed for trees to grow or nuts to ripen [JERNECK, OLSSON 2013b]. Therefore, any meaningful intervention for AFR technology adoption by policy makers must address the needs of the farmers individually or in clusters.

It is clear that peasant farmers do not neglect the roles and values of trees nor are they naïve about their immediate environment [ALTIERI 2004]. The fundamental bottleneck is that policy formulators planning horizon is at odds with benefits and management of slow growing trees. As policy makers stress the intangible benefits including carbon sinks and biodiversity; to locals, trees are a source of tangibles like fodder, timber and others. Farmers are needs specific and intangible benefits remain a distant priority to them. Therefore, opportunities to reconcile expert and non-expert knowledge are the most realistic ways to create effective AFR policies [XU *et al*. 2012].

Policy makers should understand that most AFR adoption decisions are incumbent upon natural resource and social endowments, preferences, incentives, risk assessments and levels of uncertainty [MERCER 2004]. For instance, food security requires investments but the margins are narrow hence farmers' willingness to engage in new technologies is hindered by the high opportunity cost [JERNECK, OLSSON 2013b]. This explains why resource endowed farmers in Nyando are more inclined to adoption. On the other hand, poor resource endowed farmers gravitate mainly to those technologies that can guarantee improved crop production on their parcels. The risk tolerance among peasant farmers depends on buffers, margins to destitution and levels of food security. Generally, these farmers gravitate towards activities that offer realistic chances of maintaining their current lifestyles than those that offer promising but risky cash flow outcomes [CHIBNIK 1978]. This risk philosophy ensnares farmers to safety fast strategy. In these circumstances, policy makers must focus on risk reduction and not profit maximization as a strategy for dealing with food insecure farmers.

Retail food prices constitute a constant headache for peasant farmers, especially in circumstances where their productivity is inadequate for their consumption needs. In these situations, the farmers view AFR as a time consuming labour intensive risky activity with greater uncertainty. Path dependencies and resilience shockers must also be understood in much detail. These include seasonal food insecurities, vagaries of weather and cash demands that tend to converge to create times of hardship [GABRIELSSON *et al.* 2013]. For instance, most of Nyando lies in a flood plain posing perennial losses to farmers, increases destitution and lowers standards of living. These hardships creates a scarcity and choice scenarios where AFR adoption competes with food production, recovery from illness, diseases and farmers tend to prioritize the former over the latter [JERNECK, OLSSON 2013a]. Holding all the factors constant, AFR is mostly perceived to be knowledge intensive, long term, uncertain, costly and too complex on the eyes of the peasant farmer.

The last paradox is that of poorest of the poor, a group of farmers very difficult to reach [NIND 2011]). Most of farmers in Nyando fall under this category as they live be-low a dollar a day ($288 annually). They represent a section of farmers unable to benefit from remedies of poverty alleviation due to their circumstances [JERNECK, OLSSON 2008]. Based on social differentiation, JERNECK and OLSSON [2013b], stratified peasant farmers as sub-subsistence, subsistence and supra-subsistence. Sub-subsistence-are peasant farmers chronically food insecure and rely on irregular cash income from various off-farm sources. For these, reduce burden, then provide information/inputs while building capacity. Subsistence refers to those periodically food insecure relying on irregular cash income from diversification into a range of sources. Both categories are risk evaders. Provide information and inputs for subsistence. Finally, supra-subsistence refers to peasant farmers who have adequate resources but are constrained during severe drought or ill health. These are opportunity seekers and only need to be provided with information.

ADOPTION PROCESS AND POLICY IMPLICATIONS

Adoption occurs when one has decided to make full use of the new technology as the best cause of action for addressing a need [BOZ, AKBAY 2005; STEELE, MURRAY 2004]. The adoption process will be influenced by perceived attributes of innovation, social system, channel of communication and agent promotion efforts [DENNING 2001; KABWE *et al*. 2009; ROGERS 2010]. Related studies by MEIJER *et al*. [2015], revealed that these processes are complex and mostly influenced by extrinsic and extrinsic variables all of which must be held into account for success. In Nyando, farmers have a need to increase income from crops. Our results suggested that more AFR technology adoption could be achieved by focusing on technologies that increase soil amelioration to increase crop productivity. Extension activities should therefore be tailored to emphasize soil amelioration as a key to increasing yields to address the farmers' needs.

The adoption process is generally described by a five-step process that is; 1) knowledge, where the farmer is exposed to the idea but lack information about it; 2) persuasion, where there is interest in the innovation and attempts made to seek more information; 3) decision-making, where the farmer weighs advantages and disadvantages to see whether to adopt or rejects the innovation; 4) implementation, where the farmer tries the innovation to determine its usefulness; and 5) confirmation, where the decision to use the innovation is finalized [MATTILA *et al*. 2003; RAINTREE 1983; ROGERS 2002]. Studies in western Kenya by SCHERR [1995], indicated that the best strategies for technology adoption were; initial testing of the said technologies, building on familiar practices and economic returns with AFR. Where systems are based on existing agroforestry practices, adoption proceeds quickly due to farmers familiarity with management or components of the AFR system shortening famers' learning curve or "testing and evaluation" period [RAINTREE 1991; SCHERR 1995].

In Nyando, policy formulators should therefore target new residents (farmers with less years of residence) to boost adoption. Additionally, land tenure insecurities faced by farmers with less years of residence should be addressed through support systems and synergies to revise disincentives to AFR adoption by new residents [SCHERR 1995]. From the results, income increases likelihood of AFR technology adoption because farmers have credit constraints. Therefore, financial aid is a key policy tool for increasing adoption. Farmers with smaller parcels of land should be the key target of extension agents to boost AFR technology adoption through robust income enhancing technologies. SHEPHERD and SOULE [1998], also recommended that AFR interventions must be targeted to farmers with low and medium resource endowments to increase productivity and sustainability of poor rural households. They however noted that the chief challenge would be increasing farm output and or decreasing cost of inputs. MWASE *et al*. [2015] argued further that effective remedies would include awareness creation together with stakeholder collaboration for successful implementation.

During the above process, farmers evaluate AFR technologies using up to six criteria related to innovation characteristics which include; 1) relative advantage, 2) trialability, 3) compatibility, 4) adaptability, 5) observability and 6) complexity [RAINTREE 1985; REED 2007]. These innovation characteristics are then considered in turn, to examine the factors affecting the likelihood of adoption of new AFR technologies [STUPPLES 1988]. Observability is a key factor that extension agents must emphasize, probably through trial plots and farmer field days. These events provide opportunities where semi-literate and illiterate farmers get a chance to see and experience typical outcomes of AFR technologies (seeing is believing). Similar AFR studies in western Kenya affirmed that, farmers adopted technology in incremental steps. First was small scale experimentation on lower quality land, maintenance and management of operational plots and finally, renewal of original plots or establishment new ones after production cycle [SCHERR 1995].

AFR can meet the diverse needs and objectives of farmers, but effectively communicating the benefits of using such technologies is the key to their success [REED 2007]. Studies by JACKSON *et al*. [2000], emphasized that adoption of AFR as a preferred system of land use would only be achieved by showing that it is either more productive (i.e. higher cumulative returns on tree and crop products) and or more sustainable than individual tree and crop enterprises. If AFR technology is explained effectively, its perceived complexity may be reduced; hence observability and adaptability may increase [REED *et al*. 2013]. Depending on the outcome of the evaluation, AFR technology or innovation will be adopted and implemented or rejected.

To address their diverse needs, trial farmers should be segregated according to their greatest immediate need, such as, soil amelioration, food security, environmental protection or increased financial benefits. By targeting each group individually through specific AFR technology proposals, extension agents will reduce the chance of imposing their ideas on unwilling farmers and increase the likelihood of adoption (user specificity). IIYAMA *et al*. [2014], also emphasized this point by recommending that, AFR systems must be compatible with farmers' needs in their local farming systems and socio-economic contexts.

Extension agents will appreciate that participatory learning is shifting their role of extension officers to facilitators to enable them to make impacts on small scale farmers [GHOLAMREZAI, SEPAHVAND 2017; KIPTOT *et al*. 2006]. Knowledge is dynamic and is being transformed by actors to suit their circumstances. Research and extension staff should keep in touch with trial farmers to capture this knowledge and create a feedback loop to solve problems for the farmers [KIPTOT *et al*. 2006]. Similar sentiments were shared by NYANGA *et al*. [2016], who reiterated that adoption could be increased through on farm trainings and extensions through multi-stakeholder collaborations. Studies by KIPTOT *et al*. [2006] also revealed that technical trainings were less effective compared to social networks for diffusion and dissemination of AFR knowledge. They proved that social networks served to disseminate information from farmer to farmer through kinship ties on complex AFR systems.

Despite the fact that AFR adoption is still minimal, sustainable land use and natural resource management in these areas will benefit from structurally and functionally more complex systems like agroforestry [RAMACHANDRAN NAIR *et al*. 2009]. Most experts agree that reforestation, sustainable agricultural practices, avoided deforestation are among the most feasible remedies to climate change adaptation; all of which could be achieved through AFR [NILES *et al*. 2002]. Education, extension, land tenure and other factors that farmers have no control over like farm size, researchers' performance and gender should be studied further to improve technology adaptation in Nyando.

CONCLUSIONS

The purpose of this study was to determine the socio-economic factors that influence adoption of AFR technologies in Nyando, Kenya. Preliminary results show that farm size was the most significant factor for AFR technology adoption. The remaining factors included education status, access to information, percent of income from crop, total income and years of residence. There was a clear relationship between technology adoption and livelihood improvement. For instance, farmers were growing pepper, raising individual tree nurseries and generating more income. Access to information remains the most critical factor affecting AFR technology adoption significant to policy formulators.

The research findings proved that AFR is difficult to establish in Nyando because it is more knowledge intensive and complex. It is also apparent that acceptability and success of AFR will depend on understanding diverse stakeholder perspectives and ontologies. This becomes even more critical when dealing with poorest of the poor peasant farmers because AFR is constrained by circumstances it is meant to improve. Policy formulators have therefore misconstrued poverty to be an incentive but it is a disincentive to AFR adoption.

Farmers' circumstances also affected which technologies they chose to adopt. If farmers' circumstances were favourable, some technologies were selected over others. Adoption of the technologies was based on the organization sponsoring the project initiative and the extent of collaborative efforts between the organizations involved. However, sustainability of such projects depended upon the coordinators' ability to hang on even after the exit of the project through extension activities. Therefore, AFR adoption is a conglomeration of varying ontologies, socio-economic, cultural circumstances that work for and against the peasant farmers to accept technology adoption.

Future projects should involve both farmers and extension officers from the onset and have inbuilt ways of disseminating the project findings to enhance adoption. Analysis of extension factors could shed light on challenges met during technology trials by farmers; while correlation between researchers' performance and adoption of technology could highlight farmers' perceptions. This study may be replicated in other parts of Kenya and East Africa to improve the level of AFR technology adoption for sustainable rural development.

REFERENCES

AJAYI O.C., AKINNIFESI F.K., SILESHI G., CHAKEREDZA S. 2007. Adoption of renewable soil fertility replenishment technologies in the southern African region: Lessons learnt and the way forward. Natural Resources Forum. Vol. 31. Iss. 4 p. 306–317.

ALEMU B. 2012. Carbon stock potentials of woodlands and land use and land cover changes in north western lowlands of Ethiopia [online]. MSc thesis. Hawassa, Ethiopia. Hawassa University. [Access 22.01.2015]. Available at: https://cgspace.cgiar.org/handle/10568/25151

ALILA P.O., ATIENO R. 2006. Agricultural policy in Kenya: Issues and processes. In: Future Agricultures Consortium Workshop. Institute of Development Studies p. 20–22.

ALTIERI M.A. 2004. Linking ecologists and traditional farmers in the search for sustainable agriculture. Frontiers in Ecology and the Environment. Vol. 2. Iss. 1 p. 35–42.

BEKELE W., DRAKE L. 2003. Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: A case study of the Hunde-Lafto area. Ecological Economics. Vol. 46. Iss. 3 p. 437–451.

BLEHER B., USTER D., BERGSDORF T. 2006. Assessment of threat status and management effectiveness in Kakamega Forest, Kenya. In: Forest diversity and management. Eds. D.L. Hawksworth, A.T. Bull. Ser. Topics in Biodiverisity and Conservation. Vol. 2. Springer p. 99–117.

BOZ I., AKBAY C. 2005. Factors influencing the adoption of maize in Kahramanmaras province of Turkey. Agricultural Economics. Vol. 33(s3) p. 431–440.

CHIBNIK M. 1978. The value of subsistence production. Journal of Anthropological Research. Vol. 34. Iss. 4 p. 561–576.

CLAY D., REARDON T., KANGASNIEMI J. 1998. Sustainable intensification in the highland tropics: Rwandan farmers' investments in land conservation and soil fertility. Economic Development and Cultural Change. Vol. 46. Iss. 2 p. 351–377.

CURRENT D., LUTZ E., SCHERR S.J. 1995. Costs, benefits, and farmer adoption of agroforestry: Project experience in Central America and the Caribbean [online]. World Bank Publications. No. 14. Washington, DC pp. 232. [Access 22.01.2015]. Available at: http://documents.worldbank.org/curated/en/970021468247833086/Costs-benefits-and-farmer-adoption-of-agroforestry-project-experience-in-Central-America-and-the-Caribbean

DENNING G.L. 2001. Realising the potential of agroforestry: Integrating research and development to achieve greater impact. Development in Practice. Vol. 11. Iss. 4 p. 407–416.

ERDMANN T.K. 2005. Agroforestry as a tool for restoring forest landscapes. In: Forest restoration in landscapes. Beyond planting trees. Eds. S. Mansourian, D. Vallauri. New York. Springer p. 274–284.

FENG S., FU Q. 2013. Expansion of global drylands under a warming climate. Atmospheric Chemistry and Physics. Vol. 13 p. 10081–10094.

FRANZEL S. 1999. Socioeconomic factors affecting the adoption potential of improved tree fallows in Africa. Agroforestry Systems. Vol. 47. Iss. 1–3 p. 305–321.

GABRIELSSON S., BROGAARD S., JERNECK A. 2013. Living without buffers illustrating climate vulnerability in the Lake Victoria basin. Sustainability Science. Vol. 8. Iss. 2 p. 143–157.

GHOLAMREZAI S., SEPAHVAND F. 2017. Farmers' participation in Water User Association in western Iran. Journal of Water and Land Development. No. 35 p. 49–56. DOI 10.1515/jwld-2017-0067.

HOSMER Jr D.W., LEMESHOW S., STURDIVANT R.X. 2013. Applied logistic regression. John Wiley & Sons. ISBN 9780470582473 pp. 510.

IIYAMA M., KARIUKI P., KRISTJANSON P., KAITIBIE S., MAITIMA J. 2008. Livelihood diversification strategies, incomes and soil management strategies: A case study from Kerio Valley, Kenya. Journal of International Development. Vol. 20. Iss. 3 p. 380–397.

JACKSON N., WALLACE J., ONG C. 2000. Tree pruning as a means of controlling water use in an agroforestry system in Kenya. Forest Ecology and Management. Vol. 126. Iss. 2 p. 133–148.

JERNECK A., OLSSON L. 2008. Adaptation and the poor: development, resilience and transition. Climate Policy. Vol. 8. Iss. 2 p. 170–182.

JERNECK A., OLSSON L. 2013a. Food first! Theorising agroforestry adoption in smallscale agriculture: Risk evaders, opportunity seekers and the 'the food imperative' in sub-Saharan Africa. International Journal of Agricultural Sustainability. Vol. 12. Iss. 1 p. 1–22.

JERNECK A., OLSSON L. 2013b. More than trees! Understanding the agroforestry adoption gap in subsistence agriculture: Insights from narrative walks in Kenya. Journal of Rural Studies. Vol. 32 p. 114–125.

KABWE G., BIGSBY H.R., CULLEN R. 2009. Factors influencing adoption of agroforestry among smallholder farmers in Zambia [online]. In: The 2009 NZARES Conference. Nelson, New Zealand. 27–28.08.2009. New Zealand Agricultural and Resource Economics Society (Inc.). [Access 22.01.2015]. Available at: https://www.semanticscholar.org/paper/Factors-influencing-adoption-of-agroforestry-among-Kabwe-Bigsby/210f1c2c0df6c3b814f6756bc280db9934d97bf5

KANG B., WILSON G. 1987. The development of alley cropping as a promising agroforestry technology. In: Agroforestry: A decade of development. Eds. H.A. Stepler, P.K.R. Nair. Nairobi. International Council for Research in Agroforestry p. 227–243.

KIPTOT E., FRANZEL S., HEBINCK P., RICHARDS P. 2006. Sharing seed and knowledge: Farmer to farmer dissemination of agroforestry technologies in western Kenya. Agroforestry Systems. Vol. 68. Iss. 3 p. 167–179.

KWESIGA F., AKINNIFESI F., MAFONGOYA P., MCDERMOTT M., AGUMYA A. 2003. Agroforestry research and development in southern Africa during the 1990s: review and challenges ahead. Agroforestry Systems. Vol. 59. Iss. 3 p. 173–186.

LAMBRECHTS C., WOODLEY B., CHURCH C., GACHANJA M. 2003. Aerial survey of the destruction of the Aberdare Range forests. UNEP. Division of Early Warning and Assessment pp. 35.

LINIGER H., STUDER R.M., HAUERT C., GURTNER M. 2011. Sustainable land management in practice – Guidelines and best practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT), Food and Agriculture Organization of the United Nations (FAO). ISBN 978-92-5-000000-0 pp. 243.

LIU H., HUANG Q. 2013. Adoption and continued use of contour cultivation in the highlands of southwest China. Ecological Economics. Vol. 91 p. 28–37.

MATTILA M., KARJALUOTO H., PENTO T. 2003. Internet banking adoption among mature customers: Early majority or laggards? Journal of Services Marketing. Vol. 17. Iss. 5 p. 514–528.

MCDONALD D.G., GLYNN C.J. 1994. Difficulties in measuring adoption of apple IPM: A case study. Agriculture, Ecosystems and Environment. Vol. 48. Iss. 3 p. 219–230.

MEIJER S.S., CATACUTAN D., AJAYI O.C., SILESHI G.W., NIEUWENHUIS M. 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International Journal of Agricultural Sustainability. Vol. 13. No. 1 p. 40–54.

MERCER D.E. 2004. Adoption of agroforestry innovations in the tropics: A review. Agroforestry Systems. Vol. 61. Iss. 1–3 p. 311–328.

MUCHENA F., HILHORST T. 2000. Nutrients on the move: Soil fertility dynamics in African farming systems. IIED. ISBN 1899825568 pp. 146.

MUGENDA O.M. 1999. Research methods: Quantitative and qualitative approaches. Nairobi. African Centre for Technology Studies. ISBN 9966411070 pp. 256.

MUGI-NGENGA E.W., MUCHERU-MUNA M.W., MUGWE J.N., NGETICH F.K., MAIRURA F.S., MUGENDI D.N. 2016. Household's socio-economic factors influencing the level of adaptation to climate variability in the dry zones of Eastern Kenya. Journal of Rural Studies. Vol. 43 p. 49–60.

MWANGI V.W. 2013. Energy consumption among rural households in Mukaro location of Nyeri County, Kenya. MArts Thesis. Nairobi. University of Nairobi pp. 94.

MWASE W., SEFASI A., NJOLOMA J., NYOKA B.I., MANDUWA D., NYAIKA J. 2015. Factors affecting adoption of agroforestry and evergreen agriculture in Southern Africa. Environment and Natural Resources Research. Vol. 5. No. 2 p. 148–157.

NEUPANE R.P., SHARMA K.R., THAPA G.B. 2002. Adoption of agroforestry in the hills of Nepal: A logistic regression analysis. Agricultural Systems. Vol. 72. Iss. 3 p. 177–196.

NILES J.O., BROWN S., PRETTY J., BALL A.S., FAY J. 2002. Potential carbon mitigation and income in developing countries from changes in use and management of agricultural and forest lands. Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences. Vol. 360(1797) p. 1621–1639.

NIND M. 2011. Participatory data analysis: A step too far? Qualitative Research. Vol. 11. Iss. 4 p. 349–363.

NYANGA A., KESSLER A., TENGE A. 2016. Key socio-economic factors influencing sustainable land management investments in the West Usambara Highlands, Tanzania. Land Use Policy. Vol. 51 p. 260–266.

PASTUR G.M., ANDRIEU E., IVERSON L.R. PERI P.L. 2012. Agroforestry landscapes and global change: Landscape ecology tools for management and conservation. Agroforestry Systems. Vol. 85. Iss. 3 p. 315–318.

PENDER J., PLACE F., EHUI S. (eds.) 2006. Strategies for sustainable land management in the East African highlands. Washington, D.C. Intl Food Policy Res. Inst. ISBN 0-89629-757-8 pp. 483.

RAINTREE J. 1983. Strategies for enhancing the adoptability of agroforestry innovations. Agroforestry Systems. Vol. 1. Iss. 3 p. 173–187.

RAINTREE J. 1985. Factors affecting the adoption of agroforestry innovations by traditional farmers. In: Advances in agroforestry research. Eds. J. Beer, H.W. Fassbender, J. Heuveldop. Turrialba, Costa Rica. CATIE p. 271–281.

RAINTREE J.B. 1991. Socioeconomic attributes of trees and tree planting. FAO Community Forestry Note. Iss. 9 pp. 115.

RAMACHANDRAN NAIR P.K, MOHAN KUMAR B., NAIR V.D. 2009. Agroforestry as a strategy for carbon sequestration. Journal of Plant Nutrition and Soil Science. Vol. 172. Iss. (1) p. 10–23.

REED M. 2007. Participatory technology development for agroforestry extension: An innovation-decision approach. African Journal of Agricultural Research. Vol. 2. Iss. 8 p. 334–341.

REED M., PODESTA G., FAZEY I., GEESON N., HESSEL R., HUBACEK K., LETSON D., NAINGGOLAN D., PRELL C., RICKENBACH M. 2013. Combining analytical frameworks to assess livelihood vulnerability to climate change and analyse adaptation options. Ecological Economics. Vol. 94 p. 66–77.

REYES T. 2008. Peltometsäviljely kestävän maankäytön kehittämisen keinona: tutkimuksia Itä-Usambaran vuoristoalueella Tansaniassa [Agroforestry systems for sustainable livelihoods and improved land management in the East Usambara Mountains, Tanzania]. Tropical Forestry Reports. No. 34. Helsinki. Univ. of Helsinki. ISBN 978-952-10-4556-1 p. 13–136.

ROGERS E.M. 2002. Diffusion of preventive innovations. Addictive Behaviors. Vol. 27. Iss. 6 p. 989–993.

ROGERS E.M. 2010. Diffusion of innovations. 4th ed. Simon and Schuster. ISBN 1451602472 pp. 518.

RULE L.Đ., FLORA C.B., HODGE S.S. 2000. Social dimensions of agroforestry [online]. [Access 22.01.2015]. Available at: https://www.google.com/search?client=firefox-b&biw= 1366 &bih=611&ei=EecnW5m9Ns2ckwX4q6eABA&q=10+ social+dimensions+of+agroforestry&oq=10+social+ dimensions+of+agroforestry&gs_l=psy ab.3...3078.3078.0. 3595.1.1.0.0.0.0.153.153.0j1.1.0....0...1c.2.64.psy-ab..0.0. 0....0.IUcpy 61P9Bk#

SANCHEZ P.A., SHEPHERD K.D., SOULE M.J., PLACE F.M., BURESH R.J., IZAC A.-M.N., MOKWUNYE A.U., KWESIGA F.R., NDIRITU C.G., WOOMER P.L. 1997. Soil fertility replenishment in Africa: An investment in natural resource capital. In: Replenishing soil fertility in Africa. Eds. R.J. Buresh, P.A. Sanchez, F. Calhoun. SSSA Special Publication. No. 51. ISBN 978-0-89118-946-6 p. 1–46.

SCHERR S.J. 1995. Economic factors in farmer adoption of agroforestry: Patterns observed in western Kenya. World Development. Vol. 23. Iss. 5 p. 787–804.

SCHERR S.J. 1999. Poverty-environment interactions in agriculture: Key factors and policy implications. UNDP pp. 36.

SHEPHERD K., SOULE M. 1998. Soil fertility management in west Kenya: Dynamic simulation of productivity, profitability and sustainability at different resource endowment levels. Agriculture, Ecosystems and Environment. No. 71. Iss. 1 p. 131–145.

StataCorp LLC 2007. Stata data analysis and statistical Software. Special Edition Release 10. College Station, TX: Stata Press.

STEELE J., MURRAY M. 2004. Creating, supporting and sustaining a culture of innovation. Engineering, Construction and Architectural Management. Vol. 11. Iss. 5 p. 316–322.

STUPPLES L.G. 1988. Policy strategies for the implementation of agroforestry in New Zealand. MSc Thesis. Lincoln College, University of Canterbury pp. 78.

TRAORE N., LANDRY R. AMARA N. 1998. On-farm adoption of conservation practices: The role of farm and farmer characteristics, perceptions, and health hazards. Land Economics. Vol. 74. Iss. 1 p. 114-127.

WORKMAN S.W., ALLEN S.C. 2011. The practice and potential of agroforestry in the Southeastern United States. Univ. Florida. IFAS Extension pp. 49.

XU J., VAN NOORDWIJK M., HE J., KIM K.-J., JO R.-S., PAK K.-G., KYE U.-H., KIM J.-S., KIM K.-M., SIM Y.-N. 2012. Participatory agroforestry development for restoring degraded sloping land in DPR Korea. Agroforestry Systems. Vol. 85. Iss. 2 p. 291–303.

ZARE N., KHALEDIAN M., MAILHOL J.C. 2014. Using Water and Agrochemicals in the soil, crop and Vadose Environment (WAVE) model to interpret nitrogen balance and soil water reserve under different tillage managements. Journal of Water and Land Development. No. 22 p. 33–39. DOI 10.2478/jwld-2014-0020.

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Czynniki społeczno-ekonomiczne wpływające na stosowanie technologii rolniczych i leśnych w Nyando w Kenii

STRESZCZENIE

Uważa się, że technologie rolnicze i leśne (AFR) poprawiają warunki życia i odnawialność zasobów naturalnych w gospodarstwach wiejskich. Mimo intensywnej promocji tych technologii przez liczne agencje krajowe i międzynarodowe, stosowanie technologii AFR w Kenii jest minimalne. W ramach badań przeprowadzono ankietę w celu przeanalizowania czynników społecznych i ekonomicznych, które wpływają na proces wdrożenia tych technologii w Nyando w Kenii. Wyniki wykazały, że rolnicy z większych gospodarstw rolnych i o wyższym wykształceniu byli bardziej skłonni stosować nowe technologie. Ponadto rolnicy szybciej przyjmowali nowe technologie, jeśli uzyskiwali wzrost plonów i dłużej mieszkali na badanym obszarze. Bogatsi rolnicy byli skłonni wdrożyć więcej technologii AFR niż rolnicy o niższych dochodach. Dostęp do informacji był jedynym czynnikiem, który silnie korelował z resztą zmiennych niezależnych. Wyniki sugerują, że wdrożenie tych technologii byłoby powszechniejsze, gdyby większą uwagę poświęcono dodatkowym działaniom, praktykom AFR zwiększającym przychody rolników i technologiom poprawiającym jakość gleb. Takie badania można powtórzyć w innych regionach Kenii i wschodniej Afryki, aby zwiększyć poziom stosowania technologii AFR w celu zrównoważonego rozwoju obszarów wiejskich.

Słowa kluczowe: *czynniki społeczno-ekonomiczne, rolnicy, technologie rolniczo-leśne*